

## Towards an integrated approach to mitigating multi-hazard disaster risk on the Tagliamento River, northeastern Italy

### "Vers une approche intégrée pour atténuer les risques de catastrophe multi-aléas sur la rivière Tagliamento, nord-est de l'Italie"

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#### RÉSUMÉ

Le risque dépend de la fréquence et de l'ampleur des aléas liés aux rivières, mais également de l'exposition, par exemple, le nombre, le type et la valeur économique des biens exposés. La planification de l'utilisation des terres peut augmenter ou diminuer l'exposition de la société aux risques liés aux rivières, tels que les inondations. Dans cette contribution, nous rassemblons des expériences visant à comprendre et à cartographier la perception des risques liés aux rivières, à la fois provenant des rivières et à destination de celles-ci, ainsi que les valeurs socio-culturelles riveraines associées aux rivières, telles que l'identité et le sentiment d'appartenance. Ici, nous examinons comment la perception de ces valeurs peut influencer la gestion des ressources en eau et les prises de décision en utilisant des questionnaires, des entretiens, une approche participative basée sur des cartes, ainsi que des données factuelles sur l'utilisation des terres et de l'eau, la biodiversité et les risques. Nous présentons les résultats de cette approche combinée dans le cas de la rivière Tagliamento (Italie), connue comme la dernière rivière alpine à écoulement libre. Nous explorons les synergies entre la conservation des rivières et la planification de l'utilisation des terres basée sur les écosystèmes à travers l'analyse des événements passés et des interventions humaines subséquentes sur la rivière (telles que la construction de digues et les infrastructures proposées). Nous discutons des limites des interventions sur les rivières dans le contexte de la réduction des risques multi-aléas et fournissons une liste d'aspects à prendre en compte pour la gestion du bassin versant et pour promouvoir la résilience des communautés et des écosystèmes. Enfin, nous mettons en lumière les bénéfices potentiels de l'intégration des connaissances locales et des preuves historiques dans des scénarios narratifs afin de démontrer des voies d'adaptation possibles pour les communautés riveraines.

#### ABSTRACT

Risk depends on the frequency and magnitude of river-related hazards, but also on the exposure, e.g., the number, type and economic value of exposed assets. Land use planning can increase or decrease societal exposure to river-related risks such as floods. In this contribution, we bring together experiences that look into understanding and mapping the perception of river-related risks from and to the river as well as riverine socio-cultural values linked to rivers, such as identity and sense of place. Here, we look into how the perception of such values can influence water resources- and decision management using questionnaires, interviews, a map-based participatory approach as well as evidence-based data on land and water use, biodiversity and risks. We show results of this combined approach in the Tagliamento river (Italy), known as the last free-flowing Alpine river. We explore the synergies between river conservation and ecosystem-based land use planning through the analysis of past events and subsequent human interventions on the river (such as the construction of levees, and proposed infrastructures). We discuss the shortcomings of river interventions in the context of multi-hazard risk reduction and provide a list of aspects that should be taken into account for managing the river basin and pursuing communities and ecosystems resilience. Finally, we highlight the potential benefit of integrating local knowledge and historical evidence into storylines to demonstrate potential adaptation pathways for riverine communities.

#### KEYWORDS

Multi-hazard risk mitigation, river conservation, ecosystem services, river communities, river management

Atténuation des risques multi-aléas; Conservation des rivières; Services écosystémiques; Communautés riveraines; Gestion des rivières

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## 1 THE TAGLIAMENTO RIVER: A REFERENCE ECOSYSTEM

The Tagliamento river is considered one of the best preserved European alpine rivers of the Alps, and has been recognized as a reference ecosystem for the restoration of degraded rivers (Müller, 1995; Tockner et al., 2003). There is an ongoing debate on the strategies for the future management of the river, in particular with relation to the mitigation of flood risks. Since 1966, when the last damaging flood took place in the lower course, there has been a strong debate on the potential implementation of structural measures for flood risk mitigation, in particular adopting infrastructural interventions (Brusarosco et al., 2010; Osti, 2019). Up to today, the attention devoted to the Tagliamento river has been mostly devoted to two different (and separated) objectives. On the one hand, the efforts of the scientific community, environmental associations and citizens have been focused on assessing and highlighting the importance of the river and its ecosystem services. On the other hand, governance and policy agencies have focused on achieving safety with regards to floods through structural measures (e.g. infrastructure). However, very few studies have been devoted to achieving disaster risk mitigation by considering the river-human ecosystem as a whole, and taking into account other potential strategies for long-term multi-risk mitigation. Here, we discuss this gap and provide the existing evidence that the Tagliamento river is a reference ecosystem for river restoration and for developing a new paradigm for long-term disaster risk mitigation.

## 2 THE TAGLIAMENTO AND THE RIVERINE COMMUNITIES: A POSSIBLE COEXISTENCE

Communities living in the Tagliamento river basin have been subjected to a large number of floods (Spaliviero, 2002). In the recent decades, the floods occurred mostly in the upper and lower course (Spaliviero, 2002; Scaini et al., 2024). These floods have on many occasions caused the destruction of villages and infrastructure (e.g. bridges), as well as casualties among the populations.

Our past work investigated the risk perception of the river basin communities through questionnaires. Respondents showed low perception of river-related risks in the upper basin, while the perception of risk in the lower basin is very high. However, a large fraction of the respondents to our questionnaire lacked knowledge on what to do and where to find the information in case of floods (Scaini et al., 2021a). A vast majority of respondents also believed that it is possible to mitigate flood risk while preserving the river's naturalness. There is therefore a strong demand from the river citizens to preserve the river while mitigating river-related risks and this demand should be addressed in a multi-disciplinary way, with inputs from the scientific community (with a specific role devoted to local scientist, see Scaini et al., submitted for details) and the different stakeholders involved. During our survey, the communities also pointed out the lack of information on issues that they perceived relevant, such as river ecological value and the impact of human activities and land use patterns on the river ecosystem. The analysis of newspapers communication related to the Tagliamento river also highlighted gaps in the river-related newspaper articles, which were analysed up to 2021. The newspaper communication is strongly focused on risk reduction and achievement of safety, without mention of relevant topics such as river conservation and land use planning (Scaini et al., 2021b). To fill that gap, a website and knowledge hub was developed by a consortium constituted by the WWF Germany and local scientists and organizations (Scaini et al., submitted), available at [www.tagliamento.org](http://www.tagliamento.org), that collects the contributions of multiple societal stakeholders.

## 3 FROM HISTORY TO STORYLINES: UNCOVERING ADAPTATION PATHWAYS

The analysis of historical documents and maps unravels very complex interactions between communities and rivers. In particular, two storylines were developed (Scaini et al., 2024) and tell the story of two villages, both located in the middle course:

- the village of San Paolo, which became a riverine island delimited by two river channels during approximately 100 years
- Rosa, which was relocated several times to prevent subsequent flooding due to the Tagliamento river

The storylines allowed identifying patterns of adaptation across riverine communities, in particular about the relocation of some villages in the middle course, and the construction of wide levees for flood protection. The analyzed historical documents also highlight common flood management practices in the lower course, e.g. controlled flooding in natural areas where the levees had previously been breached by the river, to prevent the river from breaking the levees close to the villages. Also, some hints for ecosystem-based river management were found in the historical documents, in particular with some technicians mentioning the need for preserving the riparian forests and the lower course wetlands in order to mitigate the river floods. The past evidence of

potential adaptation measures have not been considered or integrated in current river management practice. However, the historical documents and maps, if interpreted in the light of the history of the community and the onset of their subsequent interaction with the river, can shed light on the future pathways and provide useful information for preserving the Tagliamento river while mitigating the flood risk.

#### 4 STEPS TOWARDS MULTI-HAZARD RISK MITIGATION AND RIVER CONSERVATION

The solutions proposed so far fail to respond to the current challenge, that is, keeping the Tagliamento river as natural as possible while attempting to mitigate river-related risks. In order to achieve this, it is necessary to take additional steps that weren't taken so far. Based on our past studies and on the scientific literature and current discussions on the river, we unraveled a list of aspects that cannot be disregarded when developing a river management strategy to preserve the Tagliamento river and mitigate the risks for the communities:

- identify the objectives that should be achieved with river management strategies and disaster risk mitigation plans, accounting for the risks caused by range of river-related hazards across the river basin (e.g. drought, forest fires)
- reduce exposure by reconsidering urban expansion plans in areas prone to floods or other river-related hazards, and progressively abandon floodable areas when possible, in particular in the lower course, but also in other flood-prone areas
- actively engage the community and the societal stakeholders into collaborative activities, also in synergy with the current initiatives on the Tagliamento river (e.g. the recently-granted Water for All living lab recognition)
- promote the dialogue between international scientific research, local scientists, governance policymakers and technicians, so that the recent advancements in science can become practice. In particular, the opinion of the international scientific community should be considered and integrated into the decisional process in a formalized way. Also, the representatives of the scientific community should encompass the wide range of disciplines involved in the process, such as, and not limited to, ecology, morphology, psychology, disaster risk mitigation, sociology, geography and land use planning.

In particular, with regards to the definition of interventions on the river associated with the reduction or mitigation of risks caused by flood and other river-related hazards, the following aspects must be taken into account:

- avoid infrastructure that reduces or disrupts river connectivity (e.g. barriers, dams), in particular in the middle course where the river is more preserved
- favor river connectivity by reconnecting the river with its floodplain (e.g. removing artificial escarpments, gaining space for the river where it is deemed possible), in line with the recently issued Nature restoration law (European Commission, 2024) and the existing European Commission directives on nature and habitats conservation and on the sustainable use of water resources.
- recover wetlands in the lower course, most of which were artificially drained in the past by land reclamation

All the aforementioned factors should be taken into account before taking any decision on the implementation of measures, in particular structural measures, that affect the Tagliamento river and the riverine communities. Any decisions should formally tackle these aspects demonstrating in a scientific way that they were assessed and tackled. Also, this process should be documented and shared with all the societal stakeholders directly affected by the decision.

#### 5 CONCLUSION AND OUTLOOK

The Tagliamento river represents an unique opportunity to promote river conservation in Europe while mitigating disaster risk and achieving greater resilience for the communities. For multiple decades, flood risk mitigation on the Tagliamento river has been focused on guaranteeing safety for a specific hazard (floods) in the lower course, disregarding the multiple hazards and potential risks at stake at the scale of the entire basin. Also, risk management issues have been traditionally kept separated from the conservation efforts, resulting in some conflicting actions, while they should be accounted for together, as demanded by the population. This implies promoting an active participation of the community and stakeholders, avoiding top-down approaches used by the recent governance systems. Future work should promote the creation of a constructive and holistic vision for the Tagliamento river, following the guidelines provided here. The Water for All Living Lab recognition, recently granted to the Tagliamento river and its community is a starting point for future activities.

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