Hydromorphology of European rivers: impacts of regulation and benefits of rehabilitation

Hydromorphologie des cours d'eau européens : impact de la régulation et des avantages de la réadaptation

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RÉSUMÉ

REFORM (CE FP7 Grant 282656) est un grand projet de 4 années de recherche intégrée (2011-2015) qui aborde les défis pour atteindre les objectifs hydromorphologiques et écologiques pour les rivières comme l'exige la directive cadre européenne sur l'eau (www.reformrivers.eu). Ce projet international compte 26 partenaires de 15 pays européens. De nombreuses rivières européennes sont régulées pour soutenir la protection contre les inondations, la navigation, l'approvisionnement en eau douce ou la production hydroélectrique. Les effets secondaires de ces modifications hydrologiques et morphologiques sur l'environnement ne sont pas suffisamment connus, ni dans quelle mesure ces effets secondaires peuvent être efficacement inversés ou atténués. Le cadre de la restauration porte sur la pertinence des processus dynamiques à différentes échelles spatiales et temporelles, la nécessité de définir des points terminaux, l'analyse des risques et des avantages, l'intégration avec d'autres demandes de la société (par exemple la protection contre les inondations et l'approvisionnement en eau), et la résilience au changement climatique. REFORM développe et améliore des instruments et des lignes directrices qui contribuent au succès et au rapport coût-efficacité des mesures de restauration et d'atténuation. En outre, des protocoles et des procédures pour surveiller les réponses biologiques à des changements hydromorphologiques avec une plus grande précision et sensibilité seront améliorés ou développés. La présentation exposera comment REFORM répond aux défis majeurs pour la restauration des rivières en Europe et comment le projet renforce les liens entre politique de l'eau, mise en œuvre de la restauration et sciences de la rivière.

ABSTRACT

REFORM (EC FP7 Grant 282656) is a 4-year large integrated research project (2011 – 2015) that addresses the challenges to reach the hydromorphological and ecological objectives for rivers as required by the European Water Framework Directive (www.reformrivers.eu). This international project has 26 partners from 15 European countries. Many European rivers are regulated to support flood protection, navigation, freshwater supply or hydropower production. It is insufficiently known what the ecological side effects of these modifications in hydrology and morphology are and to which extend the side effects can be effectively reversed or mitigated. The restoration framework addresses the relevance of dynamic processes at various spatial and temporal scales, the need for setting end-points, analysis of risks and benefits, integration with other societal demands (e.g. flood protection and water supply), and resilience to climate change. REFORM develops and improves instruments and guidelines that enlarge the success and cost-effectiveness of restoration and mitigation measures. In addition, protocols and procedures to monitor the biological responses to hydromorphological changes with greater precision and sensitivity will be improved or developed. The presentation will introduce how REFORM addresses the major challenges for river restoration in Europe and how it supports to better link water policy, restoration practice and river science.

KEYWORDS

Hydromorphology, Monitoring, River Restoration, Water Framework Directive,

1 HYDROMORPHOLOGY OF EUROPEAN RIVERS: IMPACTS OF REGULATION AND BENEFITS OF REHABILITATION

1.1 Context and objectives

Europe is characterized by a dense network of rivers that provide essential ecosystem services. From an ecological perspective, rivers and their floodplains form some of the most diverse ecosystems worldwide. Recent analysis of the first round of WFD River Basin Management Plans (RBMP) indicated that 40% of European rivers are affected by hydromorphological (HYMO) pressures caused predominantly by hydropower, navigation, agriculture, flood protection and urban development. As a consequence, there is increasing emphasis on river restoration driven by demands of the WFD and EU States have drafted programmes of measures focusing on restoring river hydrology and morphology. Implementation will require substantial investment in these measures, but there remains a great need to better understand and predict the costs and benefits of future river restoration. Ecological response to HYMO restoration, however, is complex and poorly understood for the following reasons:

- Characterisation of HYMO status focuses on pattern not processes: data collected represent small spatial scales, with relevant larger spatial scales or long term impacts neglected.
- How HYMO change affects Biological Quality Elements (BQE; fish, invertebrates, macrophytes) and ecological functioning is poorly understood and is particularly challenging for multi-pressure systems.
- Exploitation of knowledge is weak between scientists and restoration practitioners.
- Unlike water quality improvement, HYMO restoration implies a demand for either space or resources, i.e. land or water. Mutual interactions and benefits for ecosystems and their goods and services are not sufficiently understood.
- Restoration projects have failed to achieve their objectives. This alienates public opinion and limits future participation and support. Risk analysis approaches are required in which objectives are explicit and used to assess project success.

Against this background, REFORM will provide guidance and tools for successful and cost effective river restoration. The consortium represents a wide range of disciplines: hydrology; hydraulics; geomorphology; ecology; socio-economics; and water management. The consortium is composed of 26 partners from 15 European countries. The ultimate goal of REFORM is to generate tools for cost-effective restoration of river ecosystems, and for improved monitoring of the biological effects of physical change by investigating natural, degradation and restoration processes in a wide range of river types across Europe. REFORM's objectives are grouped into three categories: application, research and dissemination.

APPLICATION
1. Select indicators for cost-effective monitoring of physical habitat degradation and restoration.
2. Improve tools and guidelines for HYMO restoration and mitigation.

RESEARCH
3. Review existing information on river degradation and restoration.
4. Develop a process-based HYMO framework relevant for ecology and suitable for monitoring.
5. Understand how HYMO pressures interact with other stressors and constrain restoration.
6. Assess the importance of scaling on the effectiveness of restoration.
7. Develop instruments for risk and benefit analysis to support successful restoration.

DISSEMINATION
8. To increase awareness and appreciation for the need, potential and benefits of river restoration through active interaction with stakeholders.

1.2 Interim results

The REFORM project has generated substantial mid-term outputs to support River Basin Management Planning for the Water Framework Directive.

- Interim results have been synthesised and made available to practitioners in an accessible way by the set-up and population of a WIKI (http://wiki.reformrivers.eu; D6.1).
- Key HYMO processes and variables indicating success in river restoration have been reviewed (D1.2). HYMO variables that influence ecological status and functioning have been linked to the tolerance thresholds of species with emphasis on macrophytes, macroinvertebrates and fish

(D1.3). The dynamics of flowing water emerged as the most important HYMO process. Coarse gravel maintained by stream power and flow velocity emerged as key indicator. Significant knowledge gaps need to be addressed for habitat requirements of riverine species.

- A review of case studies and literature on costs and benefits of river restoration in Europe showed that cost data are quite variable and usually not available in a form appropriate for further assessments (D1.4). Thus, investing efforts in standards and protocols to gather and incorporate cost information in a more systematic way will benefit decision-making.
- In assessing hydromorphology to date there has been too strong a reliance on the reach scale. For sustainable solutions, it is crucial to develop understanding of the functioning of river reaches in the wider spatial context (Figure 2). The ways in which river reaches have responded to changes in the past, provides crucial information for forecasting how reaches may change in the future. The REFORM framework allows users to incorporate all of these multi-scale spatial and temporal aspects into river assessment and management (D2.1).
- Riparian vegetation is not included as a biological quality element in the Water Framework Directive (Figure 2). D2.2 presents new science concepts and analyses that clearly demonstrate the importance of riparian and aquatic vegetation as a key physical control on river form and dynamics and a crucial component of river restoration.
- Existing metrics have been evaluated for their strength to distinguish the impact of HYMO pressure on the mandatory biological quality elements from other stressors (D3.1). This showed that there is potential to develop metrics from monitoring data on fish and macrophytes to indicate HYMO impacts. Contrarily, relationships between HYMO degradation and macroinvertebrate metrics were weak.
- Despite the rapid increase in river restoration projects, little is known about the effectiveness of these efforts and many practitioners do not follow a systematic approach for planning restoration projects. REFORM has developed a planning protocol that incorporates benchmarking and setting specific and measurable targets for restoration and mitigation measures (D5.1; Figure 3).
- Existing data on the effect of restoration on biota complemented by information on factors which potentially enhance or constrain this were analysed. Overall, restoration success did most strongly depend on project age, river width, and was affected by agricultural land use. Restoration still had a positive effect in catchments dominated by agricultural land use, and thus do not question the implementation of restoration projects in intensively used catchments. The influence of project age stresses the need for long-time monitoring to investigate the restoration effect over time.

All initial results have been publicly available in deliverables, for relevant parts through the WIKI and as scientific publications. Interested people are being kept informed through the half yearly newsletters and through social media (relevant LinkedIn groups on river and stream restoration and WFD implementation). Two national stakeholder workshops have been organised in the Netherlands (November 2013) and Spain (June 2014) and three special sessions during international conferences in Austria, UK and Norway.

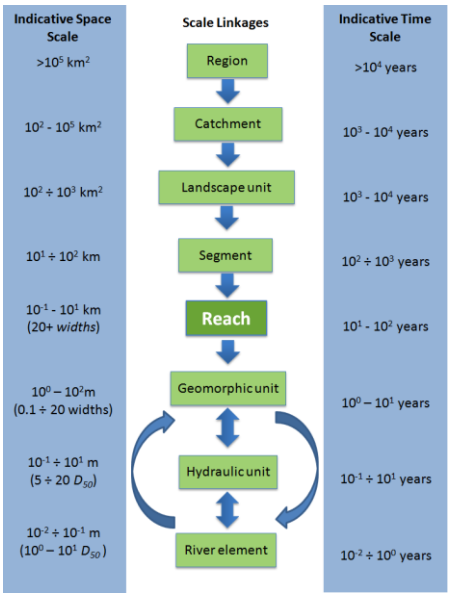

Figure 1 Hierarchy of spatial scales for the European Framework for Hydromorphology, including indicative spatial dimensions and timescales over which these units are likely to persist.

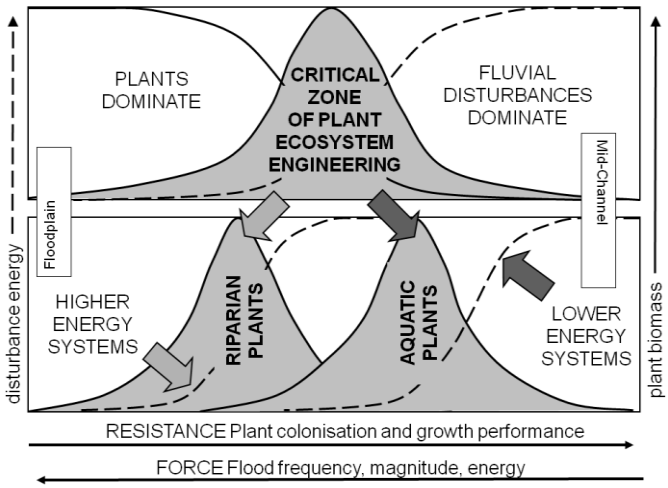

Figure 2 Plants are ecosystem engineers: interactions between vegetation and hydromorphology in rivers, streams, riparian zones and floodplains.

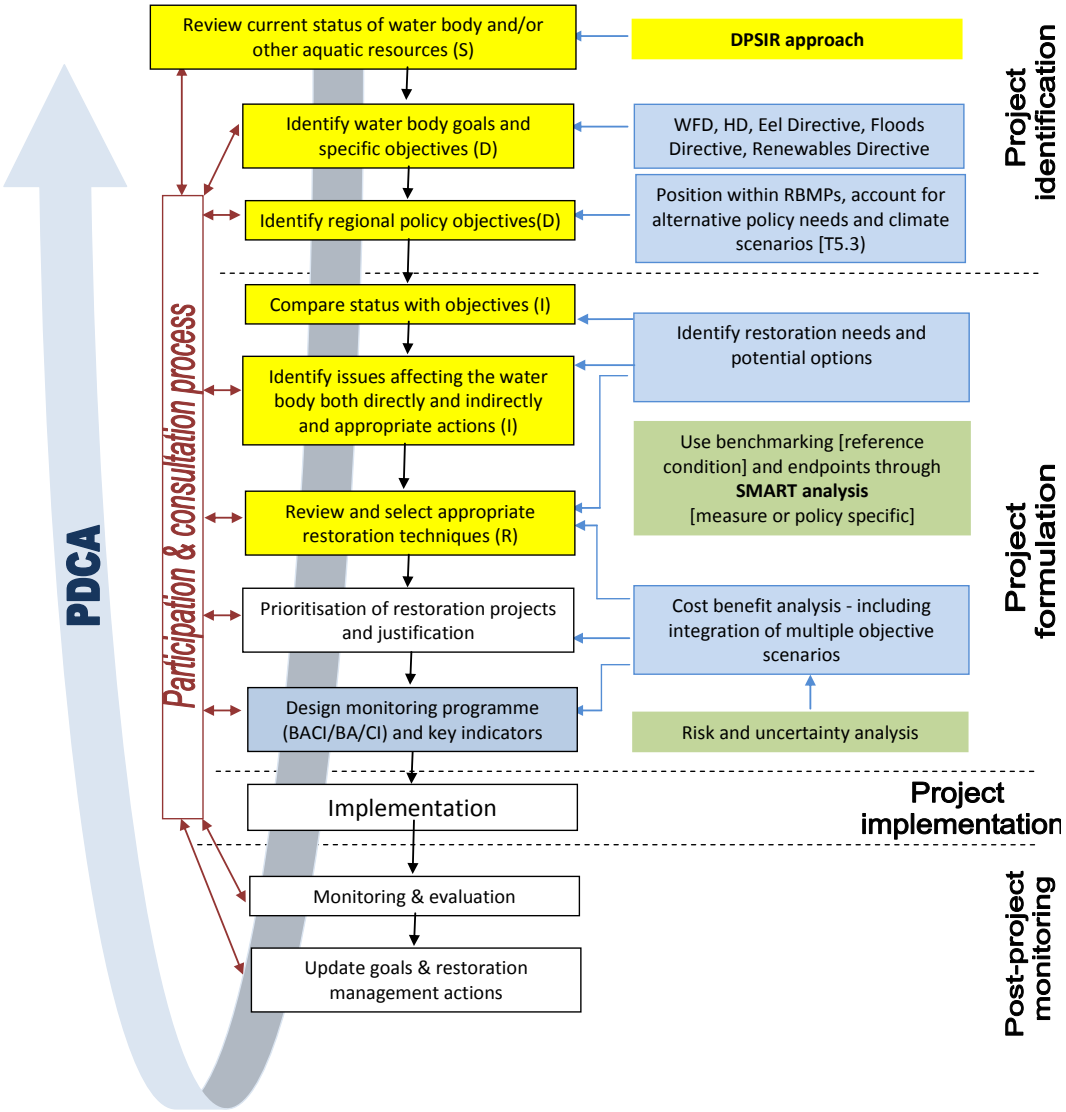

Figure 3 Planning protocol for restoration projects

1.3 Expected final results and their potential impact and use

From analysis of the first round of RBMPs, it is clear that the hydrology in many river basins and the morphology of streams, rivers, riparian zones and floodplains have been modified to serve social and economic needs (flood protection, water supply for agriculture, households and industries, navigation, hydropower). The ecological impact is poorly understood. REFORM will contribute by improving our scientific understanding of the linkages between hydromorphology and ecological status, but moreover by making its results available in various forms to support both practitioners and scientists. Practitioners will benefit from the tools for improved monitoring the impact of HYMO pressures and better planning and evaluating restoration and from the WIKI, which will be a more effective way to trace relevant information on these topics than currently available. On the other hand scientists will benefit from wide range of scientific publications regarding the role of scale and processes to shape rivers and streams by hydromorphology and vegetation, to discern the impact of hydromorphological pressures on biota from other stressors, to which extent scale matters for restoration and how restoration should become more effective in all phases of project realisation cycles.

EU Member States have set up programmes of measures to improve the ecological status of their water bodies. REFORM is the first European research project to have a strong emphasis on supporting the knowledge base for the programmes of measures, i.e. how to restore our rivers. Besides expanding the knowledge base, there is also an urgent need to share experiences. Web-based knowledge information systems are an effective means to share the know-how from practical experience and connect this with the scientific knowledge. Consequently REFORM has developed a WIKI that will be populated throughout the course of the project with information relevant for various phases of River Basin Management Planning (characterisation of basins and water bodies, objectives, impacts of hydromorphological pressures, programmes of restoration measures) to meet this need. Reflecting the foreseen outcome of REFORM with the main topics raised during the stakeholder workshop clearly highlighted the potential use of its results. Thus REFORM has been and will remain in close contact with representatives of various stakeholder groups to verify the applicability of its outputs. In 2015 a stakeholder workshop on environmental flows, a significant contribution to a CIS hydromorphology workshop, a summer school for young scientists and Ph.D.-students and an international conference “Novel Approaches to Assess and Rehabilitate Modified Rivers” will be the highlights to inform and interact with a wide range of stakeholders.

Address of public website: www.reformrivers.eu