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Grant Proposal

Methodology to evaluate the effectiveness of hydromorphological restoration of rivers in Romania

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Abstract

In the context of the requirements of the Water Framework Directive to reinstate a river's good ecological status after being severely altered by human pressures, river restoration became a major topic in the last decade in the EU and the number of projects implemented especially on hydromorphology increased. However, it is still uncertain whether these restoration measures have positive cumulative effects, i.e. hydromorphological effectiveness, when compared to reference conditions and expectations of stakeholders, because of inconsistent methodologies. Therefore, the goal of our project is to develop a methodology to evaluate the hydromorphological effectiveness of river restoration, based on standardised indicators, at various spatial scales, appropriate for implemented measures and for restored river types, weighting the expectations of actors and adapted to case studies in Romania. This methodological protocol could become also a useful tool to create a strategy and make decisions in the practice of river restoration. Moreover, this kind of analysis could contribute to clarifying the issue of standards in environmental projects.

Keywords

river restoration, hydromorphology, Water Framework Directive, standardisation, multi-criteria analysis

State of the art and preliminary work

River restoration became a major topic in the last decades. In the EU, river restoration projects increased their number and total area in the context of the Water Framework Directive requiring to reinstate a good status for rivers previously altered by human pressures. Understanding the effects of restoration has a crucial interest – it contributes to scientific knowledge and provides feedback and guidance for future restoration projects towards more effective results (Morandi et al. 2014). In practice, despite the increasing concern and funding for river restoration, the information on the success or failure of such actions is still limited (Castillo et al. 2016; Angelopoulos et al. 2017). This is mostly due to the poor quality of monitoring data. River restoration projects are frequently underfunded as budget for pre- and post-project monitoring and long-term monitoring efforts are even rarer (González et al. 2015). Moreover, the major part of the projects conducts the assessment, based on non-standardised indicators, depending on the demands of actors and financing sources (Castillo et al. 2016), as well as other political drivers (Morandi et al. 2017). Moreover, the effectiveness of the restoration solution should be compared to some references, either relative (e.g. pre-restoration), absolute (e.g. good ecological status) or pre-established (e.g. historic baseline, desired image) (Morandi et al. 2014; Wohl et al. 2015), while using similar metrics (Lisenby et al. 2017). Both spatial and temporal scales should be considered in evaluating effects of restoration works (Kondolf et al. 2006).

The hydromorphology (i.e. forms and processes created by water charged with sediments) is arduously integrated into restoration projects, because of the difficulty to quantify feedbacks at various spatial (i.e. catchment, sector, sub-reach) and time-scales, linear and non-linear responses of the hydrosystem and, thus, make predictions (Wohl et al. 2015; Poppe et al. 2015). Hydrology and geomorphology influence both ecology and biogeochemistry at catchment and reach scales; there will be benefits from restoring either, but preferably both facets (Polvi et al. 2020). Case studies showed a large variety of hydromorphological responses post-river restoration (e.g. Rinaldi et al. (2009); Sims and Rutherfurd (2021)).

The topic of the effectiveness of river restoration projects is crucial in the particular case of Romania, as large-scale restoration of the Danube floodplain is being strongly encouraged by some members of the scientific community and civil society (Constantinescu et al. 2015; Hein et al. 2016). Romania has little experience in the field of river restoration: 17 river restoration projects have been completed with a small area (average per project = 1480 ha) with the aim to improve mainly the lateral connectivity of rivers mostly for the ecological rather than hydromorphological reconstruction (Ioana-Toroimac and Zaharia 2016). Most of these projects comply with geohistorical reference conditions (Ioana-Toroimac and Zaharia 2016). All projects are independent initiatives in terms of funding, so they have been led by

different actors in the field of environment and water, without social support in some cases (Ioana-Toroimac and Zaharia 2016). The projects are not necessarily demonstrative for the types of river alteration in Romania. All projects reported good results, but very little post-restoration monitoring data were published and the scientific literature lacks critical analysis independent of their effectiveness.

Objectives and workflow

The goal of our project is to reflect on the effectiveness of completed river restoration projects in Romania and further make recommendations to plan for an effective river restoration. More precisely, our project analyses effects of river restoration and then further puts them in the form of a conceptual model to understand the effectiveness of river restoration.

The aim of our project is to design a tool to evaluate the hydromorphological effectiveness of river restoration in Romania, which may be included in larger methodologies for the assessment of the success of a river restoration project. The tool is flexible by integrating indicators appropriate for river types, for various spatial scales, for measures implemented, while weighting expectations of actors. The tool could also be useful to plan for an effective hydromorphological restoration.

The objectives of the project are: (1) to identify hydromorphological measures proposed or completed within river restoration actions in Romania as causes for riparian environment adjustments; (2) to analyse the hydromorphological effects of restoration measures implemented on rivers in Romania; (3) to conclude on the effectiveness of river restoration projects between expected and achieved results from various perspectives; (4) to create appropriate settings for learning to better plan a river restoration project.

The project has four work packages (WP) that are correlated with the four objectives of the project (Fig. 1).

- WP 1. Hydromorphological causes: report on restoration actions in Romania;
- WP2. Hydromorphological effects: effects compared to absolute and relative conditions, effects comparing restored and non-restored sites, effects expected by stakeholders;
- WP3. Hydromorphological effectiveness: methodology to determine the effectiveness of the restoration;
- WP4. Learning from river restoration projects: train the team, disseminate knowledge.

The project relies on the following approches:

- Documentation. We already have a database with river restoration projects in Romania (within Ioana-Toroimac and Zaharia (2016)). Yet, this database relies only on open access information (e.g. Natural Water Retention Measures – http://nwrm.eu/, River Basin Management Plans and scientific papers). A survey and/or

interviews would contribute to obtaining insights from actors implementing river restoration projects in Romania – implemented measures, monitoring of the effects, disponibility to collaborate. The survey will also help us decide on which case studies to focus on. We must also document on European river restoration projects, which could become good lessons for similar actions in Romania. The documentation also includes visiting successfully restored river sites.

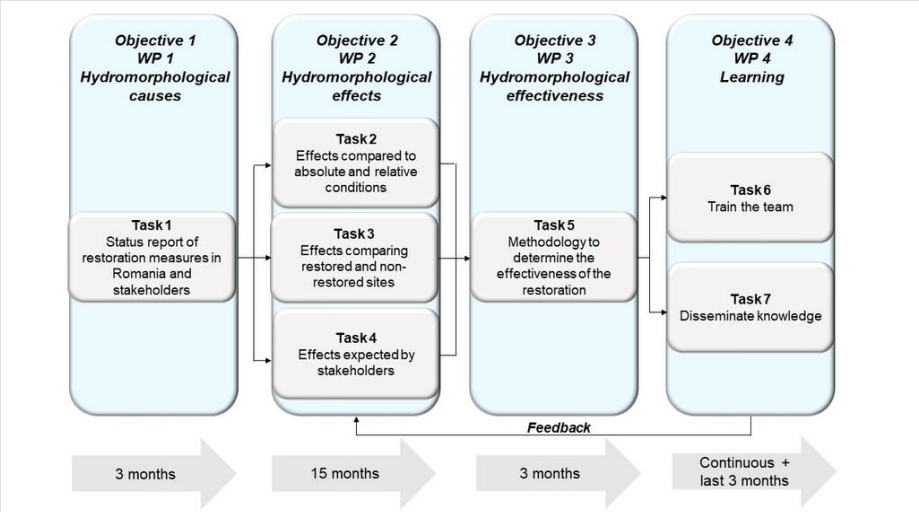

Figure 1. doi

Workflow of the project.

- Diachronic analysis to compare effects of river restoration to absolute and relative conditions. In our project, we consider the absolute reference conditions as similar to those before major human interventions in 1950s and the relative reference conditions before restoration. We compare topographic maps of 1950s and recent orthophotos. If necessary, we can purchase satellite scenes at good resolution to have additional information between orthophotos. We can also create time series of data pre- and post-restoration, based on satellite imagery. Remote sensing is an increasingly valuable tool for the assessment of restoration success (Cordell et al. 2016; Dawson et al. 2016). The use of open access satellite remote sensing, such as Landsat, is not expensive, not limited in time, therefore long time series can be extracted and further analysed (e.g. almost four decades) (Guo et al. 2017). The analysis is conducted in GIS. The interpretation of the river restoration effects must rely on the interpretation of the hydrological data and their variability.
- Fieldwork to compare the effects of river restoration to the functioning of non-restored sites with similar geographical features (both reference conditions and altered). We conduct a micro-scale experimental field survey on the selected case studies. The indicators to be monitored depend on the features of the restored site. Our priority is to work on indicators for sediment transport and grain size; secondarily, we can consider indicators for water physico-chemical and biological quality.

- Survey to understand the effects of river restoration expected by stakeholders. We design a questionnaire to better understand the objectives of various stakeholders regarding river restoration. The aim of the survey is to weight decisions of the actors in the evaluation of the effectiveness of the hydromorphological restoration.
- Multi-criteria analysis to set up a methodological framework to evaluate the effectiveness of river restoration in terms of hydromorphology. This multi-criteria analysis should be a tool with standardised indicators to evaluate the effectiveness of hydromorphological restoration at various spatial scales, appropriate for measures implemented and for river type restored, weighting expectations of actors.

Expected results and impact

The project outputs are: an improved database on river restoration in Romania; a diachronic study that compares the restoration effects with reference conditions; a multi-criteria study that compares a restored river site with an altered river site; a methodological framework that evaluates the effectiveness of river restoration. As an outcome, these results will improve knowledge on river restoration in Romania and highlight the major role of the hydromorphology as a means for achieving the ecological restoration. The project will open with an online event and will close with a workshop. The results of the project will be disseminated through scientific publications (two articles in journals with visibility) and scientific conferences (three international conferences), as well as a handbook for managers and students. The scientific information will be provided to the general public through the project website and social media. Through the project, the team will gain experience in river sciences (e.g. one Masters thesis prepared during the project).

Scientifically, this project boosts a new direction of research – a standardised evaluation of the success of an environmental project, i.e. river restoration, with application on hydromorphology. The question of standards in the evaluation of the success or failure of an ecological river restoration project was raised a decade ago in the USA (PALMER et al. 2005) and recently in the EU (Morandi et al. 2014). However, so far, besides reflections, no criteria arose. Therefore, our project is an attempt to create such an innovative methodology to evaluate the hydromorphological effectiveness of river restoration, based on standardised criteria and expert opinion, which could be later integrated into greater projects. On a larger scale, this example of post-implementation review is a crucial phase of an environmental project management; determine whether the project goals, the satisfaction of stakeholders and the project's costs and benefits were achieved, identify lessons learned and report on recommendations which can help the planning and management of future projects. The project will also allow us to enforce the hydromorphological research at the University of Bucharest (host institution and more collaborative team) and help the University compete with other Romanian universities with good labs/research team in this domain. The important place of stakeholders in the project will show that the team of the University of Bucharest is actively involved in the interactions with society.

Concerning the social impact, the project is an occasion for the actors of river restoration to meet and to further bond and bridge, which are the keys to the successful implementation of projects by collaboration and innovation (Berardo 2014). Moreover, the project takes into account the opinions of stakeholders in the process of decision-making, which is a main request of the Water Framework Directive. Furthermore, contributing to restoring a good relationship between nature and society is a success in itself.

Concerning the policy impact, the project aims to contribute to setting goals for river restoration in Romania while insisting on the major role of the hydromorphology in river restoration, as a means for achieving the ecological restoration or as a side effect of the rehabilitation process. Secondarily, by documentation, the project will find and then present within the reports innovative environmental-friendly strategies for river management and passive river restoration and will promote state-of-the-art management approaches, such as adaptive management.

Concerning the educational impact, the project aims to prepare a student and postdoctoral researcher as river specialists in order to integrate the practitioners' team and to sustain river restoration actions in Romania. Additionally, by using information from this project in class, students prepare in terms of various human impacts on river dynamics and benefit from the latest findings in terms of river management.

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Hosting institution

University of Bucharest, Research Center Water Resources and Water Related Risks Management

Ethics and security

NA

Conflicts of interest

The authors have declared that no competing interests exist.

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