Sustainable resource management in the Main River Basin

The Case Study of Main River, Germany

Background

The **Main River** is a vital European waterway at the heart of the continent, serving as the largest eastern tributary of the Rhine and linking the North Sea to the Black Sea via the Main-Danube Canal, effectively bridging the European water divide. Spanning a **densely populated and highly utilised basin** of approximately 25,000 km², the region already faces **intense competition for water, land, and energy resources.**

Climate change is expected to exacerbate these challenges, with **rising temperatures** leading to **more frequent and severe summer droughts and heatwaves**, alongside a significant decline in summer precipitations. Simultaneously, the risk of winter floods is projected to increase due to heavier seasonal rainfall. These shifts will have **profound consequences for agriculture, forestry and water and energy management.** To secure a resilient future for the region, a fundamental and forward-thinking revision of resource management strategies and governance structures is essential.

Key Challenges

Climate change presents significant challenges for the region, **intensifying competition for vital resources** such as water, land, and energy. As temperatures rise and weather patterns become more unpredictable, the impacts on agriculture, forestry, water, and energy management are expected to be profound, requiring **adaptive strategies to ensure sustainability and resilience**. Improving climate resilience while promoting sustainability and reaching the goals of the European Green Deal is a transition process that needs to be actively managed and supported by stakeholders from the region and beyond.

Why was the Main River selected for ARSINOE?

The Main River basin is at risk of being pushed beyond its resilience threshold as climate change progresses. **It needs a new level of responsiveness.** By implementing the ARSINOE-approach the challenges faced by the region become well-understood and innovative solutions are co-created and implemented with stakeholders from the region. ARSINOE builds on **data from previous projects**, governmental surveys and monitoring networks, some preexisting models and prototypes as well as existing relationships to stakeholders from the region.

Main goals

The project implements a **nexus-based approach** for the integrated management of water, land, and energy resources while maintaining the functionality and integrity of ecosystems. The case study fosters a culture of collaboration and knowledge-sharing among stakeholders and between science and stakeholders in the river basin. Key to this effort is the promotion of specific and scientifically sound climate information (**climate services**) for data-based adaptation. Climate services also enable stakeholders to evaluate their adaptation strategies. Additionally, the project raises awareness of sector-specific needs and promotes coordinated actions to mitigate the inevitable impacts of climate change, aligning with the European Green Deal objectives.

Expected outcomes, benefits and legacy

The project drives a **fundamental shift in stakeholder communication**, fostering stronger cooperation across sectors and ensuring that decision-making processes are more inclusive and informed. To this end, the **science-policy interface** in the WEFE nexus is supported by new and easy-to-apply modelling and management tools. By enhancing cross-sectoral awareness and action, the initiative **supports long-term sustainability and resilience** against climate change. Businesses and agencies will be better equipped to integrate climate adaptation strategies, improving resource efficiency and environmental protection.

Ultimately, the project contributes to a more adaptive and climate-resilient river basin, supporting both ecological health and economic stability.

Methodology & Approach

The case study implemented the **systems innovation approach (SIA)** developed in ARSINOE by **setting up a living lab in the region** to conduct a systemic analysis of climate change and its impacts in the region and to co-create innovation pathways with stakeholders, identifying goals, opportunities for action as well as innovation gaps, levers and barriers for improving the region's climate resilience.

This informed the goals of the **Open Tender for Innovation (OTI)**, which was used to identify creative solutions for closing the innovation gaps and addressing hurdles to boosting climate resilience. The open tender aimed at **primarily identifying social and governance innovations** rather than technological innovations. In accordance with this goal, one social innovation **aimed at raising awareness of challenges** connected to water management and triggering behavioural change and one innovation improving the knowledgebase for water-resource-governance were chosen. By focusing on social and governance innovations the case study demonstrated that the OTI can be used to identify and support these types of solutions, too.

Governance of the WEFE-Nexus

It was closely analysed in an interview study which focused on **actors and networks** involved in governance, levels and scales of governance, problem perspectives and goal ambitions, governance strategies and instruments as well as responsibilities and resources. The study shed light on the state of **cross-sectoral resource management** i. e. on resource management approaches involving one or more of the sectors water, energy, food and/or ecosystems.

Modelling activities

It was focused on the **hydrology of the Main River catchments**, particularly during drought conditions. A mix of traditional (process-based hydrological modelling) and innovative machine learning approaches allows to holistically address the water balance and to simulate more specific components under climate change conditions. Based on these simulations, **climate services are co-created with stakeholders** for more specific applications to inform decision-making in a data-based way.

Stakeholder engagement and participatory processes

Stakeholder engagement and participatory processes were a **cornerstone of the case study** in the Main River Basin. **Workshops, webinars and interviews** were used to collect information about the impacts of climate change on the stakeholders in the region, their preferences, past experiences, resources available to and needed by them. Relying on **stakeholder-driven co-creation processes** meant that project results were relevant, addressed the specific circumstances in the region and local stakeholders' needs. Moreover, the exchange of information between science and stakeholders was improved, ensuring that debates of climate resilience in the case study were based on up-to-date scientific knowledge and that information about climate change and changes in the water balance could be explained and interpreted accurately. Vice versa, scientists received direct feedback on the practical relevance and useability of their research. Furthermore, ARSINOE **strengthened local networks for climate resilience** by connecting stakeholders from different sectors. As the project progressed stakeholders were kept informed about the project through newsletters, mailings, social media and presentations. Stakeholders who were not directly involved in co-creation processes or interviews could learn about the methods and results of ARSINOE **at conferences and trade fairs, in webinars and videos as well as other communication.** Consequently, awareness of the project was not limited to those stakeholders directly involved with the project but extended to a larger group of stakeholders interested and active in resource management in one of the addressed sectors, politics or the scientific community.

Two different solutions proposed in the first Open Tender for Innovation (OTI) were selected to support the development towards climate resilience in the Main River Basin.

IRRIBIGDATA

Developed by **ANBI-Emilia Romagna** for collecting data from irrigation systems and supports analysis and forecasting algorithms, IrriBigData is a data provider for tools supporting operational and water scarcity management decisions. It has a crucial role for strategic planning of future water use. In such a way IrriBigData has a considerable **impact on the water usage governance** as it supports decisions for policy implementation in the water sector and, therefore, it can be viewed as an **effective social and governance innovation**. Data collected and stored in IrriBigData allow to build the basis for managing conflicts for water uses and among territories also at the river district level. IrriBigData may contribute to social or behavioural changes and governance as it aims to obtain more efficiency in agricultural water use and support regulation in the irrigation sector. Potential impacts on **social behaviour and capacity building enforcement are expected.** In addition, it will have a direct impact on water conservation and water use efficiency as it provides knowledge to decision makers and awareness of the water use to farmers and water managers. It supports cross-sectoral approaches to resource management as suggested and promoted by the EU Water Framework Directive. IrriBigData provides knowledge concerning current water uses, effective needs and potential efficiency gain rooms in the irrigation system. Therefore, it can significantly improve water management of the whole system.

Tap water friendly cycling route

The tap water friendly cycling route is created by "**a tip: tap**". The aim of the project is to create more places along the already established Main Cycle Path where water bottles can be **refilled with free, fresh tap water** connected to information about the areas' water cycle. Existing drinking fountains and refill stations will be **made more visible and new ones will be initiated**. The aim is to respond to the increasing number of hot days, create water knowledge and appreciation for the precious resource of drinking water and **contribute to sustainable tourism**. The vision is to offer cyclists the opportunity to refresh themselves with tap water **at intervals of no more than ten kilometres** in the future, while also promoting the value of water and its protection along the cycle path. Organisations and people from the region can support the project e.g. by creating new Refill-Stations or by supporting the communication about the protection of water resources and use of tap water. Private individuals of all age groups will be **educated on the ecological benefits of tap water, its provision and on how to save water** and protect its quality. Stakeholders will learn how to create public access to drinking water and will receive assistance when communicating about drinking water and sustainability. People as well as organisations will be encouraged to re-evaluate their habits of using bottled water. **Drinking tap water will be normalised and facilitated.** Understanding water conservation and water use efficiency will be connected to using tap water. Appreciation of tap water as a locally sourced product and will lead to a better understanding of the necessity to protect local water sources.

Key results & Achievements

Summary of main outcomes

Climate change poses major challenges for the Main River basin. It will further i**ntensify competition for water, land and energy resource**s. This will have considerable consequences for **agriculture** and **forestry** as well as the **water and energy sectors**. A fundamental and forward-looking review of available resource management measures and the development of new measures are essential to ensure climate-resilient and sustainable development in the region. The key challenge is **preserving the region's water balance** and **ensuring sustainable resource management**. Different climate adaptation measures, changes in land-use, changes in governance structures and shifts in consumption could contribute to solving this challenge.

It became clear that stakeholders know many measures, but solutions are not implemented widely enough, or at sufficient speed. Implementation requires the motivation and cooperation of different actors, **exchange of knowledge between sectors and a conducive governance framework.** The creation of these conditions requires education and capacity building to support social or behavioral change or new governance structures. Important areas of action include but are not limited to water retention in soil and built environments e. g. using nature-based solutions, changing water-use, and how water is valued, saving water or designing water management systems that contribute to efficiency, as well as soil protection and landscape design and protecting water quality.

Adaptation strategies need to consider the needs of and interlinkages between sectors as well as conflicting goals. Modelling activities in the case study region provide a supportive data basis for evaluating adaptation measures, e.g., by assessing the implications of management practices on the water cycle in hydrological simulations, and provide novel, easy-to-use applications like the purely data-driven simulation of water temperatures. ARSINOE demonstrated how diverse and complex the consequences of climate change are in the region and how stakeholders with partially diverging interests can come to a common understanding of challenges, agree on goals and design innovation pathways. ARSINOE identified and financially supported **two innovations contributing to the transition towards climate resilience** through the open tender for innovation and identified levers and barriers for implementing other innovation pathways.

Thereby, they highlight the challenges arising from rapidly progressing climate change in the river basin, the **importance of political and public support, knowledge about climate change impacts and strategies for addressing them, personnel for designing and implementing adaptation projects and easily accessible funding.** By using SIA and organising Living Labs, the project demonstrated the value of a systemic approach for understanding climate change impacts as well as developing transition strategies. Dedicated workshops raised the awareness of stakeholders regarding climate services and data-based adaptation planning. The governance analysis revealed room for improving nexus-governance in the region when it comes to actors and networks involved in governance, levels and scales of governance, problem perspectives and goal ambitions, governance strategies and instruments as well as responsibilities and resources. However, it also highlighted projects where cross-sectoral governance is being implemented successfully and **brought attention to a nexus perspective among stakeholders.**

Key results & Achievements

Impact on local communities

ARSINOE impacted local communities in the Main River basin. It contributed to **local networks on climate resilience** by building connections between stakeholders and fostering debates on resource governance that are expected to last beyond the project. For example, stakeholders described the Living Labs as novel platforms for debate in the region and appreciated the fruitful discussions across sector boundaries. Moreover, ARSINOE **improved the regional understanding of climate change** impacts, their consequences for different actors and interconnections of challenges.

The project **popularised the WEFE-nexus-perspective** further and promoted the idea of integrated resource management approaches as a means for mitigating water conflicts. ARSINOE **improved cooperation** between stakeholders and the scientific community and fostered a fact-based discussion of climate resilience in the river basin. The implementation of innovations funded through the OTI actively **contributes to the region's climate resilience.**

Replicability & Scability

Potential for replication in other regions

The work of the case study could be transferred to other regions. **SIA** could be applied to other regions and methods like the **Living Lab, interview studies and the governance matrix** could be utilized in other cases. Similarly, **open tenders for identifying** innovations that boost climate resilience could be used elsewhere. **Modelling approaches** can be applied conceptually to other cases but require adapted data sources and an adjustment of the model set-up to regional conditions by training or calibration. Throughout the project the partners have engaged in communication and dissemination activities to popularise the ARSINOE-approach and methods beyond the case study region.

Key success factors

- Broad and committed stakeholder participation;
- Strong stakeholder mapping and ongoing engagement;
- Relevant expertise among participants;
- Careful selection of interview partners;
- Access to quality data and models;
- Strong science–practitioner cooperation;
- Interdisciplinary collaboration.

Barriers to consider

- Missing key stakeholders;
- Lack of participant expertise;
- Poor interview partner selection;
- Limited computing/data storage capacity;
- Data not maintained after project end.

Next steps

Project results have been documented diligently in English and some in German to make them accessible to the relevant audience. The project partners will continue to **highlight the outcomes and lessons learned from the case study**, integrate them into teaching and may build on them in future projects. The latter being dependent on state, national or European funding. ARSINOE resulted in **new and stronger relationships between stakeholders** in the Main River basin who now have a heightened awareness of climate change impacts and may continue to use it to further boost the resilience of the Main River basin. Climate resilience will remain part of VKU's work in the area and political debates in Bavaria, where ARSINOE and its results may be referenced.

Learn more about the ARSINOE Case studies: **HERE**.

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