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Bridging Knowledge and Engagement: The Role of Community Involvement in Protecting Aquatic Ecosystems in the Danube Basin

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Abstract The protection of the rivers and lakes relies not only on the existence and implementation of a respective legal framework and administration but also on the environmental knowledge of local residents and communities, as well as on their dedication to environmental protection and involvement. Deeper understanding of the complex ecological and socio-ecological linkages typical for aquatic ecosystems is needed to bolster citizen engagement in their protection. Such engagement is essential to optimize the resources of environmental administrations, ensuring effective progress towards legal management goals and safeguarding ecosystem services for local residents and communities. In the Danube basin, the societal, economic and environmental values of rivers, lakes and wetlands are often overlooked or disregarded by local people, particularly in lower river sections. The ongoing project 'Danube Nature Guides' aims to enhance knowledge and attitudes related to aquatic ecosystems by fostering strong connection to the river's natural environment and increasing awareness and appreciation of the social and economic benefits provided by the Danube. The project employs bottom-up participatory approaches to empower communities of learners to co-create educational program and modes of engagement tailored to their specific needs. As a result of this process, educational materials have been developed, and field courses conducted within the 'Danube Nature Guides' project. The educational concept also encompasses teaching courses provided by already trained adult guides on aquatic ecology ("wbw Gewässerführer") from the Upper Danube in Baden-Württemberg (SW Germany) for students, motivated teachers and staff from Natural Parks in the Lower Danube in Romania. Thus, bridges have been established between generations, benefitting from a lifelong learning approach and enabling intergenerational knowledge transfer. Graduates from these courses will serve as multipliers, raising awareness of the natural assets of the Danube and its floodplains, promoting nature-based tourism, and supporting the establishment of certified nature guides in Romania.

Keywords: environmental education, community-centred approach, aquatic ecosystem

1 Introduction

Rivers and their floodplains play a crucial role in sustaining biodiversity and providing essential resources for human societies. The protection of these ecosystems does not only rely on the existence and implementation of a respective legal framework and administration, but also on the environmental knowledge of local residents and communities, as well as on their dedication to environmental protection and possibilities for their involvement of local residents. Thereby, recognizing the intricate interplay between rivers and their floodplains and river basins is fundamental to foster environmental literacy and sustainable practices. Such learning and better understanding of the complex ecological and socio-ecological linkages that are typical for aquatic ecosystems can thus support more engagement of citizens for their protection. This engagement is necessary due to the limited abilities of environmental administrations to reach their legal management goals and to secure their functions for human wellbeing for local residents.

By definition, environmental education encompasses approaches, tools, and programs that develop and support environmentally related attitudes, values, awareness, knowledge, skills and behaviours that prepare people to take informed action on behalf of the environment (Ardoin et al., 2015, 2018, 2020; Monroe et al., 2019; Thomas et al., 2018). Analysing current approaches in environmental education, a review on 220 publications on education on climate change has found that mostly top-down, science-based approaches are still dominating in formal educational settings focussing on scientific knowledge, formal curriculum, behaviour change, or mitigation/adaptation issues (Rousell and Cutter-Mackenzie-Knowles, 2020).

Effective environmental education, however, focussing, e.g., on the multifunctionality of regional floodplains should not only be tailored to the specific needs and context of the targeted community or region, but additionally empower individuals and organizations to actively contribute to the sustainable management of these valuable ecosystems (Toomey et al., 2017). In this approach, the contemporary environmental education additionally needs to include participatory approaches that enable to empower citizens, who in the best case will even form 'communities of learners' that design their own projects, e.g, on climate change adaptation, as well as their modes of engagement with the issue (Feierabend and Eilks, 2018; Figueiredo and Perkins 2013)

Based on the findings of the review by Rousell and Cutter-Mackenzie-Knowles 2020, it can be argued that creative, participatory and technologically-mediated approaches should be foregrounded in environmental education as timely and effective methods. These approaches support children and young people to engage with climate change mitigation and nature protection in ways that are culturally and regionally relevant. Examples for such community-led river projects are:

- River clean-up campaigns,
- Citizen-based water quality monitoring programs,
- Native planting and riparian restoration campaigns,
- Fish habitat restoration programs,
- Environmental education through mobile apps,
- Local river watch programs,
- Community-led environmental festivals, like water neighbourhoods.

Along with this approach, Hemmer et al (2007) have presented an example of how students became aware of the principles of education for sustainable development through their work when drafting an educational concept for an exhibition for a visitor centre.

As the Danube links many different countries, societies, cultures, and governments, the aim of the Danube Nature Guides Project is to improve the knowledge and understanding on the various regions along the Danube, as well as the awareness and appreciation of the social and economic benefits of the Danube ecosystems. For this, the project embraces a bottom-up, community-centred approach to environmental education and active engagement within local communities according with their specific needs. Designing educative projects jointly with local communities thus represents a powerful approach to complement top-down driven governmental measures on the protection of rivers.

2 Methodology

An integrated methodological approach was employed to accomplish the research objectives developing an intergenerational learning tool for training Nature Guides in the Lower Danube. These methodologies take into account the needs of adapting nature and environmental education to address current challenges and opportunities (Reid et al., 2021), including strategies that increase program success (Monroe et al., 2019), by engaging learners through experiential and outdoor learning, experience the scientific process, co-creation, role-play, storytelling and artistic expression.

2.1 SCIENTIFIC KNOWLEDGE

Environmental education in the Danube basin benefits from the results of a multitude of projects funded by several funding programs or regional strategies dedicated to the Danube region: Danube Transnational Programme (DTP), Danube Region Strategy (EUSDR), Horizon Europe, etc.. Educational activities thus represent a powerful leverage to make those project results available to citizens, and make them effective for regional and local application. On the other side, educational activities become more dynamic, relevant, and impactful when using those results, thus fostering a deeper understanding and appreciation for the Danube's ecological significance.

For example, by integrating ecosystem services (ES) concept into environmental education, learners can develop a holistic understanding of the benefits nature provides and the importance of sustainable practices for both ecological and human well-being (Richards et al., 2017; Rodríguez-Loinaz and Palacios-Agundez, 2022). The results and examples from projects as RESI (https://www.resi-project.info/), EU INTERREG IDES (https://www.interreg-danube.eu/approved-projects/ides) or studies (as Preda et al., 2015) were used to visualize the availability of several ES in different management scenarios in order to encourage critical thinking and to promote an exercise of informed decision-making among learners.

The information and maps from literature (Costea et al., 2018) and EU Horizon Project AQUACROSS on the pressures on aquatic ecosystems and mitigation measures in the Danube basin were used to develop learning materials for a scientifically informed education in order to support changing attitudes towards responsible behaviour.

Based on this information and on the educational needs identified in the protected areas of the Lower Danube, educational materials and activities fostering nature connectedness as a basis for cognitive and emotional engagement were developed in the Danube Nature Guides project.

2.2 INTERGENERATIONAL KNOWLEDGE TRANSFER

In the 'Danube Nature Guides' first project phase, a bridging approach between generations was realized with double purposes, as in order to foster life-long learning of already trained adult guides for aquatic ecology of the Danube area ("wbw Gewässerführer") from Upper Danube in Baden-Württemberg (Figure 1a), and ii) enabling exchange students from the Lower Danube in Romania to benefit from senior guides. The thematic field courses in Germany and Romania were first organized in the „Upper Danube" Nature Park in Baden-Württemberg (Germany), and second one at the Lower Danube in south-east Romania (**Figure 1**). There, visits to the Lower Prut Floodplain Natural Park, the Danube Delta Biosphere Reserve, and the Macin Mountains National Park were organized. Participants consisted of 15 young adults at the age of 16 to 24 years from Romania who were trained together with 7 nature guides from Baden-Württemberg. During these trips, ecological field methods were applied for the assessment of river hydromorphology, water-dependent biodiversity, on the ecological status of a riverine landscape and on human impacts as well as on nature-based values of tourist destinations.

The graduates from those courses will also have multiplicator functions in a future perspective. They can raise the awareness of natural assets of the Danube and its floodplains, increasing the appreciation of nature-based tourism and to support the establishment of certified nature guides in Romania, too.

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Figure 1: Thematic field courses of the 'Danube Nature Guides' project. The first thematic course was organized in Beuron (Germany), teaching in the premises of the Upper Danube Nature Park visitor center (A) and during outdoor field courses (B & D). The second thematic field course took place on the Lower Danube in Romania (C), boating in the Danube Delta (photo credits: A - O. Mormocea, B - S. Schmidt-Halewicz, C & D - G. Costea)

2.2 CO-CREATIVE PARTICIPATORY APPROACH

In the 'Danube Nature Guides' second project part, the project was extended to a new target group, as biologists, nature park staff and school teachers motivated to offer their pupils outdoor teaching lessons in nature parks (**Figure 2**). The objective of a 3-day kick-off meeting organized for this new target group was to identify and select the proper methods and techniques to be used for each nature park, respectively, to understand and communicate the importance of nearby aquatic ecosystems.

Based on the results of that meeting, suitable pedagogic materials on the ecology of the Danube and its landscape structure were developed in the third phase of the 'Danube Nature Guides' project. These materials address the crucial needs of park staff and teachers, enhancing their capabilities for higher-quality task performance.

Figure 2: Co-creation meeting in the Danube Delta Biosphere Reserve, Romania: Discussing appropriate ways of environmental education (A); experiencing non-formal education through theatre storytelling (B). (photo credits: A, B – S. Schmidt-Halewicz)

3 Results and discussion

Various teaching materials were created with 'Danube Nature Guides' to improve knowledge and understanding of the Danube ecosystem, as described in the following sections. In this way, awareness and appreciation for the social and economic benefits to the Danube environment was developed through a lifelong learning approach between generations, as e.g., between adult tour guides and children.

3.1 DANUBE BROSHURES FOR DIFFERENT STAKEHOLDERS

A comprehensive brochure 'Danube Nature Guides' (Costea and Schmidt-Halewicz, 2024) was elaborated aiming to raise awareness and advocacy for cultural linkages and nature-based development options along the Danube. It summarizes basic information on the ecosystems of the Danube and its floodplains, and also presents the ecosystem services provided by those, as well as current threats to their further availability. The brochure was released both in English (to be downloaded from www.naturschule-region-bodensee.de/wp-content/uploads/2019/07/DanubeNatureGuidesA5-sm-final.pdf) and German versions (with 37 and 46 pages, respectively (Costea and Schmidt-Halewicz, 2024) (**Figure 3**).

The brochure is intended as a source of information for biologists, employees of nature parks or environmental authorities, associations and school teachers who deal with rivers and floodplains, especially as accompanying material for environmental education courses. It is meant to contribute to raise more awareness and commitment to cultural interrelationships and nature-based development opportunities along the Danube. It also introduces the concept of ecosystem services (ES) into environmental education, so that learners may develop a holistic understanding of the benefits of a sustainable approach to environmental management, creating a win-win situation both for human well-being and nature conservation. The information about this ES concept is mainly based on the scientific results of (1) the German 'River Ecosystem Service Index' (RESI) project, and (2) the EU Horizon project 'Improving water quality in the Danube River and its tributaries by integrative floodplain management based on Ecosystem Services' (IDES).

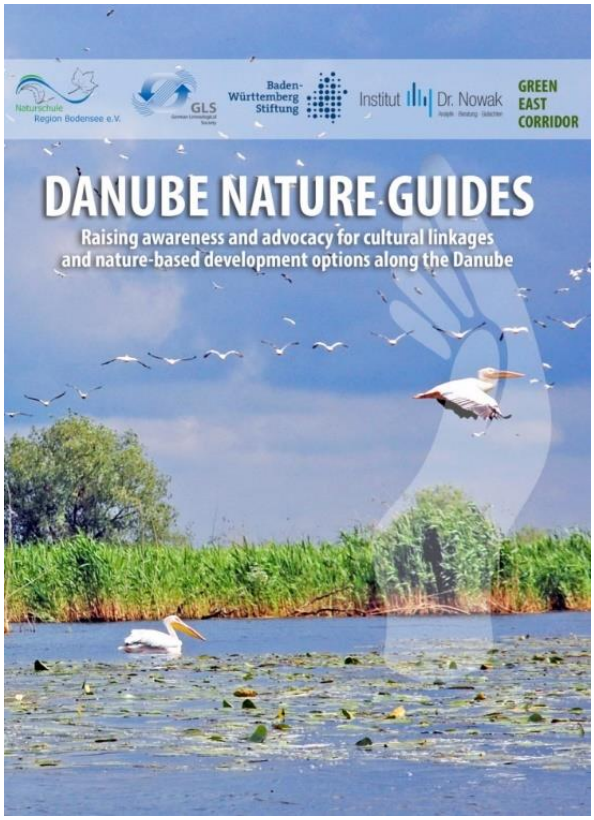

Figure 3: Front page of the brochure 'Danube Nature Guides', link: www.naturschule-region-bodensee.de/wp-content/uploads/2019/07/DanubeNatureGuidesA5-sm-final.pdf

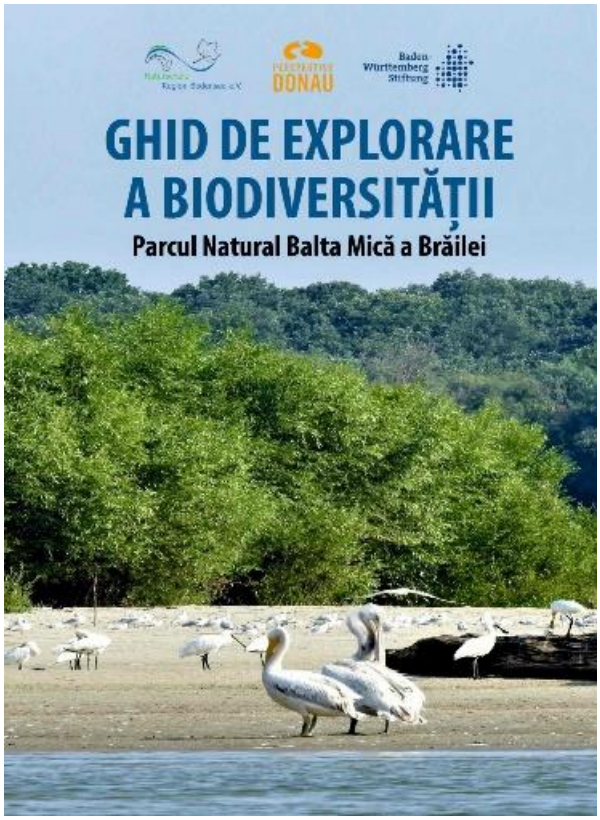

Figure 4: Front page of the 'Biodiversity Exploration Guide for the Small Wetland of Braila Natural Park' (in Romanian, *in press*).

3.2 AQUATIC BIODIVERSITY AND HABITAT ASSESSMENT GUIDES FOR TWO PARKS ON DANUBE

In the pursuit of elaborating specialized field guides, an extensive exploration of the local aquatic flora and fauna within the "Comana Delta" and "Small Wetland of Braila" parks on the lower Danube was undertaken. This involved comprehensive field documentation, with a particular focus on aquatic invertebrates. Collaborative sampling sessions, conducted in tandem with park biologists and rangers, not only contributed to the enrichment of our knowledge on those areas, but also trained park staff with essential skills for future educational initiatives. The resulting brochures 'Biodiversity exploration guide', exemplified in **Figure 4**, serve as further resources for outdoor courses. They are designed to facilitate nature-based exploration and discovery activities together with children, fostering a profound comprehension of freshwater ecosystems as vital habitats for both, flora and fauna. The guides further enable practical investigations into biological, chemical-physical indices for water quality, as well as the evaluation of riparian or river habitats. These guides thus represent a source of knowledge about the complex relationships between humans and water bodies, also shedding light on potential conflicts. Additionally, they may serve as educational tools imparting insights into possible solutions for these conflicts, and emphasize the multiple benefits of restoration measures. The ultimate goal of the brochures is to inspire a sense of stewardship for these aquatic environments and thus to promote ways of sustainable coexistence between humanity and nature.

3.3 CHILDREN AND FAMILY FAIRYTALE BOOK

Children's books represent a valuable medium to develop empathy for nature (Cress and Holm, 2000; Holm, 2012). Pupils who have a cognitive empathic understanding of environmental issues are emotionally better connected to the environment, and they are driven to take positive action towards harmonious relationship between humanity and natural ecosystems (Sobel, 1996). In today's world, characterized by pressing environmental concerns, the influence of children's literature on shaping environmental consciousness is outstanding. Moreover, children's books offer a platform for discussing complex environmental issues in a manner that is accessible and engaging for young audiences. Rivers like the Danube not only hold immense ecological significance but also embody cultural heritage and serve as lifelines for countless communities. However, despite this potential, which could also be used in children's stories, to our knowledge there are only few children's books dedicated to the Danube, as e.g., "The Adventures of Starry, the Brave Sturgeon" (Sandu et al., 2020) translated in 10 languages and "Donau: Ein magischer Fluss" (Hvorecky, 2022) published in Slovak and German. To provide a children's book dedicated to environmental education issues on the Danube that is attractive to pupils, the new educational family book 'Lau lacht wieder – eine Geschichte von der Donau´ (DE) (**Figure 5**, *book in press*), hence 'Lau laughs again. A story about the Danube' (EN) has been developed as another outcome of the Danube Nature Guides project. Targeted to children and their parents reading to them, the book has been written in the format of a fairy tale. It hence represents an easily accessible medium for discussing complex issues of river ecology and on river management. At the same time, it sparkles curiosity and empathy, thus fostering critical and creative thinking among young readers. The book describes the adventurous journey of the mermaid "Lau" from the sources to the mouth of the Danube. It thus represents a continuation of Eduard Mörike's fairy tale "History of the beautiful Lau" (Mörike, 1853) in a child-friendly writing style. The story addresses the Danube's function of linking different cultures and of hosting various aquatic biodiversity, but also human impacts, and shows as possible solutions in an attractive, partly amusing and easily understandable way. This children's book emphasising the necessity and ways to protect the water habitats is intended to be published in Romanian, German and in English versions.

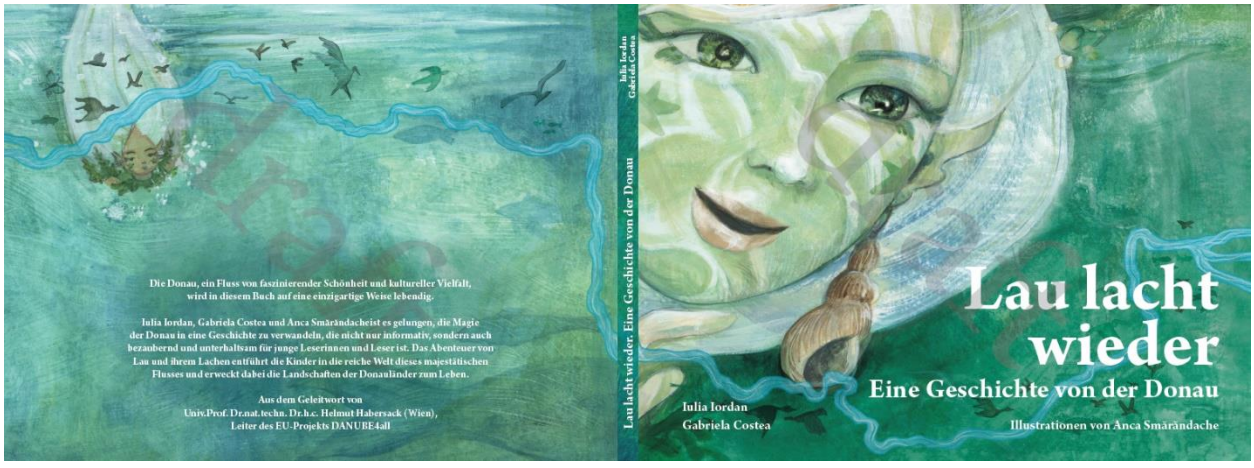

Figure 5: Front and back covers of the educational children's book "Lau laugh again. A story from the Danube". Authors Iulia Iordan and Gabriela Costea, illustrator Anca Smarandache. Here the German book version is shown (*in press*).

4 Conclusions and outlook

After establishing Danube Nature Guides networks in Germany and Romania, we intend to expand it to Moldova and Bulgaria. This phase will be facilitated by leveraging the various educational resources developed in the previous phases and building on the valuable expertise in the newly established network. Therefore, training sessions in those countries will provide future Danube Nature Guides with a comprehensive toolkit. These sessions will include modules covering ecology, sustainable development, and creative non-formal education techniques such as drawing and storytelling through theatre.

Our integrative approach aims to foster a deeper understanding of the Danube's natural landscape, interwoven with regional history and cultural heritage. By enabling motivating and immersive experiences, the 'Danube Nature Guides' project strives to empower citizens to actively participate in environmental education, serving as a starting point for co-creative efforts aimed at protecting and restoring the river ecosystem. Thus, our vision is that informed guides act as multiplicators who catalyze multiple activities of environmental stewardship and engagement along the Danube.

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