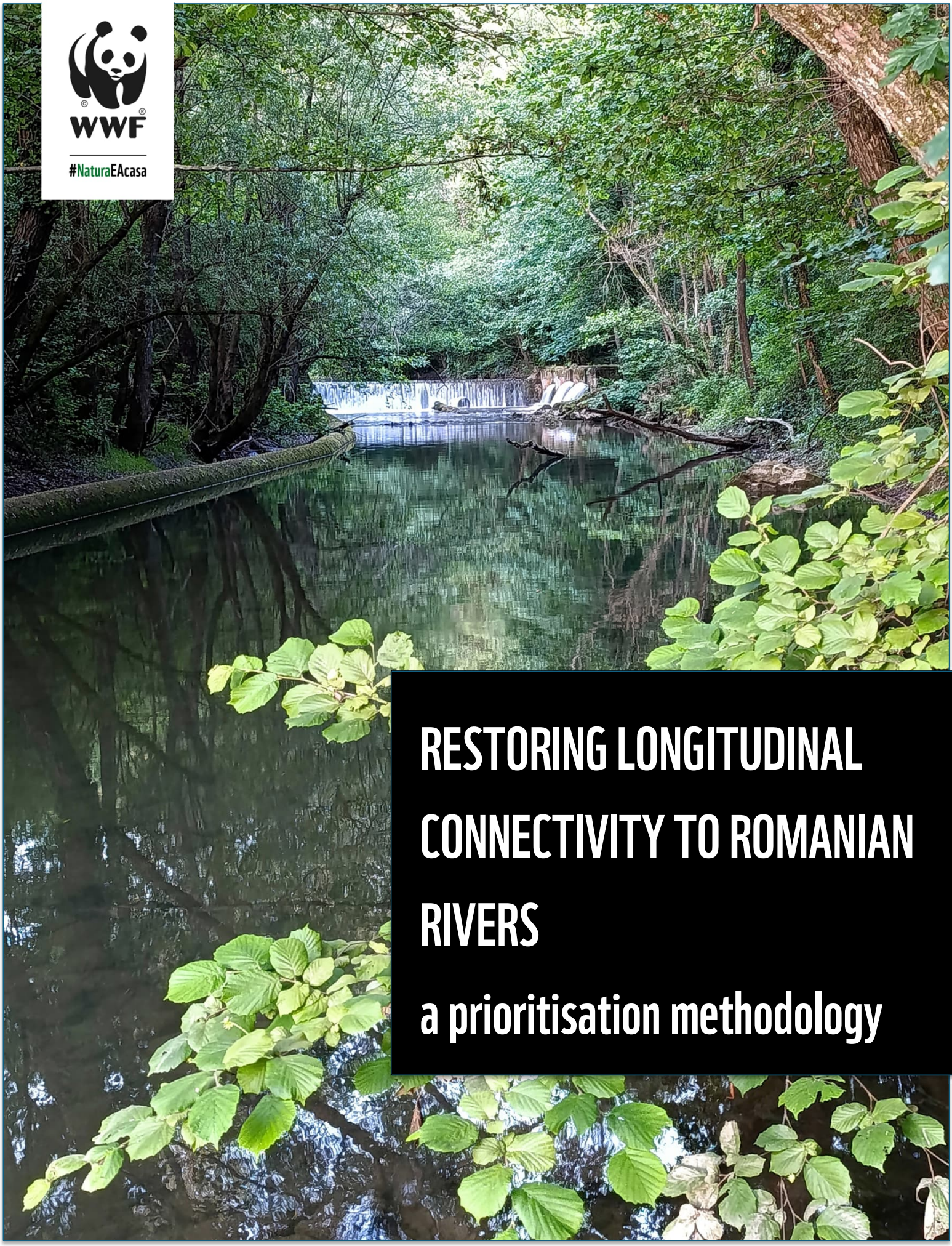

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RESTORING LONGITUDINAL CONNECTIVITY TO ROMANIAN RIVERS

a prioritisation methodology

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1. Introduction

This methodology complements the efforts already undertaken to restore longitudinal connectivity in rivers across Romania. The objective of restoring longitudinal connectivity, as outlined in the EU Biodiversity Strategy for 2030, is reflected in River Basin Management Plans (RBMPs) through dedicated connectivity restoration projects.

The prioritization approach proposed in this document is designed to be flexible and adaptable to specific objectives. This methodology initially focuses on barriers classified in categories C and D[1] that have no current use value, which is used as primary selection criteria. Once these barriers have been addressed, one or more filters may be adjusted, and alternative relevant criteria may be applied in subsequent iterations. Furthermore, the multi-criteria analysis is inherently dependent on the defined objective. For instance, if the aim is to restore longitudinal connectivity to enhance biodiversity, greater weight is assigned to criteria related to species and habitats. Conversely, if the objective is economic, increased emphasis is placed on criteria such as potential economic benefits arising from activities enabled by barrier removal, as well as on decommissioning costs.

This methodology is complementary to the approach outlined in “Criteria for Identifying Free-Flowing River Stretches for the EU Biodiversity Strategy for 2030,” a technical report published by the Joint Research Centre in June 2024.

[1] C (normal importance) and D (reduced importance) barriers are medium and small-scale structures with limited impact in the event of failure, with no significant risk to the population.

2. Prioritization Methodology

This study aims to develop a methodology for prioritizing interventions to restore longitudinal connectivity in rivers across Romania.

Decisions regarding any barrier removal should be based on rigorous and transparent analyses that clearly identify both the positive and negative effects and should involve consultation with and participation from all relevant stakeholders, including owners, users, local and central authorities, communities, representatives of the scientific community, and non-governmental organizations.

This prioritisation methodology for restoring longitudinal river connectivity in Romania is based on an analytical prioritisation process, preceded by the application of filtering questions. These questions aim to identify constraints that may hinder or substantially delay project implementation. The analytical process uses multiple criteria for the prioritisation of interventions for restoring longitudinal river connectivity in Romania:

- **technical** characteristics of the hydrotechnical structure,
- **hydrogeomorphological** - hydrological and geomorphological conditions upstream and downstream the structure,
- **ecological** - biophysical attributes of the watershed, including ecosystem service provision and the potential to restore connectivity for migratory species),
- **societal** features of human settlements and stakeholder groups, including demand for ecosystem services and stakeholder perspectives on barrier removal, and
- **economic** - current use of the structure, investment requirements, and post-removal economic potential.

Each of these criteria is assigned a weight derived from the analytical prioritisation process. The alternatives are represented by different barriers/ hydrotechnical structures, which are prioritised based on a score obtained by aggregating the weight and the actual value of each criterion. The final score depends on data availability, with two possible approaches: one based on qualitative data (using the Analytic Hierarchy Process) and another based on quantitative data (using mathematical programming).

2.1. Filter Questions

The use of filter questions enables the assessment of the feasibility of the investments aimed at restoring longitudinal connectivity along a watercourse, with responses identifying potential categories of constraints.

These filter questions rely on the availability of data at national level to ensure that the filtering process is practical rather than purely theoretical.

Table 2 *Filter questions for assessing the suitability of investments to restore longitudinal river connectivity in Romania*

	Filter question	Request
1	Does the barrier provide any use value?	The barrier should have no evident use value, not only in terms of its direct use, but also with regard to the use of the associated water resources and upstream catchment.
2	Does removing the barrier significantly increase flood risk for local communities or socio-economic assets?	The removal should not significantly increase flood risk upstream or downstream of the barrier, nor adversely affect socio-economic assets.
3	Can pollutants stored in sediment be remobilized?	No pollutants should be present in the sediment impounded behind the barrier that could be remobilized following its removal and cause significant short to medium-term downstream contamination.
4	Is the barrier located within a designated protected natural area?	The barrier is situated within a protected natural area and negatively impacts the conservation status of associated species and habitats.
5	Is the barrier classified under importance category C or D?	Barriers classified as categories C and D are prioritised over those in categories A and B, except where the latter are no longer in use.

Additional filter questions may be incorporated depending on the specific objectives pursued.

	Filter question	Request
6	Is the barrier situated on a permanent or intermittent watercourse?	Priority is assigned to barriers on permanent watercourses.
7	Is the barrier situated along a river stretch that is important for fish migration?	The barrier should be located on a river stretch that is important for the migration of fish and other aquatic organisms.

2.2 Identifying potential data sources for filter questions

Question 1. *Does the barrier provide any use value?*
Data sources: In the absence of direct data on use value, proxies from REBAR[2] can be applied, such as identifying structures that do not have a valid Water Management Notice at the time of the assessment and/or those subject to usage restrictions or requiring safety works. In such cases, a cost–benefit analysis can be conducted to determine whether the investment needed to rehabilitate the structure exceeds the cost of its removal.

Question 2. *Does removing the barrier significantly increase flood risk for local communities or socio-economic assets?*
Data sources: Hazard and risk maps or, where appropriate, modelling to identify the extent of areas at potential flood risk.

Question 3. *Can pollutants stored in sediment be remobilized?*
Data sources: Maps of degraded areas, data on industrial landfills or on the existence of polluting industries (e.g. petro-chemical plants).

Question 4. *Is the barrier located within a designated protected natural area?*
Data sources: Maps of protected natural areas in Romania

Question 5. *Is the barrier classified under importance category C or D?*
Data sources: REBAR, selecting those structures of C & D category of importance.

Question 6. *Is the barrier situated on a permanent or intermittent watercourse?*
Data sources: The existing data from the River Basin Management Plans can be used, selecting those structures that are on permanent watercourses.

When prioritizing barriers to be removed to achieve longitudinal connectivity on a given river segment, we should not limit ourselves to these filter questions alone; additional filters may be added, and some proposed in the initial iteration of the methodology may be excluded.

For example, the filter relating to barriers in protected natural areas may be removed to ensure that the prioritisation process also considers structures located outside these areas that no longer provide any functional benefit.

We may also consider removing A & B barriers if they no longer serve any useful function, poses a risk to the population, and/or if its maintenance costs are no longer justified. Finally, the filter related to the use of the barrier could be removed when the benefits of removal outweigh those of retaining it.

[2] National Register of Dams in Romania

2.3 Evaluation areas

The evaluation areas define the main categories under which criteria are identified, tailored to the specific requirements of prioritizing interventions to restore longitudinal river connectivity in Romania.

In our prioritization work we have used the following evaluation areas:

- **ecology** (all the biophysical characteristics of the catchment upstream and downstream of the barrier in terms of biodiversity status, ecological status and habitat heterogeneity);
- **hydromorphology** (the set of characteristics that define the watercourse upstream and downstream of the barrier, including those related to river continuity);
- **social** (the set of characteristics that define the actual and potential benefits/losses for local communities and stakeholder groups, the level of public participation and involvement, the position of different actors);
- **technical** (the set of technical characteristics of the barrier relevant for the analysis); and
- **economic** (the overall economic benefits of the current use of the barrier, details of the proposed investment, the benefits of dismantling the barrier).

2.4 Evaluation criteria

Criteria were selected to identify the most suitable barriers for removal, maximizing the benefits of restoring longitudinal connectivity. Relevant criteria were established for the five evaluation areas defined above.

Table 3 - *Description of criteria*

	Evaluation areas	Evaluation criteria	Priority
1.	**Ecology**	Ecological status of the river	Sites in good ecological condition are preferred over those in unfavourable condition.
		Status of fish populations	Species with a favourable conservation status are preferred over those with an unfavourable status.
		Status of aquatic habitats	Habitats with a favourable conservation status are preferred over those with an unfavourable status.

	Evaluation areas	Evaluation criteria	Priority
		Ecosystem services	Those providing new or improved ecosystem services associated with the barrier removal.
2	**Hydromorphology**	Degree of clogging	Barriers with upstream water bodies with a high degree of siltation.
		The length of the river stretch without other forms of longitudinal fragmentation	River stretches providing the longest extent of free-flowing river after barrier removal.
		Distance to confluence	Barriers located closest to the confluence.
3	**Social**	Area at risk from flooding	The smallest area adding to those affected by flood risk.
4	**Technical**	Height of the barrier	Barriers with lower heights are favoured over those that are higher.
		Volume of material to be displaced	Those requiring the removal of smaller material volumes during dismantling (height × length × width).
		Type of material used for the construction of the barrier	Barriers constructed from natural materials (earth, rock) are preferred over those made of concrete or cement.
		Technical and legal situation	Barriers for which technical documentation, as well as information on the owner and administrator, are available.
5	**Economic**	Monetisation of extracted materials	Maximises the recovery of reusable materials. No conservation, maintenance, or modernization costs.
		Dismantling costs	Dismantling costs do not outweigh the long-term benefits of restoring connectivity on that river stretch.

2.5 Weighing of criteria

The weighting of the criteria was determined using an analytical prioritization process[3], supplemented by expert judgment from those involved in developing this methodology.

The results, which reflect the relative importance of each criterion, are presented in the figure below.

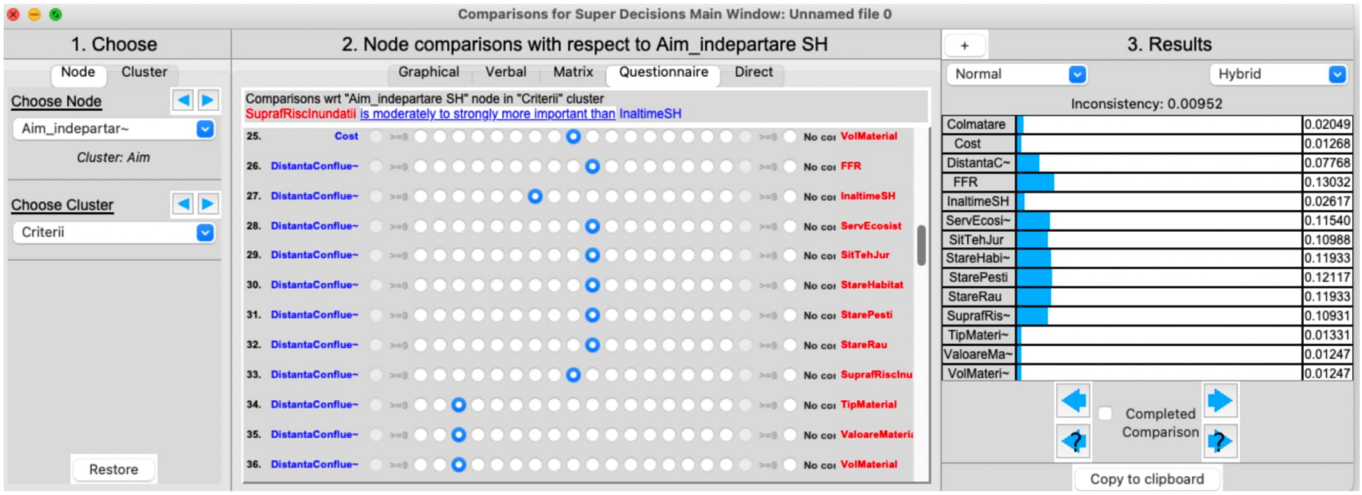

Figure. 3 - *The weight distribution of the criteria used to prioritize barriers in terms of removal priority*

Thus, the criteria with the highest weights are length of unfragmented river stretch (0.130), status of fish populations (0.121), ecological status of the river (0.119), status of aquatic habitats (0.119) and ecosystem services (0.115). Criteria related to flood risk and technical and legal status are also of high importance. Technical and economic criteria (0.01-0.02) are less important but cannot be eliminated.

[3] Super Decisions, a free decision support software

2.6 Getting the ranking scores

This step is not necessary if a decision on barrier selection has already been made, i.e. if a barrier has already been selected for removal.

The establishment of filter questions and the weighting of criteria enable the continuation of the prioritisation process for interventions aimed at the removal of river barriers. The following approach applies exclusively to those barriers that have successfully passed the initial screening stage and for which removal is being considered. Based on the criteria defined and prioritised above, the prioritisation of alternatives (barriers and other obstacles) that have passed the initial screening will be carried out.
Thus, for the hydrotechnical structures that have reached this stage, the following question arises: *Which barrier should be prioritised for removal, considering the system of criteria outlined above?*

The following multi-criteria model has been developed for this purpose:
Aim: prioritization of barriers in terms of priority for removal;
Criteria: the 14 selection criteria validated in the previous step;
Alternatives: the dams that have passed the pre-selection stage by applying the filter questions (it is recommended to work with a maximum of 10 alternatives)

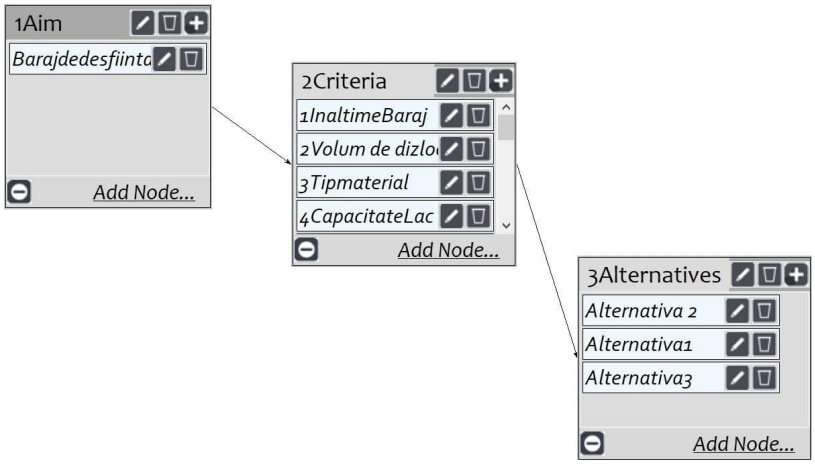

Figure. 4 - *Multi-criteria model for prioritising river barrier removal*

To rank the alternatives, the selected barriers will be compared pairwise using the Analytic Hierarchy Process. This will result in a ranking of the alternatives for each criterion, based on the questions provided in the table below.

Table 4 - *Questions used to compare alternatives for the 14 selected criteria*

Evaluation criteria	Questions used to compare alternatives
1. Ecological status of the river	Which barrier is situated on a river stretch with a higher ecological status?
2. Status of fish populations	Which barrier is situated on a river stretch with a more favourable fish population status?
3. Status of aquatic habitats	Which barrier is located on a stretch of river with aquatic habitats in better conservation status?
4. Ecosystem services	Which barriers provide new or improved ecosystem services associated with the removal of barrier?
5. Degree of clogging	Which barriers have upstream water bodies with the highest degree of siltation?
6. The length of the river stretch without other forms of longitudinal fragmentation	Which barriers, if removed, most increase the length of free -flowing river stretches?
7. Distance to confluence	Which barrier is closer to the confluence with the main river.
8. Area at risk from flooding	Which barrier, if removed, has the least impact on increasing the flood risk area?
9. Height of the barrier	Which barrier is lower in height and easier to dismantle?
10. Volume of material to be displaced	Which barrier involves displacing less material?
11. Type of material used for the construction of the barrier	Is the barrier made from natural materials (earth, rocks)?
12. Legal and technical situation	Which barriers have available information on technical documentation, ownership, and administration?
13. Monetization of extracted materials	Which barrier, upon dismantling, provides the highest percentage of reusable materials? The removal of which barrier results in the elimination of conservation, maintenance, and modernization costs?
14. Decommissioning costs	For which barrier do the costs of decommissioning does not exceed the long-term benefits of restoring connectivity along that river stretch?

For example, with regard to Criterion 6, experts evaluated the alternatives based on the available data and the rating scale presented below, assigning scores of 0.2 to Alternative 1, 0.7 to Alternative 2, and 0.06 to Alternative 3 (with the aggregate score equal to 1). This indicates that Alternative 2 has the highest potential to maximise the length of free-flowing river.

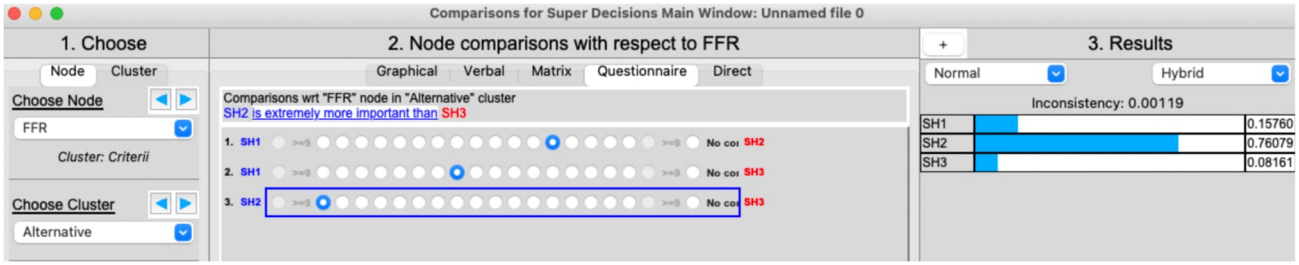

Fig. 5 - *Example of a pairwise comparison of alternatives with respect to Criterion 6, using a scale from 1 to 9 (where 1 indicates equal importance and 9 indicates a strong preference for one alternative over another).*

Scores are calculated for each criterion, resulting in a ranking of alternatives and a set of scores that sum to 1 at the end of this stage. The final score for each criterion is then determined by applying the corresponding criterion weight, with each score multiplied by its weight. In the example below, the weight assigned to Criterion 6 is 0.13.

Table 5 - *Example of score calculation for each criterion and the overall score for each alternative*

	Criteria weight	**Alternative 1**	**Alternative 2**	**Alternative 3**
...	...	...	...	...
6	0.13	0,157 *0.13 = 0,02	0,760*0.13 = 0.1	0,081*0.13 = 0,01
...	...	...	...	...
...	Total	sum of all scores for alternative 1	sum of all scores for alternative 2	sum of all scores for alternative 3

The final score for each alternative is obtained by summing the values across all criteria. Ranking these scores establishes the hierarchy of barrier structures prioritised for removal. Consequently, the alternative with the highest score is identified as having the highest priority for removal.

3 Glossary

- **hydrotechnical structure** - artificial barrier placed in the river course to raise the water level (to create a reservoir) or to regularize its course
- **no use value** - the barrier no longer fulfils the functions for which it was originally created, the functions are no longer needed due to different reasons (it no longer has a purpose, e.g. a watermill or an aquaculture pond

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