RETOUCH NEXUS

REsilienT water gOvernance Under climate CHange within the WEFE NEXUS

Deliverable D4.3

Case-study based assessment of the efficacy of society-centred approaches

Date (30/06/2025)

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

RETOUCH NEXUS

RETOUCH NEXUS Partners

Technical University of Munich - TUM (Germany) - Maria Vrachioli, Johannes Sauer, Markus Disse, Juan Pablo Henao Henao, Jingshui Huang & Nicole Tatjana Scherer

Valencia Polytechnic University - UPV (Spain) - Manuel Pulido-Velazquez, Hector Macián Sorribes, Adria Rubio-Martin & Eulalia Gomez Martin

Vrije Universiteit Amsterdam - VUA (Netherlands) - Katarzyna Negacz, Clara Luxardo, Erik Ansink, Leon Bremer

adelphi research gemeinnutzige - adelphi (Germany) - Annika Krammer, Elsa Semmling, Karolina Heck & Binayak Das

Slovak University of Agriculture - SUA (Slovakia) - Jan Pokrivcak, Ema Lazorcakova & Miroslava Rajcaniova

Euroquality - EQY (France) - Barthélémy Maillard, Clémence Gracia & Solène Fovelle

Vlaamse Instelling voor Technologisch Onderzoek - vito (Belgium) - Katrien Van Hooydonk, lilian Taverner, Steven Broekx & Wim Sciettecatte

De Watergroep - DWG (Belgium) - Pauline Ottoy, Charlotte Jacobs & Ian Montauban van Swijndregt

Energy and Water Agency - EWA (Malta) - Manuel Sapiano, Nicholas Ellul, Nadine Vella, Aaron Cutajar, Nadia Gatt Gafa & Marco Graziani

Greening the Islands - GtI (Italy) - Gianni Chianetta, Emilio Gabrielli, Fransesco Luise, Mattia Monaco, Andrea Morabito, Sabrina Pentecoste, Jean Karl Micallef-Grimaud, Graziana Salvati

Regierung Oberfranken - RegOb (associated) (Germany) - Andrea Kuenzl

Ministry of Agriculture and Rural Development - MARD (associated) (Slovakia) - Martin Kovac

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

DELIVERABLE 4.3

Project Acronym	RETOUCH NEXUS
Project Title	REsilienT water gOvernance Under climate CHange within the WEFE NEXUS
Project Coordinator	Maria Vrachioli
Project Duration	01.01.2023 – 31.12.2026

Nature of the deliverable		
R	Document, report (excluding the periodic and final reports)	X
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, etc.	
OTHER	Software, technical diagram, etc.	

Dissemination Level		
PU	Public, fully open, e.g. web	
CO	Confidential, restricted under conditions set out in Model Grant Agreement	X
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

Deliverable No.	3
Dissemination level [1]	
Work Package	4
Task	**Innovative Schemes and Practices of Water Governance**
Lead beneficiary	Vrije University of Amsterdam (VUA)
Contributing beneficiary(ies)	Technical University of Munchen (TUM), Valencia Polytechnic University (UPV), Slovak University of Agriculture (SUA), Energy and Water Agency (EWA)
Due date of deliverable	30/06/2025
Actual submission date	

Quality procedure			
Date	Version	Reviewers	Comments

This report is part of the deliverables from the project "RETOUCH NEXUS" which has received funding from the European Union's Horizon Europe research and innovation program under grant agreement N° 101086522. More information on the project can be found at www.retouch-nexus.eu

Acknowledgements

We would like to express our gratitude to all the interviewees and survey respondents who took part in this study.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Executive summary

This report (Deliverable 4.3) presents a comparative, case-study-based assessment of innovative water governance practices across the six European countries and cases that from part of the RETOUCH Nexus project – Belgium, Germany, Malta, the Netherlands, Slovakia, and Spain. The report's primary aim is to assess and evaluate the efficacy of society-centred and innovative governance schemes and practices, depicting how they act and relate to each other, showing how they emerge, develop, engage with stakeholders, and influence decision-making structures.

Context and rationale

Due to aggravating hydro-climatic and social pressures, a growing interest exists in integrated, adaptive and participatory water governance innovations. Across water governance settings, innovations can take various forms and can be expressed as approaches and tools. However, there exists a conceptual ambiguity regarding what precisely an innovation is, and whether they are society-centred or not. This report aims to contribute to this clarification, exploring how innovations take shape across contexts, to eventually offer more understanding on their broad expressions, learning from them and building upon them.

The RETOUCH Nexus promotes and utilises the Water-Energy-Food-Ecosystem (WEFE) Nexus as a guiding framework to better coordinate governance responses across sectors and levels. Applying this lens to the innovations in focus in this report aids at better understanding how these approaches and tools relate to, reflect or engage with WEFE Nexus thinking.

Research objectives

The primary objective of this report is to assess the efficacy of emerging governance schemes and practices, to understand to what extend they place stakeholders and society at the centre of decision-making.

Therefore, the report addresses the overarching question: *To what extent are innovative water governance schemes in Belgium, Germany, Malta, the Netherlands, Slovakia and Spain effective in terms of RETOUCH indicators?*

It investigates the following three sub-questions:

1. How do innovative water governance schemes emerge?
2. What is the network of stakeholders for innovative water governance schemes?
3. What impact do innovative water governance schemes have on existing decision-making structures?

This report synthesises findings at the case study level for scaling-up purposes to inform multi-level, multi-sector water governance settings. Ultimately, its purpose is not to promote a one-size-fits-all model, but to provide an overview of emerging innovative developments at the EU level and learning opportunities.

Methodology

The comparative study followed a qualitative research method and acquired formation from 17 participants of the six case studies. For this, both semi-structured interviews and survey

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

questionnaires structured according to the RETOUCH Nexus indicators developed by Work Package (WP1) were utilised. A mixed-method coding strategy was employed, also aligning with the RETOUCH indicators.

Key findings

- **Emergence of the approach/tool:** The analysis of the six case studies shows that innovative governance approaches emerged in response to socio-environmental challenges, following either incremental or radical innovation pathways. These solutions were shaped through engagement with stakeholders across multiple levels—from international to grassroots. A clear shift toward polycentric and hybrid governance models was observed, characterised by distributed authority and multi-level collaboration.
- **Participation and inclusiveness:** Participatory approaches were central to the innovations, with the majority of the case studies featuring strong multi-stakeholder elements. Both governance authorities and local actors, such as agricultural producers and municipal representatives, emphasised the value of bridging policy and practice.
- **Issues at stake:** Many approaches also included mechanisms for conflict resolution and collaborative problem solving, but more attention should be given to the extent of inclusion and diversity of stakeholders.
- **Barriers to implementation and progress:** Removing legal and procedural barriers can facilitate incremental as well as radical innovation pathways, but this requires space for experimentation and evaluation. These challenges underscore the need for supportive frameworks that foster cooperation across scales and sectors.
- **Impact on decision-making processes:** Identifying how innovative governance tools interact with existing decision-making and align with the WEFE nexus was challenging due to limited data.
- **Experimentation with the approaches/tool:** Some case studies highlight tools like interactive maps and workshops, but others lack detail or implemented solutions. Experiments with stakeholder-driven approaches vary from simple information sharing to full co-creation, with only a few using formal evaluation.
- **Outlook**: Looking ahead, there is a shared intention to refine and expand these innovations, particularly to better implement the WEFE nexus. Continuous learning from past experiences is seen as key to increasing effectiveness.

Impacts and recommendations

This deliverable offers clear recommendations for practitioners across water governance settings and policy domains:

- Context-sensitive innovation pathways should be encouraged, meaning that innovations must not be understood as a one-size-fits-all process but should be approached within they case and needs.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

- Systematic and thorough participation and co-creation (both formal and informal), which is fitting to its context, instead of superficial consultation, is beneficial when embedded early in governance design and is effectively integrated in water governance approaches/tools.
- Integrated, flexible and polycentric governance approaches should be supported and established. These could be platforms that bridge and bring together actors across all the WEFE sectors.
- Space for contextual experimentation should be facilitated by experts.
- Evaluation methods for the governance approaches and tools should be improved to ensure effectiveness.
- More attention should be given to on-ground processes and better alignment between top-down institutional settings. Recognition of 'grassroot innovations is necessary as well.
- There is a lot of scientific data but this needs to be effectively employed and communicated with stakeholder perspectives.
- Stakeholders' inclusivity and diversity require more attention and sensitivity, through for example strengthening monitoring and evaluation of societal impact and operationalising societal impact, beyond technical efficiency.
- The implementation of nexus approaches and methodologies, such as the WEFE should be further supported or implemented across the scales taking into account different governance levels. In contexts were deemed fitting, the nexus approach can be promoted more explicitly as there is room for improvement across scales and levels.
- The RETOUCH indicators should be considered in the tool/approach assessment procedures. Some case studies are lacking assessment procedures which could benefit from the RETOUCH indicators.
- The role of sustainability should be investigated. More research is needed to fully determine to which the innovative governance approaches can be considered sustainable.
- Further research should focus on the participants perspective and understanding of innovation.
- It is crucial to promote knowledge exchange as many practices and tools. As innovations strongly develop via learning processes a better documentation of outcomes needs to be facilitated and effectively communicated across cases, in order to scale successful practices.

Via the documentation and the critical evaluation of society-centred water governance practices, portraying innovative approaches/tools at EU level, this report contributes to a deeper understanding of how adaptive and resilient water governance can take place at various scales, in various contexts.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Table of contents

Contents

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Abbreviations

EC	European Commission
ES	Ecosystem Services
EU	European Union
WEFE	Water-Energy-Food-Ecosystems
CS	Case Study
WP	Worck Package

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

List of Figures

List of Tables

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

1. Introduction: Context, Objectives, Methods and Structure

1.1. Context

Innovative water governance practices and approaches are increasingly recognised as essential to address and adapt to rapidly worsening socio-environmental conditions associated with the hydro-climatic crisis (Daniell et al., 2014; Pahl-Wostl, 2017). This perspective moves away from sector-specific and rigid approaches, based on the notion that navigating complexity requires novel, creative and integrated schemes and practices that enable adaptability and resilience (Halbe et al., 2013; Melo Zurita et al., 2018). Innovation is normatively argued as a driver of sustainability transitions and enhanced water security, not only within water scholarship but also in institutional and decision-making domains (Daniell et al., 2014).

Processes of innovation explicitly advancing integrative methods are gaining impetus in water governance internationally, across scales, sectors and dimensions (Pahl-Wostl, 2017). Correspondingly, at the European scale, the combination of innovative and integrated approaches and schemes in the water sector are increasingly promoted, particularly after the introduction of the EU Water Framework Directive (WFD) legislative framework in 2000.

Nexus-thinking and its associated frameworks are considered novel integrated lenses for operationalisation that have been gaining traction over the past decades in water governance, particularly the Water-Energy-Food-Ecosystem (WEFE) Nexus (Smajgl et al., 2016; Weitz et al., 2017). The implementation of the WEFE-Nexus concept and associated approaches and tools is not formally required according to EU law and policy. However, as the European Commission encourages the EU Member States to opt for integrated water governance (Rowbottom et al., 2022), the assumption underlying the RETOUCH Nexus project is that the WEFE-Nexus concept and its practical implementation will contribute to this general goal of improved coordination and integration.

Despite the policy support and theoretical advocacy, there remains limited knowledge and coordination efforts on the effective application of the WEFE-Nexus in innovative approaches at the EU level, particularly regarding its role in governance arrangements and institutional settings. In this respect, RETOUCH Nexus recognises the necessity for a more structured understanding of how innovative schemes and tools are shaping water governance at the European level. This report presents Deliverable 4.3 on a case study-based assessment of the efficacy of society-centred approaches of Innovative schemes and practices of water governance (Task 4.3).

1.2. Objectives of the deliverable

Within the context depicted above, Task 4.3 of the RETOUCH Nexus project aims to assess the efficacy of innovative governance schemes. To meet this goal, the present report takes shape as a case study-based assessment of novel approaches to water governance in the selected case study countries as well as in the case studies, particularly looking into how these initiatives have emerged, how they network, and how they relate to and impact existing decision-making structures. Furthermore, the

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

efficacy of such novel approaches in terms of the governance indicators selected in T1.3, especially those relating to socio-economic and environmental impacts, is assessed.

This report synthesises findings at the case study level for scaling-up purposes with aims for informing multi-level, multi-sector water governance settings.

The main research question that we ask is the following:

To what extent are innovative water governance schemes in Belgium, Germany, Malta, the Netherlands, Slovakia and Spain effective in terms of RETOUCH indicators?

We address it via three sub-questions:

1. How do innovative water governance schemes emerge?
2. What is the network of stakeholders for innovative water governance schemes?
3. What impact do innovative water governance schemes have on existing decision-making structures?

1.3. Structure of the document

The present document proceeds with Chapter 2, providing an overview of the theoretical background regarding innovative schemes and practices in water governance, eventually to concretise on RETOUCH's adopted definition. Chapter 3 presents an overview of the innovative aspects that are under the focus of study in the six RETOUCH case studies, elaborating on their objectives and data availability. Subsequently, Chapter 4 focuses on the efficacy of society-centred innovative approaches based on a comparative analysis of the six case studies. Chapter 5 assesses the effectiveness of these society-centred innovative approaches, followed by Chapter 6, which critically examines the level of innovativeness. Ultimately, Chapter 7 provides the conclusions and further recommendations at the EU level and for other governance schemes and practices. The report has one annex.

2. Theoretical Background

2.1. Unpacking innovative governance approaches

Definition and key characteristics of 'innovation'

Various definitions can be attributed to 'Innovation', as the term can have multiple meanings. As Jordan and Huitema (2014) describe, innovation can both refer to a noun (a thing) or a verb (a process), and innovation can both be a product or thing that is newly introduced, or it relates to the act of innovating: 'the alteration of something established'.

A distinction of innovation is often made between radical, drastic changes and minor, incremental adjustments that "represent clear departures from existing practice" (Dewar & Dutton, 1986, p. 1422). Bypassing this characterisation, Rogers (2014, p.11) considers innovation as "an idea, practice, or

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

object perceived as new by an individual or other unit of adoption", where the perceived newness of an idea constitutes innovation despite the first discovery of time of use, arguing for context-specificity. Building on this, Huitema and Meijerink (2017) describe innovation as "the capacity to radically alter existing approaches in light of new circumstances". Innovation, thus, encompasses a comparison between two states or subjects, differentiating between the old and the new. Fundamental to the concept of innovation is the element of time. Giving time to innovation is crucial for a fitting development that is suitable for the context. Moreover, the necessity of innovations is time-bound as a sense of urgency to differ from existing practices to then recreate or adjust to innovative ones (Eshuis & van Buuren, 2014).

Innovation in water governance

A comprehensive definition of water governance is the "range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services, at different levels of society" (Rogers and Hall, 2003, p.7). The broad nature of this definition implies that water governance is the result of multiple interacting dimensions. For example, formal and informal institutional arrangements, different mechanisms for stakeholder engagement and public policy implementation (e.g., economic and non-economic instruments) can all impact the resulting allocation of water resources and the distribution of water-related benefits. In this sense, Jacobson et al. (2013) argue that water governance systems determine who receives water rights and benefits, when and how. The critical perspective to water governance argues that the concept is often subject to a normative understanding to justify specific ideological views of 'what should be done'. This view is reflected in Zwarteveen et al. (2017, p.3) definition: "To rescue the term's analytical purchase - i.e., its ability to make sense of and help understand actual processes of governing - we posit that it is fruitful, first of all, to make the question of what governance means and for whom itself the object of critical investigation: how and by whom is the term water governance used, and for what political or analytical goals?" This view highlights the importance of understanding how governance processes arise in practice rather than just focusing on the outcomes. Independent of the view, it should be noted that water governance systems (outcomes and processes) are subject to constant innovation.

Innovation in water governance has been present throughout history when coping with and solving water-related dilemmas, giving rise to novel practices, management, and governance processes (Daniell et al., 2014). Examples of this are irrigation systems, water storage infrastructure that have supported food production, the implementation of water supplies and sewage systems that improved public health conditions, drainage and flood prevention systems, laws and incentive schemes for pollution regulation, and community governance structures to manage water access, safety and use (Daniell et al., 2014).

As discerned by Jordan and Huitema (2014, p. 389), innovation in governance can refer to three perspectives of innovation, as "the novelty of emerging governance approaches" to the "extensive diffusion of these approaches" and "their effects". It is further argued that innovation implies a meso-level concept that is useful for governance change analysis (Huitema & Meijerink, 2017). Furthermore, several classifications exist that try to distinguish innovation in water governance. In this context, Daniell et al., (2014) build upon David's (1996) managerial innovation classification that distinguishes between three types of "knowledge-based innovations" or technical innovations that rely on

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

knowledge and expertise; "relation-based innovations" or governance innovations that alter the relationships between people and society in an organisation; and "mixed innovations" which relate to aims and attributes of both previously mentioned types. These classifications can help understand the different attributes and dynamics of innovations and their cojoined processes (Daniell et al., 2014).

Debates on innovation in water governance

It is important to recognise a common bias that surrounds innovation: innovation is a necessary but not sufficient condition for improvement. In other words, given the normative appeal of invention, novelty and innovation do not always lead to improvement (Jordan & Huitema, 2014). In this regard, innovations in water governance systems may sometimes exhibit short and long-term perverse incentives, as well as non-foreseen negative impacts. Boxes 1, 2 and 3 describe three cases in which water governance innovations may have unintended effects. These cases highlight the importance of understanding the context in which innovations are placed and how governance structures and power dynamics can affect water use scenarios.

Box 1. Water Framework Directive in Europe – Water pricing and cost-recovery.

The Water Framework Directive is the main policy framework for the protection of water resources in the European Union. One often debated provision is article 9 requiring member states to implement measures to recover the costs of water services, including environmental costs. Many countries often approach this goal by implementing water-pricing policies.

However, water pricing exhibits significant challenges in practice. First, estimating the total (social, environmental and economic) value of water requires data that is not always available. In this regard, Karabulut et al. (2016) find a lack of harmonized data to fully value water in one of the main European river basins, the Danube. Furthermore, under certain scenarios, water pricing might not be effective: Expósito and Berbel (2017) find limited effects of water pricing on the reduction of water demand for olive tree cultivation in southern Spain. Furthermore, in some cases, pricing schemes might be unfeasible due to high administrative and political costs (Farnault and Leflaive, 2024); Finally, water pricing schemes may create power-asymmetries and unintended welfare distribution effects that can affect vulnerable groups (Riegels et al., 2013).

This discussion highlights the importance of considering water pricing schemes in combination with other governance instruments such as "technology adoption, trade in water rights, multi-actor governance, planning, and control measures" (Berbel and Expósito, 2020, p.670).

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Box 2. The Re-bound effect.

In some cases, technical innovation and long-term sustainability do not go hand-in-hand.

This can happen in vitiated supply-demand cycles, often described as the "rebound effect", or in the "reservoir effect" (Di Baldassarre, et al. 2018). The rebound effect refers to the long-term offset of the benefits derived from an increase in water supply or water use efficiency, which is caused by the demand increase due to the newly perceived abundance of water, at either the reservoir or field levels. The reservoir effect describes the event of becoming heavily reliant on specific limited water infrastructures, which exposes to increased risks in eventuality of failure. Additionally, unforeseen negative impacts of innovative measures can materialise in the form of deteriorating water and environmental quality, due to footprint of such systems, or social consequences, as for example the physical and economic displacement of local populations. Di Baldassarre et al. (2018) documented this phenomenon in the Mornos Reservoir of Athens. In 1985 the reservoir exhibited a great quantity of inflows, which led authorities to plan under the assumption of much greater water availability. Four years later, when severe droughts struck, the water withdrawals remained unchanged putting the system under considerable pressure.

Re-bound effects can also arise from the introduction of efficient technological systems. In this regard, Berbel and Mateos (2014) study how the modernisation of irrigation technology in Spain may affect water depletion. The authors find that this scenario is likely to occur when land is not a limiting factor for farmers.

Box 3. Direct and indirect negative impacts.

Direct and indirect negative impacts are the sort of consequences that water management innovations can generate, and which are usually hard to foresee or contain. The construction of dams provides many examples.
Dams are vital infrastructures for the stable supply of water and energy, which significantly contribute to the economic development of nations around the world. However, it has been proven that dams also cause negative social and environmental impacts spanning from the unequal redistribution of their benefits to issues linked with downstream ecosystem degradation. Therefore, the proper development of dam projects relies on a delicate balance of these trade-offs. Luckily, socio-economic and environmental impact assessments have become more frequent. However, even when such negative consequences are accounted for, their management does not necessarily become easier.

For example, it is well known that by slowing down the normal river flow, dams generate an imbalance of sediment deposition. Debris progressively accumulates in the water basin slowly diminishing its volume, and therefore its economic value in the process, while ecosystems downstream are depleted of vital resources that cannot flow freely due to the dam. Sediment flushing is a mitigation strategy for this process, which can restore some degree of equilibrium in debris deposition and is often carried out in a planned manner. Espa et al (2019) report on the negative consequences of several controlled sediment flushing operations on both micro invertebrate and vertebrate fauna in the Italian central Alps region. According to their findings, even

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

when such operations are properly planned and monitored, the negative consequences of these mitigations' strategies are hardly contained.

The examples presented in the above boxes cover only some of the main issues with unintended effects of water governance. They bring evidence in support of our point of view that water governance is a multidisciplinary matter, affecting several sectors at different scales. It is therefore necessary to assess the expected impacts of any water governance innovations from a multidisciplinary perspective to ensure sustainability across economic, social, and environmental dimensions, among others.

2.2. RETOUCH Nexus definition of innovative water governance

In this report, the definition of 'innovative water governance' is built upon the above-mentioned conceptualisations of innovation, extending to the context of water governance.

The definition brought forward by RETOUCH Nexus for 'innovative water governance' and used in this study is as follows:

i. *"Innovation in governance approaches and tools involves the adaptation and application of **novel** methods, tools, and perspectives, in institutional settings, policies, and data collection and sharing mechanisms related to water resources"*

Such novel methods are context-specific and should account for the potential social, environmental, and economic impacts. Furthermore, it is critical to understand the processes that determine how these novel methods arise, and which stakeholder groups are driving their application. We take this definition as a starting point for an academic debate explored further in this report.

In the Glossary (Deliverable 2.4) of the RETOUCH project, innovation in stakeholder engagement was characterised as follows:

i. "Innovation in stakeholder engagement involves adopting new methods, tools, and perspectives to enhance participation and collaboration. This can include the use of digital platforms and tools, interactive workshops, and creative communication strategies. Innovation helps to engage stakeholders more effectively and address complex challenges with new approaches".

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

3. RETOUCH Nexus case studies and their innovative aspects

3.1. Introducing the general WEFE context of the case studies

To define the governance context, Table 1 tentatively assesses to what extent the RETOUCH Nexus countries have already explicitly adopted WEFE nexus approaches and tools, or whether they have done so implicitly through similar integrative approaches. With this, a distinction is made between national, regional, local, and case study levels.

Table 1. Assessment of the adoption of WEFE nexus approaches and tools at different levels in the six RETOUCH Nexus countries

Country	National	Regional	Local	Case study
Belgium	No	Explicit	Implicit	Explicit
Germany	No	No	Implicit	Implicit
Malta	Explicit	Explicit	Explicit	Explicit
Slovakia	No	No	Implicit	Implicit
Spain	No	Explicit	Explicit	Explicit
The Netherlands	Implicit	Implicit	Implicit	Implicit

As shown in Table 1, the state of adoption of WEFE nexus approaches and tools differs between the six RETOUCH Nexus countries at different levels, as well as between the case studies. This aspect is further elaborated upon in the description of the case studies in section 3.2.

3.2. Introducing the general WEFE context of the case studies

3.2.1. Belgium

Context of the Belgium Case Study

In Belgium, the standard practice is to connect homes and businesses to a centralised drinking water supply grid and a sewage discharge system. However, this system faces growing challenges. Drinking water is expected to become scarcer, while more intense rainfall is likely to stress the existing sewage infrastructure, increasing the risk of floods both locally and at the river basin level.

Innovative Governance Approaches

To address these issues in Flanders, individual rainwater tanks are widely installed, but these solutions are often expensive, and their capacity is limited. Therefore, we are exploring collective decentralised water management solutions and treatment techniques at three demonstration sites: a residential site and two business sites. These case studies collect and treat rainwater locally, for the re-use by multiple businesses or residents. A key research question is whether these collective decentralised systems are economically viable and which governance schemes are sustainable?

Decentralised water systems offer multiple co-benefits. They help reduce flood risks and lower the associated damage costs for nearby areas. By decreasing peak water consumption, they also contribute to cost savings for drinking water companies (peak shaving). Broadening the scope to

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

include various Water-Energy-Food-Ecosystem (WEFE) elements could further enhance the viability of decentralised systems. Collaborating with local farmers to reuse water, integrating local energy and water production services, and combining water reuse with green infrastructure, such as green spaces in residential and industrial areas, can amplify the benefits of these projects. However, realizing these synergies requires innovative governance approaches.

WEFE Nexus Aspects and Scale

The WEFE nexus approach is not formally implemented at any level of governance in Belgium - national, regional, or local. However, at the regional (Flemish) level, recent policy notes explicitly reference nexus-related principles. Stronger links between water-related opportunities and the domains of energy, mobility, nutrition, and spatial planning need to be pursued. Regional river basin management already incorporates integral water management, addressing multiple objectives such as water quality, flood management, and groundwater levels. While local governments, such as municipalities or districts, do not explicitly adopt the WEFE nexus approach, they often combine projects to optimize costs and resources. At the case study level, WEFE principles are explicitly integrated into project design, ensuring a more deliberate and comprehensive approach.

3.2.2. Germany

Context of the Germany Case Study

The case study, called Upper Main catchment, is based in the northern part of Bavaria with an area of 4.646 km² (Schaffhauser, 2017). The region faces increasing water management challenges due to frequent hydrological extremes, such as floods and droughts, and competing demands for limited water resources (Schaffhauser, 2017). Agricultural production is affected by growing water scarcity, while water use remains dominated by households and small businesses (LfS, 2020). Moreover, most of the agricultural land (60.3%) is non-irrigated, and the predominance of soils with low water storage capacity (Schaffhauser, 2017) makes the sector highly dependent on natural precipitation patterns—patterns that are increasingly uncertain under changing climate conditions. Despite efforts to modernise, water governance in the region is still shaped by a traditional top-down approach, with limited coordination and fragmented communication among institutions and users.

Innovative Governance Approaches

A weighted indicator-based governance framework combines model outputs with a structured set of indicators rooted in the WEFE Nexus. The approach is intended to provide a planning framework for developing strategies to adapt to climate change and socio-economic scenarios for sustainable and resilient water governance. Stakeholders are integrated by giving them the possibility to weigh the indicators, revealing the main challenges of local actors. Additionally, this allows them to co-evaluate the relevance and impact of model-based scenarios and serves as a feedback mechanism for modellers and policymakers to adjust assumptions, refine scenario design, and align governance strategies with local needs. This participatory process enhances transparency, fosters mutual learning, and supports the development of more resilient, context-specific, and widely accepted water governance solutions.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

WEFE Nexus Aspects and Scale

In the Upper Main catchment, all four WEFE sectors are directly relevant and interlinked, though no formal WEFE Nexus framework is currently applied by governing authorities. Water availability is increasingly affected by climate change, with more frequent droughts and floods creating tensions between agriculture, ecosystems, and domestic users. Agriculture, which covers nearly half of the catchment area, relies primarily on rainfed systems and is highly sensitive to seasonal water variability. Energy is embedded in the system through over 350 mini-hydropower plants, as well as one larger installation (>1 MW), highlighting the water-energy connection (LfU, 2023). Ecosystem concerns are tied to both land use—dominated by forests and low-retention soils—and altered flow regimes affecting aquatic habitats. The public water supply depends mainly on groundwater and springs, underscoring the need for sustainable water resource management (LfS, 2020).

In Germany, the WEFE nexus approach is not formally implemented at any level of governance (national, regional or local). However, locally the WEFE nexus approach is implicitly applied through an exchange and various working groups with heads of government departments within the government of Upper Franconia (e.g. water management, agriculture, nature conservation and environmental law). The same accounts for the German case study.

3.2.3. Malta

Context of the Malta Case Study

Malta is the EU's smallest Member State and has the highest population density within the Union. As a small island situated in the Mediterranean, its water management challenges are compounded by its semi-arid climate. Malta has relied heavily on energy-intensive desalination of sea water to meet the potable water requirements of its population for over four decades, making the Water-Energy nexus a central and integral part of both water and energy governance in the country which, as a Mediterranean state, is anticipated to be highly susceptible to the effects of climate change.

Being an EU member state, Malta must also comply with obligations arising out of relevant EU law, such as the EU Water Framework Directive (2000/60/EC), which shapes its water management policies at a national level. Island-specific challenges, such as seawater intrusion and climate change-related impacts, increased water stress, add multiple dimensions to the challenges Malta faces, including those due to the impact of such stresses on food production and on ecosystems.

Innovative Governance Approaches

The "Water Table" in Malta is a stakeholder grouping that brings together representatives from central government, public bodies and authorities from a variety of sectors, non-governmental organisations, and representation from private sector associations. This inclusive model is in practice rendered possible largely due to Malta's small scale, which allows for a high degree of centralisation and where the absence of multiple administrative layers renders relatively direct and efficient communication among all parties possible. The grouping facilitates the design and implementation of Malta's River Basin Management Plan, which is mandated by the Water Framework Directive. The grouping's role is anticipated to evolve further as the growing importance of the water-energy-food-ecosystems (WEFE) nexus becomes more relevant and mainstream. It is envisaged that this novel governance

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

approach shall address the relative challenges holistically through direct integration into Malta's fourth river basin management plan. This integrated approach is also deemed necessary in the light of increasing pressures from climate change on all four WEFE nexus elements.

WEFE Nexus Aspects and Scale

It is anticipated that embedding energy, food, and ecosystem considerations into Malta's river basin management plan should result in a water governance model which is resilient and adaptive in the face of the challenges posed by climate change and resource limitations. It is planned for this approach to lead to cohesive governance frameworks at the national level, with the possibility of extending this internationally through water diplomacy efforts by proposing governance strategies that could offer a replicable or easily adaptable model for other island states and regions facing similar challenges.

In Malta, the Regional and Local elements carry less significant weight. At the National level, the notion of a WEFE Nexus approach is gaining traction. Water and energy have been intrinsically and necessarily always considered in tandem in policy drafting. The holistic incorporation of the Food and Ecosystems elements into the policy-making process is ongoing.

3.2.4. Slovakia

Context of the Slovakia Case Study

The study area of south-western Slovakia, where the capital Bratislava is also located, is a region distinct from the generally mountainous terrain of the country. Characterized by lowlands and a valley along the Danube River, this area includes the most significant Slovak water aquifer, the Zitny ostrov ("Rye Island"). It also features protected landscapes such as the Danube's side streams, floodplains, wetlands, and alluvial forests. Southwestern Slovakia is notable for its fertile soils, making it the main agricultural region of the country. These factors create ideal preconditions for a synergistic nexus approach to water, agriculture, and ecosystems. However, current challenges, including climate change and inadequate agricultural irrigation, have increased the risks of droughts and floods. Addressing these issues through improved water retention, modernised irrigation systems, and resilient landscape structures in southwestern Slovakia is essential to ensure water security.

Innovative Governance Approaches

The Carbon and Water Bank is an innovative solution proposed by the Ministry of Agriculture and Rural Development of the Slovak Republic to address the challenges of climate change, water retention, and sustainable agriculture. This concept aims to protect and restore the production capacity of soil by increasing its water-holding capacity and organic material content. As soil is not only a production factor for agriculture, it is also the largest reservoir of water in the landscape and helps to prevent droughts, the new approach to soil protection aims to combine an improvement of the soil's agricultural productivity as well as its water holding capacity and ecosystem function. It reflects on the results from the Dialogue on Water and Soil. The Dialogue has the form of workshops of representatives of the Ministry of Agriculture and unions, associations, firms and other entities from the agricultural and food sector, as well as other ministries, organisations from other sectors, municipalities and cities, insurance companies, nonprofit organisations, and the civil sector.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

The Carbon and Water Bank initiative involves the creation and operation of a national Certification System, the establishment of a unified Soil Information and Monitoring System, and the creation of a Climate Fund for Soil. These measures are designed to involve landowners and land users in sustainable agricultural and forest practices that contribute to enhancing soil's water retention capacity and capturing carbon from the atmosphere. The Ministry of Agriculture informed about their intention to prepare a law on the Climate Fund for Soil in August 2022.

WEFE Nexus Aspects and Scale

In Slovakia, the NEXUS approach is not implemented at the national level of governance. Efforts to overcome this gap include the proposed concept "Soil – the Carbon and Water Bank of the Landscape" initiated by the Ministry of Agriculture and Rural Development and supported by a committee focused on the Nexus knowledge base established under the Ministry. However, the practical implementation of this concept lags. The Carbon and Water Bank interlinks water, energy, agriculture (food) and ecosystems, which means all WEFE elements. However, energy is understood as the energy balance of the landscape and its temperature profile, not as energy production from water resources (the Bank does not address, e.g. water power plants). Land owners and land users can implement principles of sustainable land, soil and water management supported by the Carbon and Water Bank on each square meter of land. The plots together assemble a micro-basin, a basin and finally the whole country.

At the regional level, river basin management plans interconnect water and ecosystems. Other partial policies link only certain elements of the WEFE Nexus, but all components of the WEFE Nexus are not integrated concurrently. Local governments (e.g. municipalities) in general do not have strategies explicitly oriented at the WEFE Nexus, but they consider the relationships when preparing spatial planning plans. At the case study level, the studied activities implicitly cover the components of water, food (agriculture), and ecosystems.

Implementing the Carbon and Water Bank principles in south-western Slovakia could improve soil moisture, increase agricultural production, restore water circulation, and reduce the risks of floods and droughts. This comprehensive approach addresses major issues identified by the government and scientific documents to ensure water security, agricultural productivity, biodiversity, and sustainable use of natural resources.

3.2.5. Spain

Context of the Jucar River Basin

The Júcar river is located in the East of Spain, running from the mountains of Montes Universales to Valencia at the Mediterranean Sea. The upstream areas are mostly characterized by agricultural activities. The Júcar basin is an important source of agricultural irrigation waters in the area. Further, there is a 56 MW hydroelectric dam in the upstream part of the Júcar. Midstream river brings water to ecologically important ecosystems. Downstream water serves urban and industrial water users.

The Jucar River basin faces various water challenges, including the protection of the ecosystems midstream and the balance between water supply and demand under climate change. The traditional

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

way to tackle water scarcity issues is increasing the availability of water resources through non-conventional sources, whose costs are beyond affordability for most users in the recent context of rising energy prices. Innovative water governance policies appear to be promising alternatives to achieve sustainable water use and reconcile it with energy production and consumption, and food production from agriculture.

Innovative Governance Approaches

Innovative water governance integrates adaptive policies, advanced methodologies, and multi-stakeholder engagement to enhance sustainability, resilience, and participatory water management solutions that address water scarcity and climate change in the Basin. The main solutions that could be feasible are water pricing, water markets, payment for ecosystem services and insurances. Often, co-creation of these solutions involves bringing together key stakeholders such as, among others, the river basin authority, water users and researchers. Local water users like farmers will share their views on daily struggles with access, scarcity, and allocation. Regional policymakers and representatives of river basin authorities will focus on governance frameworks, innovative policy implementation, and coordination efforts. Researchers and experts will provide technical perspectives and recommend advanced methodologies and data-driven solutions for more efficient water management. By engaging stakeholders at different levels who have varying perspectives, expertise, and needs, the governance process will become more effective, innovative, inclusive, and adaptive.

WEFE Nexus Aspects and Scale

In Spain, the Nexus approach is not formally implemented as a distinct framework at the national, regional, or local levels of governance. However, elements of the Nexus are implicitly applied through various integrated resource management practices and collaborative initiatives. At the national level, Spain's policies on water (National Hydrological Plan), energy (National Energy and Climate Plan), and agriculture (Common Agricultural Policy implementation) address interconnected challenges, but they are not explicitly framed under the WEFE Nexus. Regionally, particularly in water-stressed areas like the Mediterranean River Basin, local authorities, water management boards (Confederaciones Hidrográficas), and agricultural stakeholders engage in cross-sectoral coordination to balance water allocation, energy demands for irrigation, and food production while preserving ecosystems. For instance, in regions like Murcia and Valencia, working groups involving water agencies, farmers, energy providers, and environmental organisations collaborate to address trade-offs, such as optimising water use for agriculture and hydropower while protecting fragile ecosystems like wetlands. These efforts reflect the WEFE Nexus principles, even if not explicitly labelled as such, aligning with Spain's commitments to Sustainable Development Goals and EU environmental directives.

However, the innovation of the case study - the model for the Jucar River basin –includes all WEFE sectors in order to represent the complex interrelationships across the sector at the basin scale. Water availability is highly vulnerable to climate change, leading to conflicts between users and having an impact on agricultural production and hydropower generation. Energy generated by a private company (Iberdrola) is crucial for water distribution and irrigation systems. Hydropower production is moderate amid ongoing local and regional transitions. The food sector is characterized by the production of citrus, which is strongly influenced by water markets and regulated by the regional authority (GVA). Wetland ecosystems, depending on irrigation returns are in poor condition,

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

according to the WFD. This allows us to account for all these interactions to define a viable trade-offs and synergy space that can be used to steer management toward sustainable water governance in the basin.

3.2.6. The Netherlands

Context of the Netherlands Case Study

The case study of **the Netherlands** involves a governmental **water authority**. The Hoogheemraadschap Holland Noorderkwartier (HHNK) (hereafter referred to as HHNK) is an ancient water authority responsible for the administrative area of the North Holland region, which includes 1.2 million inhabitants. The HHNK area depends on three key freshwater sources: precipitation, groundwater reserves, and water intake from the IJsselmeer water body. Additionally, wastewater treatment plants indirectly contribute by returning processed water to the surface water system. Furthermore, 8% of the area consists of surface water, which is managed by HHNK in terms of quantity and quality levels.

Historically, the Netherlands has been a country where there was either always sufficient freshwater available or, in some cases, too much. As a result, the water system has been designed to drain water and has only been minimally adapted to ensure the availability and supply of fresh water. However, freshwater availability is under pressure due to climate change and rising sea levels (more evaporation, longer periods without rainfall, and increasing salinisation), a growing population, and the expansion of agriculture and industry. A major challenge for water managers is developing a strategy to meet the increasing demand for freshwater while the supply is decreasing, requiring consideration of all stakeholders who are affected by increasing drought. Therefore, HHNK aims to develop a *Freshwater Availability Program*, of which one of the sub-elements involves incorporating the interests of stakeholders through a participatory process, working together with the surrounding community.

Innovative Governance Approaches

Two innovations can be attributed to the specific Dutch case study. Namely, first, the programmatic approach to Fresh Water Availability and, second, the participatory process embedded in the Fresh Water Availability program. These two developments represent the innovative water governance approach in question for this report. The establishment of a participatory approach that leads to well-supported information for decision-making processes and freshwater management is, thus, considered innovative. Participation has always taken place within the water authority in various forms and projects, but systematically and integrally addressing it in the early stages of policy development, specifically in a program plan focused on freshwater with a long-term vision, has not been done in this form before.

WEFE Nexus Aspects and Scale

In the Netherlands, the WEFE Nexus approach is not formally implemented at any level of governance, be it national, regional, or local. However, the country has a long tradition of using integrative policy approaches, and this is also the case with respect to water governance at different levels. This allows the conclusion that the Netherlands implicitly adopts a WEFE Nexus approach at national, regional

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

and local levels. The same accounts for the Dutch case study focusing on the development of a regional freshwater availability program, as it will be based on a multi-stakeholder effort representing all relevant sectors. The water authority does not apply the WEFE Nexus supported by RETOUCH nor other Nexus methodologies, but it does consider an implicit nexus approach that involves all relevant sectors, which is also desired.

3.3. Synthesis of the case studies and their innovation

Table 2 gives an overview of innovative governance approaches and tools that are being analysed in the RETOUCH Nexus case studies. However, the innovation(s) listed in the current section refer only to those identified by the RETOUCH Nexus case studies. It is, therefore, important to note that stakeholders may consider various other aspects, approaches, and tools of water governance to be innovative (see chapter 5).

Table 2. Innovative governance approaches and tools to be analysed in the RETOUCH Nexus case studies

Country	Level	Innovative governance approaches and tools	Type
Belgium	Local: The city of Tielt and three locations	• Collective decentralised water management approach and treatment techniques. • Approach to bring different stakeholders together and facilitate decision-making and collective water management, to deal with droughts and flooding. • Approach which facilitates finding a sweet spot between bottom-up participatory system thinking workshops and top-down expert opinions and water balance modelling approach.	Approach
Germany	Regional: Upper Main	• Weighted indicator-based framework for climate- and socio-economic resilient water governance • The developed Model Framework is intended to provide decision-makers with a planning framework for developing strategies to adapt to climate change and socio-economic scenarios for sustainable and resilient water governance. This Model Framework considers Stakeholder Engagement and builds on an Indicator System. The Indicator System in turn is based on the WEFE (Water-Energy-Food-Ecosystem) Nexus. The indicators are derived from the output of the models used within the Model Toolbox and are evaluated by the Stakeholders through weighting. • In addition, synergies and trade-offs between the different indicators are identified. The results can be used by decision-makers to develop strategies and plans for sustainable and resilient water management under climate change scenarios.	Tool and approach
Malta	National	• Water Table meetings to facilitate informal exchange of knowledge and ideas between stakeholders • WEFE NEXUS is being automatically built into MT's 4th River Basin Management Plan (which plan is required by the Water Framework Directive)	Approach
Slovakia	National	• Holistic policy approach to improve soil management by landowners and users that helps increase water retention in	Approach

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

		landscape, consisting of Climate Fund for Soil, Carbon and Water Bank, and Soil Information and Monitoring System	
Spain	Regional: Jucar River Basin (JRB)	• River basin specific drought index tailored to the highly regulated water systems of the JRB • Creation of groundwater users' associations to monitor the use of groundwater and to periodically report the status of aquifers to the JRB authority	Approach and tool
The Netherlands	Regional: area governed by HHNK	• Freshwater availability programme for North Holland • Programmatic and thorough execution of participatory processes	Approach

4. Methodology

This section outlines the methodology applied to analyse innovative governance solutions presented in this report.

4.1. Research design

To reach our objectives, we followed the research process outlined in Figure 1.

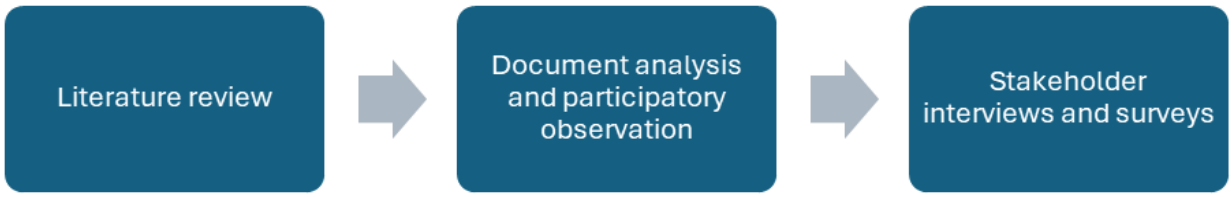


Figure 1. Research process

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Further, this study applies qualitative comparative analysis, based on content analysis, interviews and surveys.

4.2. Operationalisation of definitions

To further guide the analysis, two additional definitions present in the interview guide were operationalised: 'Explicit and implicit approaches in the context of the WEFE Nexus' and 'Overarching policy paradigm' (see Table 3).

Table 3. Definitions of utilised terminology

Terminology	**Definition**
Explicit and implicit approaches in the context of the WEFE Nexus	The ways in which strategies or frameworks, like the Water-Energy-Food-Ecosystems (WEFE) Nexus, are applied in practice. These approaches can differ in how visibly and intentionally they acknowledge and use the WEFE Nexus. A distinction can be made between explicit and implicit approaches: • 'Explicit approach' = the WEFE Nexus is clearly and intentionally referenced in the design, implementation, and/or communication of a project or process. Stakeholders are aware that the WEFE Nexus is being used, and it often shapes discussions, decisions, and outcomes. • 'Implicit' approach = when elements of the WEFE Nexus are applied in practice, such as integrating water, energy, food, and ecosystems considerations, but without explicitly naming the Nexus or using it as a formal guiding framework. The integration is present, but not evident. • In some cases, the Nexus framework is not considered at all - neither in design nor practice - meaning the approach falls outside both the explicit and implicit categories.
Overarching policy paradigm	An overarching policy paradigm refers to the broader, guiding framework of ideas, assumptions, and values that shape how problems are understood and how policy solutions are designed and justified over time. It goes beyond individual policies or tools, as it reflects the general direction of thinking within a governance system. Daigneault (2014) defines a policy paradigm as a shared framework of normative and cognitive ideas held by policy actors. These ideas help actors interpret the world, define problems, set policy goals, and choose appropriate tools or solutions. Following Daigneault's definition, a policy paradigm has four main dimensions: • Values, assumptions, and principles (e.g., beliefs about social justice or the role of the state) • A definition of the problem that policy should address • Goals or policy objectives that should be pursued • Instruments or strategies to reach those goals

4.3. Data collection

The initial information about the case studies was collected via document analysis as well as participatory observation conducted by the researchers in each country. It provided necessary background information used to design interview and survey questions.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Further, we designed the interview guides, including the set of questions following the RETOUCH indicators and clustered as follows:

- Emergence of approach/tool
- Participation and inclusiveness
- Issues at stake
- Decision-making processes
- Experiments with the approach/tool
- Outlook

Each case study researcher conducted three semi-structured interviews or obtained answers from three respondents for the survey from March to April 2025. For Germany, two questionnaires were collected. Through training of the interviewers, the provision of common definitions, and repeated email contact served as ways to add validity and rigour in the data collection.

4.4. Participants

As a result, the sample consists of 17 respondents who can be characterised as presented in Table 4.

Table 4. Sample characteristics

Country	**WEFE area(s)**	**Number of respondents**
Belgium	Water, Energy, Food, Ecosystems	3
Germany	Water, Energy	2
Malta	Water, Energy	3
Slovakia	Water, Agriculture (Food)	3
Spain	Water, Food, Ecosystems	3
Netherlands	Water	3

4.5. Data analysis

To analyse the data obtained via interviews and survey Atlas.ti software was used. We applied bottom-up and top-down (mixed) coding strategies. First, codes were derived from the RETOUCH indicators following the six categories: *Emergence of approach/tool*; *Participation and inclusiveness*; *Issues at stake*; *Decision-making processes*; *Experiments with approach/tool;* and *Future outlook*. Subsequently, additional codes were added following a bottom-up approach. Similar codes were merged, resulting in the code tree outlined in the code tree map (see Appendix A).

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

5. Efficacy of society-centred innovative approaches

Following the introductory information of the case study-based innovation presented in Section 3 and Table 3.2, this section draws from the collected data per case. The structure and content are based upon the WEFE indicators developed by the RETOUCH Nexus project.

5.1. Emergence of approach and tool

This subsection proceeds by describing how and why the governance approach/tool emerged. It outlines whether the approach was planned, emerged spontaneously, or built on earlier formal or informal practices. Further, the section describes the actor-initiated approach, innovative aspects, and whether the approach integrates the WEFE Nexus approach or thinking.

Case-specific insights into the innovations

A total of 17 case-specific innovations (approaches or tools) were brought forward by the respondents and are listed in Table 5. Out of the 17 participants, 16 discussed and recognised innovation(s) in their respective cases, whereas 1 participant provided a critical perspective, considering there to be no innovative elements in their situation. The innovations primarily operate at the governance perspective level(s).

Table 5. Innovations discussed per case study by the participants, with defining characteristics (total of 17 innovations)

Case-Study	Innovations in question	Characteristics	Type	Acronym
Belgium	DuCoop cooperative and project • Local level (urban)	• Decentralised circular water management and treatment: grey water reuse in the production process of neighbouring industry • Coupling opportunity of heat recovery	Approach	BE1
	Basin board governance structure and processes • Basin level	• Administrative and coordinative innovation • Multi-stakeholder engagement • Cross-sectoral collaboration and early intervention • Promotes integrated water policies in the basin	Approach	BE2
	BoerenNatuur Flanders • Regional to local level (cross-scalar)	• Non-profit organisation that creates a bridge between agriculture (farmers), nature (biodiversity) and policy in Flanders • Collective approach • Seeks synergies between ecology and economy	Approach	BE3
Germany	Model renaturation route at the catchment area • National and regional level	• Watercourse restoration, runoff retardation, continuity, avoidance of inputs, species protection/biodiversity, in combination with recreational use possibly in harmony with nature	Approach	GE1

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

		creating synergies between water management objectives and nature conservation objectives		
Malta	The National Stakeholder Water Table • National level	• Approach which underpins water policy development in Malta • Supports the development of comprehensive frameworks via strong engagement process of public entities, stakeholder representatives	Approach	MA1
	Green bonds • National level with area specific project case studies	• Financing structure and instruments that finances of five projects which contribute toward socio-environmental sustainability	Approach	MA2
	Systemic integration of long-standing water governance approaches into national governance frameworks • National level	• Rediscovery and integration of traditional and alternative water supplies such as rainwater harvesting, reclamation of wastewater for agricultural water in Malta's national water governance • In combination with the national major water source: seawater desalinisation • Through a series of actions: legislation, pricing structures for different types of waters, rainwater harvesting and use in buildings, the involvement of numerous public agencies and stakeholders in the management of the system etc.	Approach	MA3
Slovakia	The Carbon and Water Bank (Systemic Assessment and Financing of Soil and Landscape Ecosystem services) ▪ National level	• Program for assessing and financing ecosystem services (e.g. water retention, carbon capture) • Includes a national certification system, Climate Fund for Soil, and integrated information and monitoring system for soil, water and climate • Multisectoral integration of landowners, local governments and EU policy	Approach	SL1
	Regenerative agricultural practices ▪ Local level (farm)	• Farmers use of regenerative practices (no-till ploughing and pro-eco practices) to improve water sequestration capacity of soil	Approach	SL2
	Data development methodology for water retention measures ▪ Local level (municipal)	• Involvement of the cadastral area in the preparation and the implementation of water retention measures	Approach	SL3
	Measures for hydro-meliorations (adaptation and optimisation of water infrastructure)	• Procedure for the adaptation and optimisation of irrigation and drainage systems to ameliorate	Approach	SL4

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

	▪ National level	water retention and mitigate climate-change induced risks • Focuses on water infrastructure management through water cooperatives of landowners		
	Local water planning ▪ Local level (municipal)	• Localised and integrated landscape planning for risk reduction to floods, droughts and other hydro-climatic problems • Methodological development which links water-soil-climate • Management of rainwater budgets, wastewater treatment, and pollution control in municipalities	Approach	SL5
Spain	River Basin Authorities user cooperations further institutionalisation of stakeholder cooperation, new water policies and investments of water infrastructure and technologies • Basin level	• Stakeholder-led action and collective water management	Approach	SP1
	Mar Menor Priority Actions Framework • National level	• !0 lines action framework with a WEFE-integrated structure • Tackling the interlinkages of agriculture, pollution and biodiversity, tourism • Integrates scientific modelling and policy instruments	Approach	SP2
	The Mohican App[1i] • Local level	• Hydro-economic modelling platform as a tool for public and citizen participation in water management • Simulation of water scenarios and the visualisation of trade-offs	Tool	SP3
The Netherlands	Freshwater availability program • Regional level	▪ Program under development for freshwater availability, to manage increasing demand and decreasing supply of freshwater	Approach	NL1
	Programmatic participatory plan within the freshwater availability program • Regional level	• Programmatic and formalised procedures for a participatory approach in the Freshwater Availability Program	Approach	NL2

Table 5 indicates that vast majority of the innovations are approaches.

[1] The "Mohican" application (Hydro-Economic Model as a Tool for Citizen Participation in Water Management) is a digital platform developed by the University of Córdoba WEARE group under the project TED2021-131066B-I00, funded by MCIN/AEI/10.13039/501100011033 and by the European Union "NextGenerationEU"/PRTR. http://www.uco.es/gams

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Cross-cutting themes - Emergence of the governance approach/tool

The following themes emerged across cases and are considered strong findings:

1) The emergence of innovative approaches and tools across the 6 European countries all originates from a response to socio-environmental challenges and pressures. The most common pattern across all the cases is that novelties and experiments arise out of hydro-climatological crises and pressures intersecting with existing managerial and governance structures. For example, in the Spanish case study, the innovative governance emerged due to the hydro-ecological crisis, including floods and droughts, that were acknowledged as direct drivers for the innovations.

    - "*Despite policy and management efforts in recent decades and the existing stakeholders' cooperation within basin authorities, water withdrawals have continued to increase, aggravating water scarcity in major basins. The current situation is especially acute in the basins of southern Spain, where outflows at the estuary of rivers are dwindling.*" – Spanish CS Participant 1

2) Each case illustrates how water-related stressors threatening water resources in a changing socio-environment context spur the development of innovative approaches and tools for adaptation or mitigation. The overarching theme linking the cases is the consequential aim for long-term sustainability and resilience. The envisioned sustainability is context-dependent and oftentimes not directly stated by the participants.

    - "*Our mission is to create more sustainable agricultural operations through commitment to biodiversity and nature, landscape, soil and water management, for climate resilience*" – Belgian CS participant 3.
    - "*Because the scarcity that we think we are going to experience in freshwater, that will lead to social discontent and that will perhaps even lead to an exaggeration of what we are already seeing happening. So how on earth are we going to deal with that, you know? That will really require an innovative way*" – Netherlands CS participant 3.

3) Further, we observe a dynamic interplay between physical hydro-ecological changes and socio-political, institutional, and technological transformations. The mutual interaction creates water governance innovations, for example, via renewal and adaptation of irrigation infrastructure in Slovakia, water systems to manage water scarcity in the Netherlands, user cooperation with coordination of water allocation for severe scarcity and quality issues in Spain, and the integration of alternative water strategies.

    - "*Adaptation and optimisation of existing drainage and irrigation infrastructure to reflect contemporary conditions in Slovakia was formulated in an expert material of the Ministry*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

of Agriculture and Rural Development of the Slovak Republic. [...] Its functions will be extended by water retention in the landscape to minimise negative impacts on the water regime and to increase water retention capacity of agricultural land" - Slovakia CS participant 3.

Context-specific insights – Drivers of the innovations' emergence

1) Beyond the commonalities, each country holds contextually identifiable triggers, as the combination of specific events or conditions. These align strongly with the identified causes of emergence in the contextual background of the cases (section 3). The major challenges that incentivised the innovations are synthesised in the table below:

Table 6. Case-study specific socio-ecological drivers of innovation emergence as recognised by the respondents

Case-study	Identified driver(s)
Belgium	Tension field between water quality goals and water quantity goals – both cannot be achieved simultaneously on the short term, since there is too little water. Test the collective management of agricultural landscapes and simultaneously achieve biodiversity and landscape quality.
Slovakia	Conventional sectoral and fragmented water and soil policies were insufficient for the climate-related risks, particularly for land degradation. It led to the development of a structural integrated model, and for water retention measures at local and ground-level.
Spain	The challenge is the recurrent and worsening water scarcity and droughts in the arid region, and uneven water distribution. The function of river basin authorities is the traditional governance approach to these recurrent issues, however, now they need to adapt to the exacerbation of the problems and the limits of the institutional setting, coordination and cooperation mechanisms, and technologies.
The Netherlands	The freshwater availability program with its participatory track was born out of recent experiences of freshwater scarcity, droughts and rising salinity levels with an incompatible water system that conventionally deals with large water quantities. This challenge is being integrated into existing regional institutional frameworks and thus broadens the remit of the water authority.
Malta	The increasing necessity for water source alternatives and diversification due to Malta's historical limited resource base, contemporarily exacerbated by over-abstraction, salinisation, vulnerability of aquifers in coastal areas.
Germany	NA

2) The contextual factors (historical, political, institutional, and cultural) shape the path-dependency of the innovations. Three typologies of innovation can be discerned by the data:
    a. The **incremental** evolution of the innovation. Here, the innovation builds on and blends within longer-established governance systems
    b. The **'radical'** emergence of the innovation. Here, the innovations reformed novel activities and governance systems, and did not develop out of pre-existing ones. This does not mean that the 'radical' innovation exists in isolation and does not interact with other institutions.
    c. A **combination** of incremental-radical emergence of the innovation. Here, the innovation does not extend previously existent practices but does emerge in response to pre-existing and operating water governance systems.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

The pathways typology, attributed to the cases, is presented in the Table 7.

Table 7. Pathway typologies per case study, as derived from the participants' responses, where applicable

Case-study	Innovation pathway	Contextual factors and explanation of pathway
Belgium	Combination	The innovation surges to meet and incorporate new socio-environmental demands and broader stakeholder inclusivity in response to new layers of environmental and participatory policies. The decentralised system of DuCoop (BE1), however, can be considered as a pioneering project at the case-study site level.
Slovakia	Radical (SL1, SL2)	The Carbon and Water Bank (SL1) is a national novel initiative in Slovakia. Currently, it is not exclusive to Slovakia, although the national framework is developed and managed within the country.
Spain	Incremental (SP1)	Most of the discussed innovationsr extends previous practices, adapting to broader and changing socio-environmental demands. The River Basin Authorities (SP1) have been a tradition consolidated at the beginning of the 20th century to coordinate water management among the different user groups and economic sectors. The current water crisis spurred the same River Basin Authorities to the implementation of a wide range of water policies linked to significant investments in water infrastructure and technologies of the recent decades.
The Netherlands	Combination (NL1) Incremental (NL2)	The Fresh Water Availability (NL1) program is developing from existing governance structures at the regional water authorities, but the programmatic approach to freshwater availability is completely novel in its kind and thematic focus for the authorities. Participatory practices have always been part of the regional work conducted at the water authority. While the future participatory plan (NL2) is considered innovative in this report, the degree to which 'participation' is not always clear, as it is an extension of previously existing activities. However, there is a shift of larger legislation on a global, national and regional scale that pushes for the involvement of stakeholders. In addition, internal realizations, drives the change in its approach, which asks for novel ways of conduct and thinking. The innovativeness lies in the formalization and pragmatic framing of participation (NL2).
Malta	Incremental (MA1, M2, M3)	The discussed innovations flow out of pre-existent water governance approaches to meet novel regulations, due to the long-term institutional commitment to diversifying water sources, primarily for the agricultural sector. The processes regarding water up-take, supply and allocation are being adapted and slowly improved. The emergence of alternative water sources (ML3), such as wastewater reclamation, are also considered 'traditional' practices.
Germany	NA	

Founding actors and key-enabling institutions, and processes

Key actors or institutions that initiated the innovative approach were examined across the cases. The idea for innovative governance solutions emerged through consultation with partners or stakeholders in various case studies. For example, in Spain in appeared due to existing river-basin workways and in Belgium river basin boards created innovations through collaborative processes. In Malta CS, the integration of water use alternatives (MA3), policy makers and public agencies undertook the strategic effort and development of the innovation.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

For other innovations, the emergence occurred primarily through internal or other specific actors. In the Netherlands, program managers and policy advisors proposed a strategy while thinking about the needs of other stakeholders. In Malta CS, the Green Bond funding innovation (MA2), came internally from the corporation and the subsidiary, whereas the National Stakeholder Water Table initiative (MA1), was taken by the Energy and Water Agency.

Finally, some cases combine both approaches, for example, in the Belgium CS DuCoop cooperative (BE1) or the Slovakia CS (SL1, SL2).

The governance and policy arrangements which were mentioned by the case study's participants, categorised per influence level, are categorised in Table 8. The cross-case emergence of approaches/tools is both influenced by broader and high-level institutional developments and paradigms (top-down influences for innovations), and bottom-up processes are steering innovative developments from the ground up. This has been seen especially in the Belgian case study, where the Subsidiary principle aims at shifting institutional focus on the on-ground localised experiences. As a result, a bridge for farmers, with policy and nature demands (for synergies between agriculture-ecology-economy) was formed in Belgium (BoerenNatuur, P3). The two participants of the German CS, more critically, share that the innovations referred to are driven forward out of politically motivated individual approaches and interests, rather than a clear overarching political paradigm.

Table 8. Institutional and policy influences on case study innovations across governance levels as pointed out by the respondents

Governance level	**Policy / paradigm of influence**	**Case study**
International	Regenerative agriculture and indigenous knowledge	Slovakia CS ○ SL2
	UN climate objectives	Netherlands CS
EU	Water Framework Directive	Germany CS Belgium CS Slovakia CS Netherlands CS Malta CS ○ MA3
	Natura 2000	Netherlands CS Germany CS
	Urban Waste Water Directive	Belgium CS ○ BE1
	Flood Directive	Belgium CS ○ BE2
	Integrated Water Resources Management (IWRM)	Slovakia CS ○ SL1 Malta CS ○ MA1
National	National policy frameworks	Applicable to all case studies: each innovation is shaped by national institutional context
Urban (meso) level	Urban development	Belgium CS

Economic viability of the innovation

For Belgium, Spain, and Slovakia, it was directly stated that the emergence of the approach was dependent on the economic and financial viability and opportunities. In this respect, the interests of

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

external private investors or public funding play a large role, also for continuity and further progress. Especially within the Belgium CS (P1 and P2), it is acknowledged that the facilitation of the decentralised water systems and treatments in the three demonstration sites was dependent on a combination of starting funds and private investors with an interest in sustainable initiative development. Investments were also mentioned in the Spanish case study. In Slovakia and the Netherlands CS, the process relies mainly on governmental internal financing systems. The synthesis of the case-study specific key actors involved in the creation of the initiatives, as well as public, private, and hybrid funding involved, is depicted in Table 9.

- "*The unique thing about DuCoop is that it is not a utility company that manages water treatment, but that we have financed water treatment from private initiative, and an important part with European funds, through subsidies. So, without those European funds, we could never have realised that given that the scale of the innovation is so great*" – Belgium CS participant 1.
- "*To increase water supply and reduce pollution, considerable investments have been made in seawater desalination, urban wastewater treatment, and the reuse of treated water*" – Spain CS participant 1.

Table 9. Initial key actors and enabling processes for the emergence of the approaches/tools as stated by the respondents

Case	Key-actors and initiators	Enabling processes
Belgium	DuCoop cooperative and project: • The cooperative (main initiator and operator) • Private investor partnering with real estate developers • The city of Ghent (enablers) Demer Basin Authority model: • Flemish national government BoerenNatuur: • Flemish national government (e.g., ANB, VLM)	• Funding start-up mechanisms • EU subsidies (Horizon 2020, Interreg) – demo project • Facilitation of sustainable urban development • Test project that became an independent non-profit organisation
Germany	Model renaturation route at the catchment area • Upper Bavaria government	• Via the World Weather Attribution (WWA) and the EU-Life programme financial support
Malta	The National Stakeholder Round Table: • The Energy and Water Agency The Green Bond: • Internally from the corporation • It's connected subsidiary Integration of traditional water governance and management approaches • Broad combination of stakeholders (state and non-state actors)	• Reclaimed water was first identified as a feasible solution, piloted, and then advanced through the

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

		development of three tertiary treatment plants. This was followed by the planning and phased implementation of a dedicated distribution network for delivery of reclaimed water directly to agricultural areas.
Slovakia	Carbon and Water Bank (CWB): • Ministry of Agriculture and Rural Development, led by the State Secretary of the Ministry (national government) • New Water paradigm expert team and NGOs Measures for hydromeliorations (adaptation and optimisation of water infrastructure) ▪ Ministry of Agriculture and Rural Development (national government) ▪ Knowledge assistance from state-owned enterprise ▪ Other associations of legal entities Local water planning ▪ Association of Towns and Municipalities of Slovakia ▪ National government Water retention data development ▪ Municipality	• Political endorsement in early stages • The New Water Paradigm • EU trademarks for the CWB ▪ National government initiative and approval ▪ Local support ▪ Legal support ▪ Extreme flooding events as drivers ▪ Decentralisation and involvement of municipalities in landscape and water planning ▪ National-level policy recognition
Spain	River Basin Authority model: • Basin authorities • Top-down: Spanish government • Bottom-up: Basin water users (farmer associations, irrigation boards, industry, water user groups etc.) • Environmental NGOs Mar Menor Priority Action Framework: • Ministry of Ecological Transition and Demographic Challenge (national government) The Mohican App: • University of Córdoba	• Spanish water law and EU directives • Basin's plans • Institutionalisation of stakeholder inclusion • General State Budget investment as part of the intervention of the Ministry for the Ecological Transition and Demographic Challenge • EU project funding
Netherlands	Internal actors at the regional waterboard: • Program managers • Policy advisors	• Internal processes for formalisation with a sub-thematic structure

Cross-case assessment of the Integration of the WEFE Nexus

For the emergence of the innovation, we investigated the integration of the WEFE Nexus and thinking variables per country of study.

1) We find that almost all participants (15/17) show a strong **awareness of inter-connected and integrative dynamics**, here recognised as cross-case 'nexus thinking and consideration'. This

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

perspective is reflected in the innovative approaches across the EU, with its benefits being mentioned in direct connection. Further, there exists a strong cross-case shared interest in **applying integrated approaches** that follow Nexus-thinking. When explicitly considered beneficial, there is a tendential preference for adopting the explicit WEFE Nexus methodology within the approaches and tools.

- *"Yes, this cooperative approach adopts a Nexus WEFE perspective, as basin authorities coordinate water use in basins across different sectors at spatial and temporal levels. The adoption of the Water Framework Directive established the requirement to protect ecosystems. To this end, environmental flows have been established for river sections, which have been implemented in the basin plans of the three planning cycles (2009, 2015, 2022). Therefore, the basin plans incorporate the Water-Energy-Food-Ecosystems Nexus"* – Spain CS participant 1.

2) Additionally, 8 out of 17 respondents specifically acknowledge the connections of the WEFE Nexus, or at least partial sectoral interlinked dynamics, being made in their specific case/context, and the approach/tool.

   - *"So, my experience is mainly related to trying to think about water for agriculture. Which obviously from the WEFE Nexus, links, the water component, links the energy component, because everything we do in the water sphere either is it is to pump water from the ground. That is a big amount of energy, for a farmer, for example, or water for food, no? It's, it's very linked, but also when you speak about natural freshwater resources, a big part of the water is actually used for ecosystems for our natural environment to survive. So, in my work, the WEFE NEXUS is something which we maybe we don't, explicitly"* – Malta CS participant 3.

3) Respondents also reflected on the utility and the feasibility of explicitly using the WEFE nexus, acknowledging that implicit approaches can be more appropriate. The explicit incorporation of the WEFE framework is not always feasible or difficult to be actualised in practice (BE1, NL1, NL2, SL1) or considered necessary for a tool or approach to be effective in certain instances (GE1, NL1). The Spanish case study, which explicitly recognises and operates the WEFE Nexus, did refer to its utility and benefits (SP1, SP2, SP3).

   - *"The most important thing is that there is a concrete implementation. There is no harm in explicitly naming new concepts, but they must also be put into practice immediately without delay. A concept alone is not enough, whether explicit or implicit. Synergy effects should be presented in a way that is easy to understand. One and the same euro can be used to protect nature, achieve water management objectives and ensure extensive, resilient agriculture, while also guaranteeing gentle recreational use*" – Germany CS participant 2.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

- "*A practical tool within this framework is the Nexus Solution Assessment Framework (SAF), which evaluates the impacts of policy interventions (e.g., water allocation strategies or renewable energy adoption) on all nexus components. By translating complex climate and hydrological data into actionable insights, this tool empowers policymakers to make informed decisions that balance economic, environmental, and social objectives. In my surroundings, where water scarcity and ecosystem degradation are pressing issues, this integrated approach fosters resilience and sustainability in a way that traditional water governance tools, focused solely on supply or demand management, cannot achieve*" – Spain CS participant 1.

4) Lastly, we observe an indication for prioritisation of sub-sectorial connection - such as the strong Water-Energy link (BE1), or Water-Agriculture link (SL1, BE3) - or one specific sector of the WEFE Nexus, in a few specific approaches/tools.

   - *"As a water authority, our core task is water, so we automatically **prioritise** water over, for example, energy. Even though we, as a government, have committed to the climate agreement and have an obligation to reduce energy consumption, if it conflicts with flood prevention, we will always prioritise flood prevention. That's our core responsibility. So, I think these trade-offs happen implicitly all the time, and within a water authority, water will always take precedence over energy*" - Netherlands CS participant 1.

Case-study specific insights - The explicit/implicit WEFE Nexus integration

Innovations from three out of six case studies explicitly consider and reflect all four elements of the WEFE Nexus:

- The Spain CS's water use coordination as basin authorities (SP1), the Mar Menor Action Framework (SP2) the Mohican App (SP3).
- The Slovakia CS, with the Carbon Water Bank (SL1). It should be restated that the innovation has not yet been put in practice.
- The Malta CS, the Water Table (MA1).

Innovations from one out of six case studies, the Belgium CS, explicitly consider sub-connections. The Belgium CS, for the DuCoop innovation (BE1), there is an overt and strong connection between the Water and Energy dimensions. The integration of the other sectors is not present, despite acknowledging the potential benefits (Ecosystem or Food, such as improved greenery and environmental improvement with the outcomes of wastewater treatment). The participant stated that food certification is unfeasible because the small scale of the project makes struvite reuse difficult under current national legislative barriers and restrictions, impeding room for food and ecosystem-related actions (Participant 1).

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Further, for innovations of three out of six case studies, the integrated manner facilitated by frameworks, such as the WEFE Nexus, is not explicitly practised and relied on. The following case studies showcase the implicit integration of the WEFE nexus:

- The German CS, the action planning connected to the model renovation (GE1), also implicitly corresponds with WEFE Nexus thinking.
- The Netherlands CS has already been working with all WEFE sectors, underscoring an implicit consideration of the nexus domains and connections.
- The Malta CS, in terms of its broad integrative approach of combining alternative water sources with its operating governance structures (MA3), implicitly considers the WEFE Nexus.

    - *"Explicitly, no, definitely not. We are not yet used to working in an integrated manner. Implicitly, I think so, because trade-offs between interests are often made naturally. For example, if we need to choose between ecology and water availability, we might know that a measure will negatively impact ecology but benefit water availability. These choices are made, but not often explicitly discussed- they remain implicit"* - Netherlands CS participant 1.
    - *"So my experience is mainly related to trying to think about water for agriculture. Which obviously links the, from the WEFE NEXUS, links, the water component, links the energy component, because everything we do in the water sphere either is it is to pump water from the ground. That is a big amount of energy, for a farmer, for example, or water for food, no? It's, it's very linked, but also when you speak about natural freshwater resources, a big part of the this water is actually used for ecosystems for our natural environment to survive. So in my work, the WEFE NEXUS is something which we maybe we don't, explicitly"* – Malta CS participant 3.

Summary of findings

To sum up, we identify five overarching salient themes from the analysis of the 'innovation emergence':

- Participatory and integrated governance is developing and gaining recognition, either implicitly or explicitly, across various scales (top-down and bottom-up interactions), which is reflected in the approaches and tools.
- The majority of innovations seek to aid navigation/coordination in multi-level governance.
- There is a broader shift toward stakeholder-centred solutions, which is made evident by the presence and the increase of collective action in water governance.
- Water governance settings tend to rely on evidence-based and adaptive governance, science-based land use planning, thus giving value to empirical findings.
- Nexus reasoning, or integrated thinking, is very much present in the water governance innovations, either implicitly or explicitly. The explicit operation of the WEFE Nexus in tools/approaches isn't always required.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

5.2. Participation and inclusiveness

The current section assesses which sectors and stakeholders are involved in the innovations, the inclusivity of the processes, and whether gender equality and social inclusion are considered and implemented.

Cross-cutting themes of participation and inclusiveness

1) Participation plays an integrative and enabling role within the society-based efficacy of approaches at the European level. The stakeholders involved in the **society-centred governance approaches** are diverse and are increasingly so. This trend aligns with the integrated focus of current governance models. We see that participation, or participatory processes and plans, are increasingly evolving to encompass multiple sectors, levels, diverse representatives and actors, and play a major role in the identified innovations. Namely, in all case studies, the participatory aspects and stakeholder engagement mechanisms are integral to the innovation itself, with 12 innovations out of 17 including multi-stakeholder collaborative, informative or connective elements. For the Netherlands CS, and the Malta CS innovation MA1, participation itself is directly stated as the innovation:

    - *"The innovation in the tool relates to the establishment of a structured dialogue with stakeholders and hence the integration of stakeholders in policy making, which moves beyond standard 'consultation' exercises."* – Malta CS participant 1.

The following actors and sectors were identified across cases:

Table 10. Sectors and stakeholders involved in the innovations, as mentioned by the participants

Case study	Sectors and stakeholders
Belgium	BE1: • Water, Energy, Ecology sector • Public sector - The cooperative, residents and the city • Private sector – Funding agent, industry, real estate developers BE2: • Water sector – Water managers, basin actor, • Agriculture sector – Agricultural collectives, land agency, farmers • Nature sector – Environmental, nature and forest agencies • Municipalities, the province BE3: • Water sector – river basin managers, water managers and authorities • Local governments, policy makers, sectoral organisations
Germany	GE1: • Water sector • Ecosystem sector – nature conservation authorities and associations
Malta	MA1: • Water, Energy, Food, Ecosystem sectors -The representatives cover explicitly the four pillars of the Nexus

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

	• Public sector entities - Ministries, Agencies and Authorites which have a stake in water management • Private sector entities - Stakeholder representatives, • Non-profit sector entities - eNGOs and academia MA2: • Water sector directly • Energy and Food sector indirectly • Private sector – Regulatory bodies, financial intermediaries, banking institutions MA3: • Water sector • Agricultural (Food) sector – Farmers • Energy sector – Desalinisation • Ecosystem sector – NGO, local nature authorities and actors, farmers
Slovakia	SL1: • Private sector – Farmers, landowners and co-owners, water companies, water course managers • Public sector – Cities, municipalities, self-governing regions, ministries (the Ministry of Environment of the Slovak Republic, the Ministry of Agriculture and Rural Development) SL2: • Private sector – Water company, water management company • Public sector – Civic associations, the national government (department of the environment), the municipality, forests of the republic
Spain	SP1: • Water sector – representatives of basin authorities, water user (urban supply, irrigation, hydropower and industry) representatives, federal and state government, municipalities, famers' unions, environmental associations, business associations, workers' unions SP2: • Agriculture – farmers and agricultural associations (irrigators' communities) • Water management authorities – the respective Basin Agency, • Environmental (Ecosystem) sector – Environmental NGOs, conservation groups • Civil society organisations and municipalities – municipalities and local organisations representing urban water users • Energy sector – hydropower operators, energy companies • Research and academia – Universities, research institutes SP3: • Water sector • Agricultural sector • Ecosystem sector
The Netherlands	NL1 and NL2: • Water sector – water board and water authorities • Agricultural (Food) sector – Agricultural (umbrella) organisation representatives • Ecosystem sector – Nature conservation and land management organisations

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

	• Public sector – The national government, municipality representatives, the province • Private sector – The drinking water company, the bulb industry, • The general public and citizens

2) A second cross-case emergent theme is that of the **innovations' capacity to institutionalise self-organisation**. By this means, differentiated participation strategies, such as cross-pollination (Belgium CS), and novel stakeholder-engagement mechanisms, such as e-platforms (Spain CS), are diversely set up and employed across case study areas. Alongside novel practices, existing stakeholder-engagement mechanisms and communication channels are relied upon continuously, such as sending invitations to agricultural councils (Belgium CS), recurrent meetings with farmers and the province (Netherlands CS), or board meetings (Spain, Belgium CS), roundtables (Germany CS). For the Malta CS, the Green Bond projects (MA2) have mechanisms in place to provide transparency through reporting for the investors and a monitoring tool for the general public.

    - "*A few years ago, we set up a kind of sounding board group for the water distribution strategy… And that was fairly new. And three years ago, four years ago, we once had a very dry summer. And then they also organised information evenings. And simply invited people to come and provide explanations about how we deal with the drought*" – Netherlands CS Participant 3.

3) Water governance authorities and policy practitioners are increasingly recognising **the value in participation**. The local actors involved (such as agricultural producers, municipal figures and academics) emphasise the importance of cross-sectoral collaboration via stakeholder participation. This is made evident between the agricultural and environmental sectors (Belgium CS, Slovakia CS). Participation is viewed as a way to close the gap between on-ground field experiences with higher-level policy and decision-making processes.

4) Through participation, there is a clear **ambition to integrate scientific/academic insights with on-field expertise and knowledge with policymaking** (policy-academia-field). This is exemplified within the Mohican citizen-led e-tool (SP3), and water allocation processes in the river basin authorities (SP1) of the Spain CS; the Carbon Water Bank (SL1); the local water planning (SL2) and the citizen-led data development (SL3) and hydromelioration measures (SL4) of the Slovakia CS; the DuCoop cooperative structure (BE1), the BoerenNatuur connective role between agriculture and policy (BE3), and the participatory frameworks of the Belgian basin (BE2).
5) Along with the overall cross-emergent trend, there are specific connected **challenges**. The participants pointed to a series of difficulties which result from participatory approaches and obstacles to effective implementation, thereafter. These will be addressed further in Section 5.3 (the barriers to innovation).

Stakeholder involvement, inclusivity and diversity

In three case studies (Belgium, Netherlands, Spain), a major point raised is the **co-production of knowledge due to multi-actor learning through participation**. The integration and recognition of

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

multiple knowledge systems support governance policies, measures, technology, infrastructure and data development. This is thought to be strongly connected to positive developments and effects, such as increased legitimacy, support of informed decisions, adequate adaptation, flexibility and practical relevance for the innovation's goals. Notably, the development of trust among actors and stakeholders was the most mentioned positive effect and development from participatory processes.

- "*It incorporates citizen science and participatory methods to integrate local knowledge and stakeholder priorities into decision-making. This ensures that solutions are not only technically robust but also socially accepted and policy-relevant*" – Spain CS Participant 2.

The **diversity** and inclusion of stakeholders vary across the cases, reflecting case-specific innovations and contexts. In the DuCoop cooperative (BE1) in Belgium and the Mar Menor Priority Actions Framework (SP2), the participation of stakeholders is described as well-balanced, though respondents emphasise that it remains subject to ongoing iteration and refinement. In the Malta CS, the Water Table approach (MA1), the representatives are described as "*balanced between public and private sectors, and also within sectors to ensure that the views expressed are not one-sided*" by participant 1.

In the River Basin approach in Spain (SP1), such as the specific Júcar River Basin, the equity and balance of the sectors and actors depend on the power distribution among the stakeholder groups. In other river basin contexts in Spain, and for the Netherlands (NL1, NL2), Slovakia CS (SL1), it is found that the active involvement and prioritisation of the major, or 'critical' stakeholders. For the German CS (GE1), and the Slovakia CS (SL2), the respondents mention a lack of stakeholder involvement, referring to their sector.

- "*A good example of this is the difference between agriculture and nature conservation. Agriculture is a major water user and stakeholder, meaning we are used to engaging with them frequently. Naturally, we have more contact with the agricultural sector. And then I noticed that we have much less contact with nature conservation organisations… But at the same time, it makes sense when you consider that agriculture is a major water consumer, whereas nature conservation areas typically require much less water*" - Netherlands CS Participant 1.
- *"Regarding the number of representatives in basin authorities, the most incredible power belongs to state governments, water users, and the federal government. However, governments accumulate large decision-making power since more than half of the representatives are from the state or federal governments"* – Spain CS participant 1.

Despite the increasing diversity of stakeholders involved, it becomes evident that there is an overall lack of mechanisms or frameworks that facilitate and mainstream gender equality or broader social inclusion, such as for youth. 7/17 participants referred to a lack of inclusion or an incomplete stakeholder representation, as a matter which has not yet been institutionalised in the approaches or because it is seen as a topic that doesn't require active incorporation. For example, in some cases,

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

gender equality and inclusion are not systematically addressed, and at times, rather left to the discretion of the participating stakeholders (Malta CS, Slovakia CS).

- "*Specific mechanisms for gender equality and social inclusion are not in place. Still, the CWB innovative program is in its preparatory stage open for ideas. No one is discriminated or excluded from cooperation nor participation in the program*" – Slovakia CS participant 3.
- *"All key stakeholders across the different sectors are generally involved; however, I believe those from rural areas facing depopulation are the least represented in the participatory process"* – Spain CS participant 1.

5.3. Issues at stake

This section assesses the main issues being addressed by the innovative governance approach/tool. This includes the matters or questions that are being discussed or decided upon that are important in relation to stakeholders, and which milestones have been achieved to date. Further, we analyse to what extent the stakeholders agree on the goals, the disagreements or any mechanisms included for resolving these.

The matters or questions that are being discussed or decided upon are mostly contingent on the case and specific innovation, with overlapping elements across cases. Across all case studies, the **key matters addressed** by the approaches/tools in question are the following:

1) Informing how to adequately and fairly allocate water across stakeholders and sectors in complex socio-environmental circumstances.
2) The reduction of pollution and the increase in water quality.
3) If the use of non-conventional water sources is economically viable.
4) Creating policies that support co-benefits whilst decreasing trade-offs across the WEFE sectors.
5) How to achieve institutional coordination across diverse governance actors and mechanisms.
6) The implementation of integrated models and monitoring systems.

The majority of case study countries with actively implemented approaches and tools delineate the achievement of various successful milestones, as projects or specific events. The following matters are brought forward by the participants as **successful milestones** achieved this far:

1) Collaboration for problem solving and strong participatory processes (applicable to all six case studies).
2) Ensuring water availability in periods of water scarcity (Spain CS, Malta CS).
3) Ecology and biodiversity improvement (Spain CS, Slovak CS, Germany CS).

    - *"The renaturation routes have been significantly enhanced ecologically, species on the Red List have been supported; even the white-tailed eagle (Seeadler) has*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

returned to the area. Monitoring studies (at the government of Upper Franconia) prove the ecological enhancement of the Upper Main" – Germany CS participant 2.

4) Bridging the gap between policy and practice (Slovakia CS, Spain CS):

   - *"What I consider particularly innovative about the Mohican app is its accessibility. The innovation lies primarily in the fact that it makes a hydro-economic model available to any member of society, allowing them to simulate different scenarios without needing technical knowledge. This means that farmers, citizens, or local decision-makers can engage with complex water management scenarios through a simple, user-friendly interface. The app translates technical output into intuitive visualisations, empowering non-experts to participate in discussions and decisions about water allocation and policy. It truly bridges the gap between science and society, making hydro-economic modelling a tool for participatory engagement rather than just an academic exercise"* – Spain CS participant 3.

5) Addressing fragmentation and sectoral siloing with WEFE and nexus-informed approaches (Spain CS, Malta CS, Belgium CS).

   - *"An important milestone relates to the contribution of the NWT in the drafting of Malta's 3rd RBMP which worked towards engraining the Nexus in this national water management plan"* – Malta CS participant 1.

6) Creating successful consultation structures that inform projects and events (Belgium CS, Malta CS).
7) Identification of problems with experiments that can thereafter be addressed (Spain CS, Belgium CS).

   - *"The institutional process that led to this collective action began when farmers realized the problems with the aquifer's depletion and responded by creating an irrigation board to manage the aquifer in 1994. This response was a consequence of the Hydrographic Confederation's request for control of extractions, with the strong support of irrigators with water rights in the Lower Júcar region, the Confederation's threats to refuse pumping permits to farmers, and the rising costs of pumping due to the progressive decline in the water table with the depletion. The result has been a gradual reduction in annual extractions by 100 Mm3 during the decade 2000-2010, successfully bringing extractions down to the recharge level"* – Spain CS participant 1.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

8) Context-specific simulation development, with models linking water-energy-food-ecosystems (Spain CS) and a specific trademark for innovative soil and water management (Slovakia CS).
9) Integration of hydro economic modelling into stakeholder dialogues (Spain CS).
10) Sustainability assessment for impact measurement (Spain CS).
11) Improving water retention measures (Slovak CS).

    - "*Since 2014, we have evidence of a sustained increase of organic matter in soil. Also on higher water retention – sequestration of water in our soils on our farm)"* – Slovakia CS participant 1.

12) Good progression of the projects from a financial disbursement perspective (Malta CS).
13) Maintaining a reliable water availability despite scarcity (Malta CS).

Agreement on goals

Cross-case findings with five out of six case studies point to an overall tendency and willingness among stakeholders to participate in the discussed innovations.

- *"Stakeholders participate actively in the Water Table Meetings – which in itself shows that they are seeing this forum as a useful tool"* – Malta CS participant 1.

However, potential conflicts of interest and perspectives on the innovations are discussed in five out of six case studies (Netherlands, Slovakia, Spain, Belgium, Malta CS). It is emphasised that the interconnected dynamics of water and its governance (e.g., quality, quantity, allocation, provision), and their links with other sectors and domains, are matters which hold and can generate contestations or conflicting viewpoints, both among and across internal and external stakeholders of the innovation.

- *"Well, what I found most challenging was the different opinions on the matter. Some people within the organisation see participation as very important and want to dedicate a lot of time to it, while others don't find it as important and prefer to spend less time on it. Balancing these perspectives was tricky. In the end, I had my own opinion as well"* – Netherlands CS participant 1
- *"You can want meadow birds in a certain area, but if you're going to have to flood your fields to do that, then farming stops there. Those are conflicting views. But I think that in many areas much more can be achieved if you start talking to the people instead of a circular, policy line, new eco-regulations etc. from Brussels"*- Belgium CS participant 3

Disagreement mechanisms

For six out of 17 innovations, disagreement and conflict resolution mechanisms are, or will be, formally embedded within the approach/tool in question. For one out of 17 innovations, these mechanisms are either informal or preparatory, and for one out of 17 innovations, it is clearly stated that there are no existing mechanisms to solve or mitigate conflicting views and perspectives. For nine out of 17

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

innovations, the respondents did not mention whether conflict resolution mechanisms are formally or informally incorporated in the innovation.

- *"Conflicts and disagreements tend to be resolved through extended discussions and where possible including amendments to take into account reasonable concerns raised by stakeholders"* – Malta CS participant 1.

In Slovakia CS, the creation of incentives and financial contributions is considered a conflict resolution mechanism for the mitigation of conflicts in the agricultural sector and the acceptance of nature-based solutions and regenerative/biodiversity measures (SL1). In Spain CS, conflict resolution mechanisms are effectively embedded within the River Basin governance structure (SP1):

- "*Water management is decentralised, with the basin authorities in charge of water allocation and water user associations in charge of secondary infrastructure and water usage. The main advantage of this institutional setting is that stakeholders are inside all management bodies in the basin authority. They cooperate in designing and enforcing decisions, rules, and regulations, which results in the smooth operation of implementation and enforcement processes. Although conflicts appear among stakeholders, most frictions are resolved by agreements among groups rather than by resorting to judicial litigation or political decisions by the central government*" – Spain CS participant 1

5.4. Barriers to implementation and progress

The conducted interviews mainly provided extensive information on the issues challenging the implementations and the continuity of the innovative water governance approaches or tools, hereafter considered as 'barriers'. This section provides an overview in this respect.

Barriers and resistance to the implementation of the innovative governance approach/tool are discussed in four out of six cases.

The barriers indicated by the respondents include the following (listed from most frequently to least frequently mentioned):

- Friction between top-down regulations and local innovation development, connected to the trend of scale interconnections and cooperative settings.
    - "*We certainly shouldn't go to the wild west, but it is true that very often things are said to have no impact, that was the case with Natura2000 delineation. That is a very clear example, which had a lot of consequences for everybody, not just farmers. These demarcations are not always very well behaved, but the consequences are very real afterwards. People talk about this with soothing words beforehand, but when the chips are down. And then it is within so many meters of Natura2000 you already have consequences, which is already 500m certainly for the new groundwater train. Farmers who have experienced that too many times, I understand that the trust towards the government in that area is very low. You can't blame them for that either.*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

That's a problem that that the wildlife sector is also facing now, with the legacy of the past. The water is deep between the two camps. Regardless of who has that right. Of course, nature goals are also important […] The gap between policy and field is huge. " - Belgium CS participant 3.

- Friction between scales, where scales are perceived as barriers for the implementation or continuity of the innovation.
- Economic and financial challenges for further implementation or continuity.
    - *"A limiting factor are insufficient financial resources needed for a deeper and more intensive development of the CWB."* - Slovakia CS participant 3
- Conflicting perspectives on innovation among stakeholders.
    - *"Well, what I found most challenging was the different opinions on the matter. Some people within the organization see participation as very important and want to dedicate a lot of time to it, while others don't find it as important and prefer to spend less time on it. Balancing these perspectives was tricky. In the end, I had my own opinion as well, but the programme manager, as the program manager, made the final decision—of course, in consultation with management."* – Netherlands CS participant 1
- Administrative burdens and bureaucratic complexities slow down processes .
- Institutional barriers to the implementation of innovation, policy-practice gap, policy siloing, and sometimes weak continuity of policies.
- Knowledge-action gap due to a perceived lack of data and research which does not engage with field engagement and stakeholder experiences.
    - Lack of human resources and expertise to implement the innovation fully. *"We are a very small organization and that guaranteeing systems and keeping the systems operational in such a small organization is a titanic task. Keeping systems running, you have to do waiting phones, we lack leverage to do price negotiations like big companies. So you create a de facto situation that is challenging*" - Belgium CS participant 1.

5.5. Decision-making processes

This section assesses how the innovative governance approach/tool interacts and affects already existing decision-making processes and whether it coordinates with WEFE sectors.

Table 12. Synthesised description of the interactions with existing decision-making processes and respective coordination of WEFE sectors, as stated by the participants

Case study	Innovation	Interaction with existing decision-making processes	Coordination of WEFE sectors
Belgium	BE1	The cooperative primarily informs internal decision-making	Not stated

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

		processes, in communication with external stakeholders.	
	BE3	Informs existing decision-making processes by creating a bridge between the agricultural sector and policymaking at higher level. maximising both the ecological and economic opportunities related to biodiversity on farms, while minimising any obstacles or limitations.	Primarily focusses on the coordination agricultural sector and nature.
Germany	Not stated		
Malta	MA1	Supports the formulation and implementation of the River Basin Management Plan, and hence there is a direct interface with the national water management framework.	The tool itself is the mechanism to coordinate decision-making processes between stakeholders of the four Nexus pillars. It strives to ensure more cohesive and nexus integration in water management.
	MA2	The green bond primarily informs internal decision-making structures, building on already existing processes of the corporation.	NA
	MA3	Seeks to inform existing decision-making processes through communication, while creating space to learn how to address sectoral siloing and increase their integration.	Not stated
Slovakia	SL1	The innovation is not yet employed in practice, therefore does not interact with existing decision-making processes, nor coordinates with the WEFE sectors.	
Spain	SP1	Decision-making processes are informed collaboratively, through workshops and dialogues and scenario analyses, co-designing solutions and alignment with stakeholder priorities and national planning cycles.	Specifically aligns with WEFE nexus sectoral needs.
	SP3	The interactive platform complements existing decision-making structures, by being user-friendly for water management scenario simulations. Enhances the ability of the stakeholders to visualise and understand potential scenarios, informing the water allocation strategies. This can directly inform and strengthen decision-making at the river basin level.	Keeps water-food into the account, which can be better aligned with the WEFE sectors (energy-ecosystems)

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Netherlands	NL1, NL2	The innovation is not yet employed in practice, therefore does not interact with existing decision-making processes, nor coordinates with the WEFE sectors.

Based on the findings presented in Table 12, the key takeaways of the decision-making processes and their coordination between the WEFE Nexus pillars are as follows:

- Innovations vary across cases in how they engage with existing decision-making processes, with some innovation being embedded or aligned with national frameworks and planning cycles (SP1, SP3, MA1), others primarily inform internal decision-making structures (BE1, MA2), and some currently lack interactions or implementation. 7/ 17 were not included in this section, due to a lack of provided information.
- The WEFE Nexus coordination in decision-making processes is often not mentioned by the respondents or is still emerging. The full coordination is directly found in the MA1, SP1, and SP3 innovations. At times, the innovation (BE3) is also found to be partial or not fully developed when it comes to informing existing decision-making processes.
- Practical implementation is influential in informing decision-making processes. The Slovakia and the Netherlands CS discuss innovations which have limited influence on decision-making and WEFE coordination at this stage.

5.6. Experimentation with the approach/tool

This section examines the degree of experimentation at the EU scale with innovative approaches, further assessing to what extent the experiments are stakeholder-driven and whether they are monitored and/or evaluated. An eventual compilation of the primary outcomes can be compared.

Table 11. Experimentation, their stakeholder involvement characteristics and evaluation mechanisms, per case study as informed by the respondents

Case study	**Type and level of experimentation(s)**	**Stakeholder involvement**	**Evaluation mechanisms**
Belgium	Testing pilots and demo-sites of the circular water treatment in different areas • Local level (urban & rural)	Consulted and informed • Bottom-up, high involvement	In place: Formalised evaluation of experimentations through standard reporting • There are difficulties with administration, and lack of iterative learning
Germany	Not stated	Not stated	Not stated
Malta	Not stated	Not stated	Not stated
Slovakia	Not yet executed	Stakeholders show interest in the development of the innovation • Low involvement	No evaluation mechanisms in place (yet)

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Spain	Testing of Solutions Evaluation Framework through case studies to co-design and evaluate solutions for integrated governance (participatory workshops, modelling to assess policy and technical measures) ○ Global, continental, river basin scale	Co-creation • High involvement	In place: Nexus Solution Assessment Framework (SAF), which evaluates the impacts of policy interventions (e.g., water allocation strategies or renewable energy adoption) on all nexus components (SP2)
Netherlands	Exploratory conversations with critical stakeholders for the establishment of the programme (governmental authority, private water company) • Regional scale	Consultation and information • Low involvement	No evaluation mechanisms in place (yet)

Based on the findings presented in Table 11, the key takeaways of the experimentation with the approaches/tools are as follows:

- The levels and types of experimentation vary significantly across cases.
- The degree of stakeholder involvement in the experimentations varies as well. The high-level stakeholder involvement is found present in implemented, participatory-oriented approaches/tools (Belgium CS, Spain CS). The low-level stakeholder involvement is found present in not (yet) implemented approaches/tools with a participatory element (Netherlands CS, Slovakia CS).
- It is unclear whether the evaluation mechanisms are effectively in place. The Spain CS points to a structured evaluation tool, the Belgium CS denotes formalised evaluations with specific issues, and for the remaining cases they are missing or remain unspecified.

Additionally, the German CS participant 1 critically conveys that the current approaches and tools in water governance are only reaching aesthetic milestones in the Upper Main area. Aside from this, the participant states: "*According to the WWA's implementation concepts, there is no rethinking, just 'business as usual"*.

- "*Overall, these experiments, conducted at basin, continental, and global scales, use our model toolbox to provide evidence-based insights. The results, shared through dialogues and fact sheets, are helping stakeholders make informed decisions, and I am confident they are paving the way for more integrated governance, even as we refine our approach for diverse contexts"* – Spain CS participant 3.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

5.7. Outlook

This section looks at the future perspectives for the cases and their approaches. With this overview, a broader picture can be made for the overall movement of innovations.

The across-comparison of the respondents' answers shows that, across the cases and thus at the continental scale, there is a consistent **aim to improve and adapt the current innovations**. This prospect is highly dependent on both context and the respondents' role.

The majority of the CSs (5 out of 6), and all the participants who provided elaborated answers to the interviews and surveys outline a future trajectory that involves the further elaboration, or 'extension', of their current activities. In the cases in which the WEFE Nexus is explicitly adopted, respondents specifically mention that a key future objective is to fully implement and operationalise this integrated approach. There is a clear ambition to further advance integrated practices.

Another important connection made is **learning from the experiences, successes, and failures of governance efforts and approaches** to refine and deepen their effectiveness. This is associated with solving existing bottlenecks, which is particularly mentioned in relation to stakeholder involvement and coordination, alongside active participation processes and learning from other cases and contexts. Namely, 5 out of 17 respondents aim to strengthen and widen their approaches and tools in this matter. These findings are illustrated in the following two responses:

- "*The future plan for advancing this innovative governance tool focuses on expanding its functionality and improving the realism of the modelled processes to create a more accurate digital twin. One key area is enhancing the integration of additional sectors, such as energy and ecosystems, to better align with the WEFE nexus. The tool will also continue to incorporate feedback from users to improve its usability and accuracy. Additionally, there are plans to increase its accessibility through wider outreach and training programs to ensure that more stakeholders, including local communities, can actively participate in the decision-making process. Over time, the goal is to refine the platform to address broader water management challenges, ultimately making it a comprehensive tool for more inclusive, transparent, and effective governance*" – Spain CS participant 3.

- *"And so it's somehow you need to be able to listen, to these different social partners who have possibly different aspirations or different needs in terms of the quantity and quality of the water. […] if you're thinking now in different areas of protection or conservation of our natural environment or looking at food, sustainable food systems. Often the questions we think about in the water sector might not be as easily transferable or the language we use might not be so transferable to these different groups of people. One thing we, it we to push us to do is learn how to be able to communicate between these different interest groups, you can say, these different sectors and there different sectors and basically, together, like co-create a plan to together try to come up with a plan which will, which considers the needs of these four of these different areas. [00:13:04] So I think this would be something which we will have to learn. I*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

think there's a lot of what's going on, a lot of learning, a lot of learning, which would be involved" – Malta CS participant 3.

The development of the activities is associated with the emergence of more novel activities, approaches and tools. Ultimately, the depicted iterative pathways of learning and adapting the innovations aim to create future capacities of dealing with and mitigating future socio-climatic hazards and challenges.

6. Critical assessment of the innovativeness

In this section, we critically scrutinise our results, putting them in a broader perspective, discussing implications and recommendations.

6.1. Interpretation in the broader context

This study aimed at assessing to what extent innovative water governance schemes present in Belgium, Germany, Malta, the Netherlands, Slovakia and Spain are effective. To answer this question, we examined the emergence of the innovative governance schemes, stakeholder networks and their perceptions in each of the focus countries and the potential impact of these schemes. Using content analysis, participatory observation, interviews and surveys in the selected countries, we conducted a comparative analysis guided by seven subtopics.

The innovative **governance** approaches/tools **emerged** as a response to socio-environmental challenges and pressures in each of the analysed case studies. Considering the **typology of innovation** utilised by Daniell et al. (2014), the majority of innovations present in the case studies are 'mixed innovations', combining both relational and technical elements. This implies that most innovative approaches, across all relevant scales, include attributes of both reliance on knowledge and expertise, as well as the altering of relationships within the governance domain. The role of conventional governmental actors and institutions is changing, along with the shift to either decentralised, polycentric, or hybrid governance. We distinguished between incremental (building on and blending within longer-established governance systems) and radical (novel and reforming) innovation pathways. The emergence of the idea for innovative governance solutions came in consultation with partners or stakeholders at different levels, including international/EU, national, regional and local grassroots initiatives. The analysis of the six case studies reveals that there is a general shift to polycentric and hybrid forms of governance (Pattberg & Widerberg, 2020). This refers to governance arrangements in which decision-making power and authority are distributed among multiple centres, rather than having a centralised, hierarchical decision-making entity (Ostrom, 2010).

In all case studies, the **participatory and inclusive aspects** and stakeholder engagement mechanisms are integral part of the innovation itself. 10 out of 13 innovations include multi-stakeholder collaborative, informative or connective elements. Water governance authorities and policy practitioners acknowledge the importance of participatory processes. The local actors involved such

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

as agricultural producers, municipal figures and experts also appreciate the policy-practice link. Respondents indicated willingness to increase participation of the agricultural and environmental sectors.

The **issues at stake** in the case studies focus on collaboration for problem solving and bridging the gap between policy and practice. Some of the innovative governance approaches included mechanisms for conflict resolution, mitigation, and prevention among stakeholders.

Barriers and resistance to the implementation of the innovative governance approach/tool are discussed in three out of six cases. The most common barriers in these cases include friction between top-down regulations and local innovation development, connected to the trend of scale interconnections and cooperative settings, economic and financial challenges as well as conflicting perspectives on the innovation.

The identification of how the innovative governance approach/tool interacts and affects already existing **decision-making processes** and whether it coordinates with WEFE sectors proved difficult to identify based on the available data. While some case studies indicate interactive maps and collaborative workshops emerging from the innovative tools, others provide limited information in this regard.

We observe various degrees of **experimentation** with the stakeholder-driven approaches that range from information provision, consultation to co-creation. Two cases mention formalised evaluation mechanisms. Therefore, it can be assumed that there is a lack of reported experimentations with the approaches/tools in question, and consequently, a lack of evaluation mechanisms.

For the **future outlook** for cases and approaches, there is a consistent aim to improve and adapt the current innovations. Elaborations and extensions are planned, also in terms of the implementation of the WEFE nexus. The effectiveness of the approaches is also improved by learning from the experiences, successes, and failures of governance efforts and approaches.

To sum up, we observe that the success rate of the innovation and its efficacy in terms of WEFE nexus indicators vary across case studies. In the two out of six case studies, Netherlands CS, and Slovak CS, the innovations are in the planning phase as of now, making assessing their probability of success difficult.

Further, we highlight the critical perspectives emerging from the analysis of the innovative governance approaches.

To what extent are the analysed solutions innovative?

The innovative character of the approaches is bound to the definition applied in this report. While our definition of 'innovative water governance' is built upon the conceptualisations of innovation, extending to the context of water governance, there is a need to better account for the potential social, environmental, and economic impacts. Future definitions of the innovative governance

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

approaches should include elements such as the role of innovation across different governance levels, sustainability, inclusion of the WEFE nexus or even RETOUCH indicators.

The RETOUCH Nexus case studies present a wide range of innovative governance approaches and tools reflecting a significant degree of innovation as a response to complex environmental, social, and institutional challenges.

All case studies respond to urgent, real-world stressors (e.g. droughts, water scarcity, degraded ecosystems), which are drivers for innovation. Innovations include both technical tools (e.g. drought indices, modelling platforms) and governance mechanisms (e.g. participatory processes, cooperatives). Many innovations reflect WEFE Nexus integration—explicitly or implicitly linking Water, Energy, Food, and Ecosystems. Innovations presented by respondents of the interviews/surveys differ among case studies; we could not identify one approach or tool that would be innovative for all case studies, neither an approach nor a tool that would be applicable to all case studies. Any approach or tool can be innovative under specific circumstances.

The innovativeness of the solution is different in each case study. Belgium CS highlights the innovative use of public-private partnerships and cooperatives for urban sustainability. Germany CS uses model-driven, stakeholder-weighted indicators for adaptive governance. Slovakia CS includes innovative certification, data system and financial instruments integrating soil, water, and carbon governance. Spain CS combines science, policy, and citizen participation in innovative ways and provides a public hydro-economic modelling tool for stakeholder engagement. The Netherland CS brings a participatory process in water governance, previously absent in long-term freshwater planning. The Malta CS includes bringing together stakeholders at the national level, investment approach in socio-environmental science via projects and the integration of pre-existing water governance approaches with more 'modern' ways.

What is the role of actor networks?

Secondly, we observe that in all cases, there are different layers to the innovations. Numerous cases involve reconfiguration of roles and structures of relations, altering roles and relations in the case study, and re-establishing the responsibility and agency of the involved actors. Alongside, we see the large trend of integrated governance approaches and tools. Comparative trend moves towards participation and stakeholder engagement, transversally across scales and sectors. The innovative governance approaches create space for top-down and bottom-up interaction, allowing for ground-level processes and issues to be recognised and integrated into formal governance arrangements. The analysis of the six case studies reveals that there is a general shift to polycentric and hybrid forms of governance. This refers to governance arrangements in which decision-making power and authority are distributed among multiple centres, rather than having a centralised, hierarchical decision-making entity (Ostrom, 2010). The decision-making centres are formally independent of each other but can be regarded as an interdependent system of relations (Ostrom, 2010). In this respect, governance and innovations are becoming increasingly networked.

What is the impact of the analysed governance approaches?

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Participation should be approached adequately in connection with its context for it to be effective. The RETOUCH Nexus case studies make it clear that effective participation is not one-size-fits-all, and its success depends on how well it aligns with the specific context in which it operates. For example, the innovative approach in the Netherlands CS lies in formalising and structuring participation for new challenges (e.g., drought). Participation in Belgium CS is decentralised and community-driven and relies on collective action. In Spain CS, participation occurs within basin authorities.

Uptake level, and employment of effective activities and the achievement of milestones. The uptake level of individual innovations is limited. The case studies demonstrate substantial employment of effective governance activities, including multi-stakeholder platforms and participation (e.g., Belgium CS - basin boards, Slovakia CS - local planning workshops). Knowledge co-production (e.g., Spain's Mohican App, Netherlands CS stakeholder boards). Data-driven planning and modelling tools (e.g., Germany CS indicator framework). Notable milestones achieved include: Operational decentralised water systems in DuCoop and establishment of BoerenNatuur as a functioning intermediary between farmers and nature (Belgium CS), stakeholder-led irrigation boards, and app-based stakeholder modelling (Spain CS), participatory framework developed and piloted; not fully adopted yet, but used for scenario evaluation (Germany CS), participatory boards institutionalised (The Netherlands CS), a certification label for the Carbon and Water Bank, though this program is not implemented yet (Slovakia CS).

The impact of the innovatory trend in the RETOUCH Nexus case studies is signaling a paradigm shift in water governance across Europe and the growing momentum for deeper institutional change. First, the innovations are reshaping governance models - moving from centralized, top-down systems to more polycentric, hybrid, and participatory structures. Second, although explicit WEFE implementation is limited, all case studies express an interest in integrated approaches that follow Nexus thinking. New tools (e.g., Mohican App, indicator frameworks) are helping to bridge the gap between science and policy, making planning more transparent and adaptive. And finally, participation is becoming a core feature, 10 out of 13 innovations include multi-stakeholder mechanisms.

What are horizontal, diagonal, and vertical upscaling opportunities?

Horizontal upscaling is possible for example in case of the decentralised circular water systems that could be replicated in other cities facing similar urban water challenges (Belgium CS), the Mohican App and a public hydro-economic model for water trade-offs can be adopted in other river basins within or outside Spain (Spain CS), or the regenerative agricultural practices could be shared with other farmers, municipalities or regions (Slovakia CS). Diagonal upscaling could lead to an indicator-based framework moving from a regional tool to a cross-sectoral national planning model (Germany CS), or local water retention planning linked to agriculture could be upscaled to national ecosystem service planning, connecting various sectors through the WEFE Nexus (Slovakia CS). Integrating innovations into higher governance levels (vertical) could be achieved in the Netherland CS as the participatory water governance approach could be institutionalized nationally and potentially influence EU water directives.

To what extent are the governance approaches sustainable?

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Most case studies are explicitly aimed at improving long-term environmental outcomes, such as water retention and drought mitigation (Slovakia CS, Spain CS), reduced pollution and decentralised water reuse (Belgium CS), freshwater management under climate change (The Netherlands CS), restoration of aquatic ecosystems (Germany CS). These efforts address climate risks and aim for systemic resilience. The integration of WEFE Nexus thinking enhances environmental sustainability by recognizing interdependencies across water, energy, food, and ecosystems. Innovative approaches require funding and public support, so their economic sustainability and viability are not straightforward. However, new challenges that might emerge in the future can lead to the emergence of other, new innovations.

6.2. Limitations

This comparative analysis is bound by specific limitations. To start, the collection methods were non-uniformly executed, varying between case studies, with a combination of both in-depth interviews and surveys and questionnaires. The mixed-method approach served beneficially as a flexible and context-specific approach, yet it also introduces inconsistencies across the various cases. For example, the survey answers proved to be relatively shorter compared to the interview questions, where the interview tended to stray on other subjects at times. The interview questions were not fully standardised in practice, although the interviewers followed the same guidelines with a set of core questions for consistency. These limitations were considered when drawing cross-case comparisons in the interpretative phases of data analysis.

Another important limitation lies in the selection of innovations addressed in the current report: the selection was primarily steered by the projects and interviewers' primary identification of the innovations, which influenced both the direction of questioning and the answers of the respondents. In certain instances, participants did mention additional innovations; however, it is to note, that the selection of innovation is ultimately steered by the project's and case study leaders' notion and understanding of innovation. This may have resulted in a skewed or partial representation of innovations in water governance at the EU level. Moreover, since some singular innovations were discussed by only one participant, a nuanced depiction of specific approaches/tools is sometimes lacking in the result sections. However, the comparative case-analysis could still be informed based on the collective portrayal of all innovations.

Further, we acknowledge the potential bias of the participants who are interested and supportive of nexus and integrative water management. Given the small sample size, the results should be interpreted with caution and cannot be generalised to the broader population. Finally, due to unforeseen circumstances, the Germany CS and the Malta CS could not be included to the full extent in comparison to other CSs.

7. Conclusion and recommendations

The main aim of this report was to evaluate the effectiveness of innovative governance models in regard to the RETOUCH indicators through a case study-based approach focused on selected countries

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

and local contexts. The analysis explored the emergence of these novel initiatives, their networking dynamics, and their interactions with existing decision-making structures. Their effectiveness was assessed using governance indicators developed in Task 1.3, with particular emphasis on socio-economic and environmental outcomes.

The analysis of the six case studies shows that innovative governance approaches emerged in response to socio-environmental challenges, following either incremental or radical innovation pathways. These solutions were shaped through engagement with stakeholders across multiple levels—from international to grassroots. A clear shift toward polycentric and hybrid governance models was observed, characterised by distributed authority and multi-level collaboration.

Innovations are found present across the EU water governance domain, with the innovative schemes requiring space to deviate from earlier practices to various extents. Removing legal and procedural barriers can facilitate incremental as well as radical innovation pathways, but this requires space for experimentation and evaluation. Participatory approaches were central to the innovations, with the majority of the case studies featuring strong multi-stakeholder elements. Both governance authorities and local actors, such as agricultural producers and municipal representatives, emphasised the value of bridging policy and practice. Many approaches also included mechanisms for conflict resolution and collaborative problem solving, but more attention should be given to the extent of inclusion and diversity of stakeholders. However, implementation faced barriers in several cases, including tensions between top-down regulations and local innovation, financial limitations, and divergent stakeholder views. These challenges underscore the need for supportive frameworks that foster cooperation across scales and sectors. Identifying how innovative governance tools interact with existing decision-making and align with the WEFE nexus was challenging due to limited data. Some case studies highlight tools like interactive maps and workshops, but others lack detail or implemented solutions. Experiments with stakeholder-driven approaches vary from simple information sharing to full co-creation, with only a few using formal evaluation. Looking ahead, there is a shared intention to refine and expand these innovations, particularly to better implement the WEFE nexus. Continuous learning from past experiences is seen as key to increasing effectiveness.

Based on this analysis, we formulate the following **recommendations** for science, policy and practice:

- Context-sensitive innovation pathways should be encouraged, meaning that innovations must not be understood as a one-size-fits-all process but should be approached within they case and needs.
- Systematic and thorough participation and co-creation (both formal and informal), which is fitting to its context, instead of superficial consultation, is beneficial when embedded early in governance design and is effectively integrated in water governance approaches/tools.
- Integrated, flexible and polycentric governance approaches should be supported and established. These could be platforms that bridge and bring together actors across all the WEFE sectors.
- Space for contextual experimentation should be facilitated by experts.
- Evaluation methods for the governance approaches and tools should be improved to ensure effectiveness.
- More attention should be given to on-ground processes and better alignment between top-down institutional settings. Recognition of ‘grassroot innovations is necessary as well.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

- There is a lot of scientific data but this needs to be effectively employed and communicated with stakeholder perspectives.
- Stakeholders' inclusivity and diversity require more attention and sensitivity, through for example strengthening monitoring and evaluation of societal impact and operationalising societal impact, beyond technical efficiency.
- The implementation of nexus approaches and methodologies, such as the WEFE should be further supported or implemented across the scales taking into account different governance levels. In contexts were deemed fitting, the nexus approach can be promoted more explicitly as there is room for improvement across scales and levels.
- The RETOUCH indicators should be considered in the tool/approach assessment procedures. Some case studies are lacking assessment procedures which could benefit from the RETOUCH indicators.
- The role of sustainability should be investigated. More research is needed to fully determine to which the innovative governance approaches can be considered sustainable.
- Further research should focus on the participants perspective and understanding of innovation.
- It is crucial to promote knowledge exchange as many practices and tools. As innovations strongly develop via learning processes a better documentation of outcomes needs to be facilitated and effectively communicated across cases, in order to scale successful practices.

The findings from the case studies offer valuable insights for scaling up these approaches and provide guidance for advancing multi-level, multi-sector water governance frameworks. They are particularly useful for policymakers, researchers and practitioners in the area of water governance. The next phase of this study will explore pathways for implementing innovative and sustainable water governance policies tailored to the diverse contexts and governance baselines of each case study. Recognising the shift toward polycentric and hybrid governance models characterised by distributed authority and multi-level collaboration, this task will focus on designing strategies to overcome identified barriers, such as tensions between top-down regulations and local innovation, financial constraints, and divergent stakeholder perspectives. By leveraging the participatory and inclusive processes central to these innovations, including multi-stakeholder engagement and mechanisms for conflict resolution, the study will propose context-specific frameworks that foster cooperation across scales and sectors. These pathways will aim to bridge policy and practice, enhance socio-economic and environmental outcomes, and ensure the scalability and adaptability of governance approaches to meet the unique needs of each case study's local and regional context.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

References

Bayerisches Landesamt für Statistik (LfS), (2020). [Statistische Berichte–Öffentliche Wasserversorgung und Abwasserversorgung in Bayern 2016]. https://www.statistik.bayern.de/mam/produkte/veroffentlichungen/statistische_berichte/q1100c_201651.pdf

Bayerisches Landesamt für Umwelt (LfU), (2023). [Information about Hydropower in Bavaria]. https://www.lfu.bayern.de/wasser/wasserkraft/ueberblick/index.htm

Berbel, J., & Expósito, A. (2020). The theory and practice of water pricing and cost recovery in the Water Framework Directive. Water Alternatives, 13(3), 659-673.

Berbel, J., & Mateos, L. (2014). Does investment in irrigation technology necessarily generate rebound effects? A simulation analysis based on an agro-economic model. Agricultural Systems, 128, 25-34.

Daigneault, P. M. (2014). Reassessing the concept of policy paradigm: Aligning ontology and methodology in policy studies. Journal of European Public Policy, 21(3), 453–469. https://doi.org/10.1080/13501763.2013.834071

Daniell, K. A., Coombes, P. J., & White, I. (2014). Politics of innovation in multi-level water governance systems. Journal of Hydrology, 519(PC), 2415–2435. https://doi.org/10.1016/j.jhydrol.2014.08.058

David, A. (1996). Structure et dynamique des innovations managériales. https://www.researchgate.net/publication/285767306

Dewar, R. D., & Dutton, J. E. (1986). The Adoption of Radical and Incremental Innovations: An Empirical Analysis. Https://Doi.Org/10.1287/Mnsc.32.11.1422, 32(11), 1422–1433. https://doi.org/10.1287/MNSC.32.11.1422

Di Baldassarre, G., Wanders, N., AghaKouchak, A., Kuil, L., Rangecroft, S., Veldkamp, T. I. E., ... & Van Loon, A. F. (2018). Water shortages worsened by reservoir effects, Nat. Sustain., 1, 617–622.

Eshuis, J., & van Buuren, A. (2014). Innovations in water governance: The importance of time. International Review of Administrative Sciences, 80(2), 401–420. https://doi.org/10.1177/0020852313514518/ASSET/IMAGES/LARGE/10.1177_0020852313514518-FIG2.JPEG

Espa, P., Batalla, R. J., Brignoli, M. L., Crosa, G., Gentili, G., & Quadroni, S. (2019). Tackling reservoir siltation by controlled sediment flushing: Impact on downstream fauna and related management issues. PLoS One, 14(6), e0218822.

Expósito, A., & Berbel, J. (2017). Why is water pricing ineffective for deficit irrigation schemes? A case study in southern Spain. Water resources management, 31, 1047-1059.

Farnault, A., & Leflaive, X. (2024). Cost recovery for water services under the Water Framework Directive. OECD Environment Working Papers.

Halbe, J., Pahl-Wostl, C., Sendzimir, J., & Adamowski, J. (2013). Towards adaptive and integrated management paradigms to meet the challenges of water governance. Water Science and Technology, 67(11), 2651–2660. https://doi.org/10.2166/WST.2013.146

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Huitema, D., & Meijerink, S. (2017). The Generation, Diffusion, and Impact of Innovations in Global Water Governance. Journal of the Southwest, 59, 83–105. https://doi.org/10.1353/jsw.2017.0007

Jacobson, M., Meyer, F., Oia, I., Reddy, P., & Tropp, H. (2013). User's guide on assessing water governance. United Nations Development Programme, Oslo.

Jordan, A., & Huitema, D. (2014). Policy innovation in a changing climate: Sources, patterns and effects. Global Environmental Change, 29, 387–394. https://doi.org/10.1016/J.GLOENVCHA.2014.09.005

Melo Zurita, M., Thomsen, D., Holbrook, N., Smith, T., Lyth, A., Munro, P., De Bruin, A., Seddaiu, G., Roggero, P., Baird, J., Plummer, R., Bullock, R., Collins, K., & Powell, N. (2018). Global Water Governance and Climate Change: Identifying Innovative Arrangements for Adaptive Transformation. Water, 10(1), 29. https://doi.org/10.3390/w10010029

Ostrom, Elinor. 2010. "Beyond Markets and States: Polycentric Governance of Complex Economic Systems." American Economic Review, 100 (3): 641–72.

Pahl-Wostl, C. (2015). A Theory on Water Governance Dynamics (pp. 159–180). https://doi.org/10.1007/978-3-319-21855-7_8

Pahl-Wostl, C. (2017). An Evolutionary Perspective on Water Governance: From Understanding to Transformation. Water Resources Management, 31(10), 2917–2932. https://doi.org/10.1007/S11269-017-1727-1

Pattberg, P., & Widerberg, O. (2020). Global Sustainability Governance: fragmented, orchestrated or polycentric?. *Civitas Europa*, *45*(2), 373-392.

Rogers, P., and A. W. Hall, 2003, Effective Water Governance, vol. 7, Global Water Partnership, Stockholm, Sweden.

Rogers, E. M., Singhal, A., & Quinlan, M. M. (2014). Diffusion of Innovations. An Integrated Approach to Communication Theory and Research, 432–448. https://doi.org/10.4324/9780203887011-36

Rowbottom, J., Graversgaard, M., Wright, I., Dudman, K., Klages, S., Heidecke, C., Surdyk, N., Gourcy, L., Leitão, I. A., Ferreira, A. D., Wuijts, S., Boekhold, S., Doody, D. G., Glavan, M., Cvejić, R., & Velthof, G. (2022). Water governance diversity across Europe: Does legacy generate sticking points in implementing multi-level governance? Journal of Environmental Management, 319, 115598. https://doi.org/10.1016/j.jenvman.2022.115598

Riegels, N., Pulido-Velazquez, M., Doulgeris, C., Sturm, V., Jensen, R., Møller, F., & Bauer-Gottwein, P. (2013). Systems analysis approach to the design of efficient water pricing policies under the EU water framework directive. Journal of Water Resources Planning and Management, 139(5), 574-582.

Schaffhauser, T. (2017). Flood Modelling of the Upper Main with the Soil Water Assessment Tool (SWAT)–Is SWAT applicable for Flood Modelling? [Study Project, Technical University of Munich (TUM)].

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

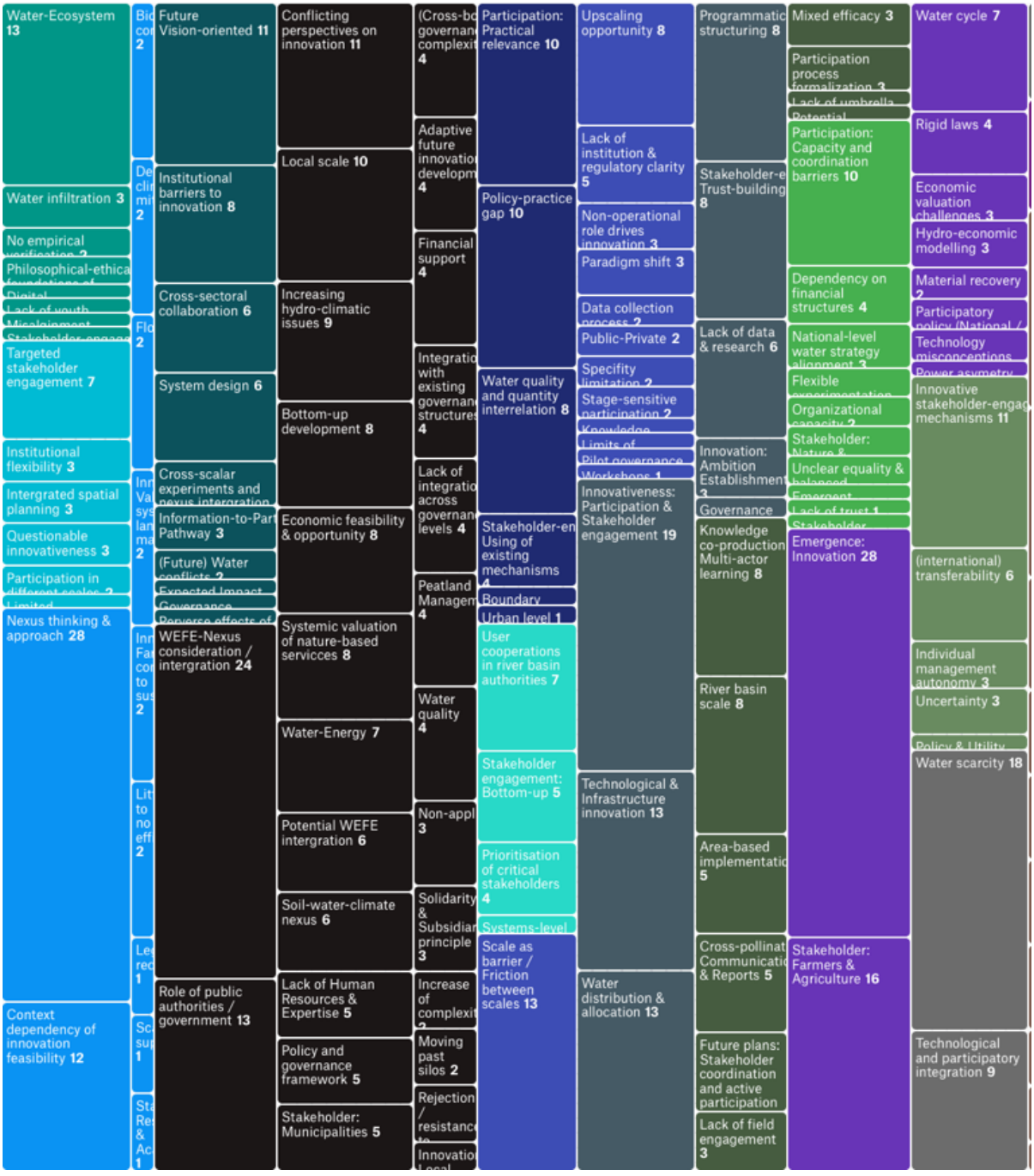
Smajgl, A., Ward, J., & Pluschke, L. (2016). The water–food–energy Nexus – Realising a new paradigm. Journal of Hydrology, 533, 533–540. https://doi.org/10.1016/J.JHYDROL.2015.12.033

Weitz, N., Strambo, C., Kemp-Benedict, E., & Nilsson, M. (2017). Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. Global Environmental Change, 45, 165–173. https://doi.org/10.1016/J.GLOENVCHA.2017.06.006

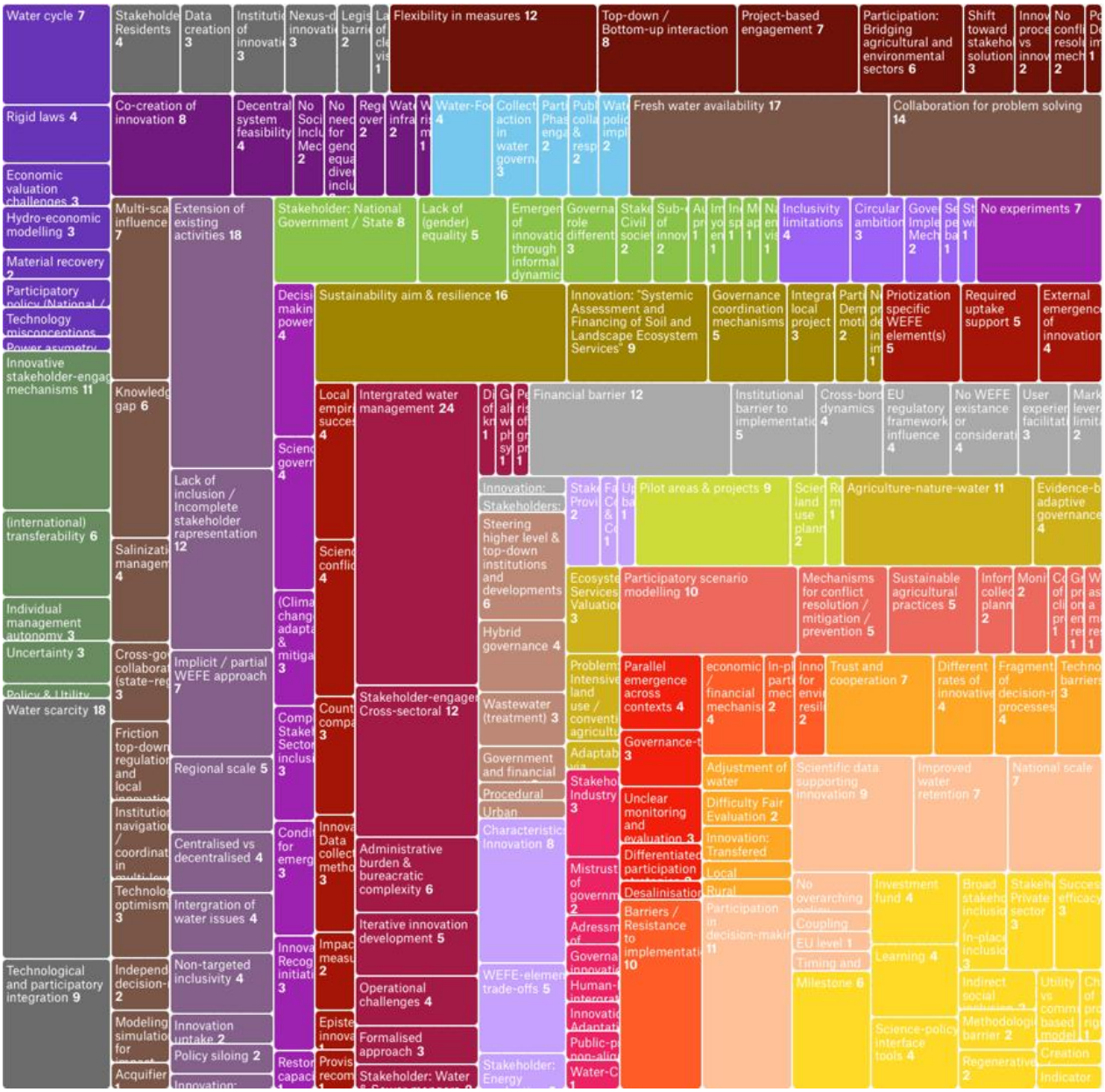
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Appendix

Appendix A. Coding tree distribution used for the data analysis, from Atlas.ti web version



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.