Systematic comparison of cases

GOVAQUA Deliverable 1.4

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Governance innovations for a transition to sustainable and equitable water use in Europe.

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Contents

Summary

The overall goal of the GOVAQUA project is to identify, assess, develop and validate water governance innovations to support and accelerate a transition towards sustainable and equitable water use in Europe. In the four thematic work packages (WPs) of the project, we have been analysing and comparing a small number of cases of water governance innovations: legal and regulatory instruments (WP2), participatory and collaborative approaches (WP3), economic and financial instruments (WP4), and digital solutions for information sharing (WP5).

This report is a deliverable of WP1, which focuses on transitions in water governance. The main objective of WP1 is to define, assess, and develop recommendations for advancing the transition towards sustainable and equitable water governance at multiple levels and across multiple sectors. To reach this objective, we have built a conceptual framework of water transitions, and developed and applied a tool to assess how the broader governance regime affects innovation. With this deliverable, we present a systematic comparison of the four types of water governance innovations studied in WPs 2-5.

Building on the multi-level perspective framework for sustainability transitions, we use six policy intervention points as the conceptual basis for the comparison: stimulating niches, accelerating the niches, destabilising the regime, addressing the broader repercussions of regime destabilisation, coordinating multi-regime interactions, and tilting the landscape. These intervention points function as conditions for a successful transition to sustainable and equitable water use, which are expected to appear in different patterns in different types of governance innovations. We selected 18 cases across Europe and analysed them using data collected through semi-structured interviews with case experts, based on meetings with WP2-5 leads, and document reviews. Then we compared these cases by applying qualitative comparative analysis (QCA), a highly suitable method for our purposes, as it enables addressing causal complexity and interpreting causal patterns.

Our comparative analysis revealed six patterns, which are combinations based on the presence or absence of one or more policy intervention points. We analysed the results in terms of the four innovation types, which depend on different combinations of the policy intervention points. Legal and regulatory innovations depend on how rule changes interact with sectoral coordination and implementation dynamics, whereas participatory and collaborative innovations are most consistently associated with niche stimulation and bottom-up learning processes, and by contrast, economic and digital innovations are more strongly shaped by addressing the broader repercussions. We observe that the presence or absence of policy intervention points varies across individual innovations and innovation types. The intervention points on stimulating niches and addressing broader repercussions appear to be the most associated with successful cases. Reflecting on the hybrid nature of governance innovations, we also observe that many innovations include elements of multiple innovation types, with participation and collaboration appearing in many of the legal-regulatory, economic-financial and digital innovations.

These results are relevant for a broad audience in water governance, including water managers at the local and basin/catchment levels, decision-makers at all levels, and researchers of comparative water governance and transitions. Our next steps in WP1 will be to apply the conceptual framework by synthesising results from the whole project and co-creating transition pathways to achieve the broader policy aims for water governance in Europe. This report contributes to both steps by presenting comparative insights into the four types of governance innovations and by identifying the combinations of conditions for the transition to sustainable and equitable water use in Europe.

1. Introduction

1.1. Comparing governance innovations to accelerate the transition to sustainable and equitable water use in Europe

Europe is aiming to transition to a sustainable and resilient water system (European Commission, 2025). In the last decades, this transition has been supported by the European Water Framework Directive (WFD) with its good water status goals along with various types of implementation measures, including legal or regulatory, participatory or collaborative, economic or financial, and digital approaches (Berbel & Expósito, 2018; Markopoulou & Papakonstantinou, 2021; Newig & Koontz, 2014; Voulvoulis et al., 2017). Despite considerable efforts from different actors, the transition has not been successful to date confirming that water challenges are intertwined with governance challenges (Whaley, 2022). The overall water quality in freshwater bodies has shown only slight improvement compared to 2010 (EEA, 2024), and due to climate change, other challenges, such as water scarcity and droughts, are expected to increase (EEA, 2025).

Water governance innovations have the potential to accelerate a transition to sustainable and equitable water use in Europe. Through the GOVAQUA project, we aim to identify, assess, develop and validate legal and regulatory, participatory and collaborative, economic and financial, and digital innovations to support water governance. The project consists of eight work packages (WPs), four of which analyse and compare a small number of selected cases of water governance innovations with thematic focuses: legal or regulatory instruments (WP2), participatory or collaborative approaches (WP3), economic or financial instruments (WP4), and digital solutions for information sharing (WP5). Each of these WPs covers various governance innovations, for example:

- WP2: instruments for reconciling water uses, implementation of e-flows and regulating value chains and sustainable water footprints;
- WP3: multi-stakeholder collaboration across levels and sectors, empowerment and involvement of citizens, and the engagement of private companies;
- WP4: water markets, tariffs, water pricing and impact investments;
- WP5: open data initiatives and tools supporting data generation, enabling data sharing and the improvement of decision-making and governance.

GOVAQUA further houses six Living Labs (WP6) in diverse geographical contexts and governance arrangements in various locations in Europe: Crau Aquifer in France, Archipelago Sea Basin in Finland, Axarquía Region in Spain, River Thames in the UK, Nordic Hydropower in Finland and Sweden, and the Dunavăț Region in the Danube delta, Romania. Through the Living Labs, a representative and complementary set of innovations is explored, experimented with, and evaluated by key stakeholders and experts. Examples of innovations developed within the Living Labs include water markets, water stewardship and innovative financing mechanisms, water user participation, citizen science, and drought management plans, among others.

This report is a deliverable of WP1, which focuses on transitions in water governance, and presents a systematic comparison of water governance innovations. The positioning of WP1 and its links within the overall framework of the GOVAQUA project are illustrated in Figure 1. The main objective of WP1 is to define, assess and develop recommendations for the advancement of the transition towards sustainable and equitable water governance at multiple levels and across multiple sectors. We adapt the highly-cited definition of Rogers & Hall, (2003, p. 16) of water governance: "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"; and complement it with environmental protection and cover also governance systems beyond the traditional water sector, i.e., sectors with major direct or indirect water use or impacts.

Sustainable and equitable water governance enables a normative goal of water transitions when looking at its use. We understand sustainable water use as "the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it" (Gleick, 2000, p. 131). Equitable water use refers to a fair water allocation from a societal perspective, which goes beyond environmental sustainability and resource efficiency (Hoekstra, 2014).

To reach the objective of WP1, we 1) built a conceptual framework of water transitions (D1.1), 2) developed and applied a tool for assessing how the broader governance regime affects innovative approaches (D1.2 and D1.3), 3) systematically compare innovative approaches (D1.4), 4) synthesise the results from the whole project (D1.5), and 5) co-create transition pathways to reach the broader policy aims (D1.6). This report addresses the third step. It presents a systematic comparison of 18 cases of governance innovations, considering both multiple types of governance innovations and the multiple factors that affect the success of innovations in achieving sustainable and equitable water use.

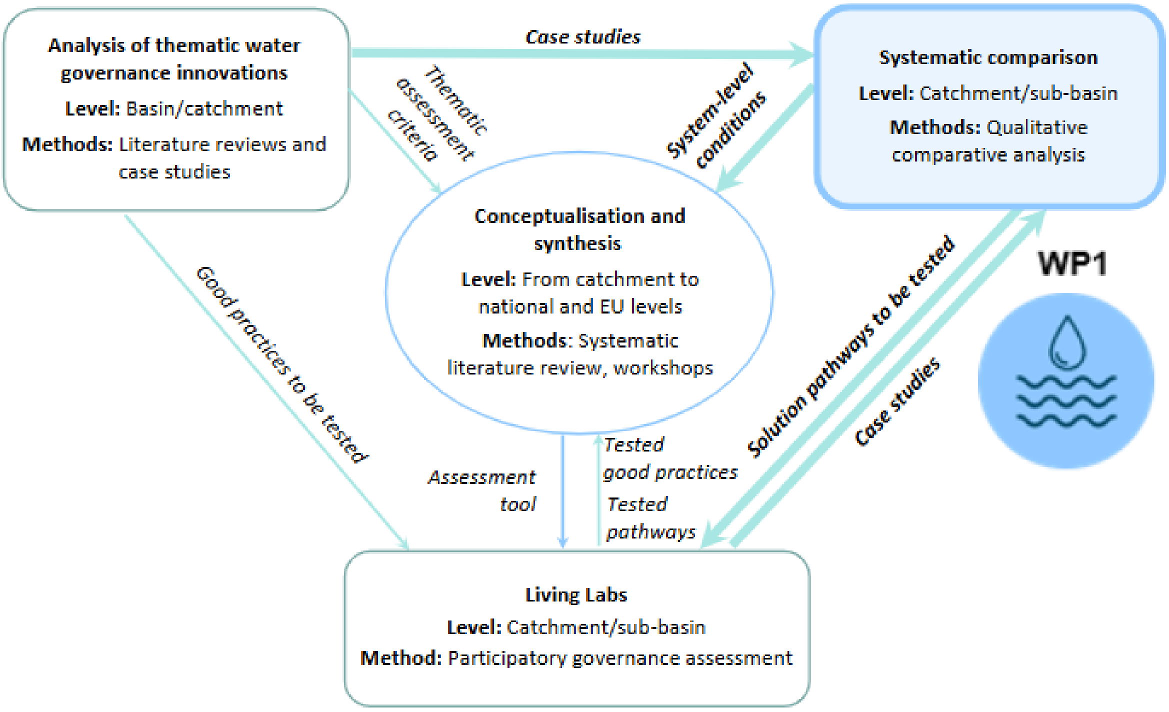

Figure 1. Positioning of the systematic comparison of cases in the overall framework of the GOVAQUA project.

1.2. Towards sustainable and equitable water use in Europe

Currently, we consider that there are three factors that limit our understanding of European water governance innovations and policy interventions:

- **Limited inclusion of economic, financial and information-related factors in comparative water governance research:** Comparisons of water governance often have a narrow focus, mainly on law and policy or public participation, while economic, financial and information-related factors are rarely included (Özerol et al., 2018).
- **Limited scope for generalisation and future-oriented insights in water governance research:** Small number of cases and retrospective case studies remain the most common research methods, offering limited scope for generalisation and for analysing future scenarios, both in water governance research (Özerol et al., 2018) and in sustainability transitions studies (Kanger et al., 2020).
- **Restricted thematic focus of water governance transition studies:** Studies on water governance transitions are often limited to a socio-technical framing of urban water management issues, such as stormwater and greywater management, flood governance, port development, or water utilities (de Haan et al., 2015; Ferguson et al., 2013; Wong & Brown, 2009).

These gaps can be partially attributed to the water sector's notorious resistance to change, which undermines the possibility of a system-level transition (Fuenfschilling & Truffer, 2016; Molle et al., 2009), and the fact that sustainability transitions scholarship has primarily focused on the technological dimensions (Geels, 2019; Mintrom & Rogers, 2022; Røpke, 2016). We bridge these gaps by using a transition approach as the theoretical basis and by conducting a comparative analysis of how policy intervention points have supported water governance innovations in transitioning to a more sustainable and equitable water use in Europe. We define water governance innovations as *instruments, approaches and arrangements that have the potential to accelerate a transition to sustainable and equitable water use in Europe*. These innovations include legal reforms (Belinskij et al., 2019), cross-sectoral collaborations (Cialdea & Pompei, 2022), market mechanisms (Berbel & Expósito, 2020), and information technologies (Amador-Castro et al., 2024).

Due to its alignment with the objective of this research, we selected the framework of policy intervention points developed by Kanger et al. (2020) as our conceptual base to assess water governance innovations. The framework identifies six policy intervention points in section 2 at three different levels for innovations: niche, regime, and landscape (Kanger, 2021). The intervention points can provide a systematic way to understand the transition of the four governance innovations: 1) legal and regulatory, 2) participatory and collaborative, 3) economic and financial and 4) digital solutions for information sharing, towards a sustainable and equitable water use in Europe. The selected framework is applied to 18 European cases in which at least one of the four types of governance innovations is present, using a Qualitative Comparative Analysis (QCA) (Rihoux & Ragin, 2009). In this comparative approach, we ask the following research question: **What (combinations of) policy intervention points in governance innovations are associated with a transition toward sustainable and equitable water use in Europe**? By using QCA and systematically comparing different innovation types, we can associate the (un)successful transitions to sustainable and equitable water use with different (combinations of) policy intervention points. Our hypothesis is that for an innovation to facilitate a transition to sustainable and equitable water use, it must be facilitated by one or more policy intervention points.

The remaining chapters of the report are organised as follows: Section 2 elaborates on the selected theoretical framework to answer our research question. Section 3 explains our methodological approach. Section 4 presents the results, and Section 5 presents our discussion and conclusion.

2. Policy intervention points as conditions for sustainable and equitable water use

The theoretical approach of GOVAQUA is informed by sustainability transitions research, and particularly for the comparative analyses of cases by the role of multi-level factors in advancing governance transitions across geographical and political contexts (Köhler, 2019). The literature distinguishes the need to coordinate change by focusing on specific and often local niche innovations, developments within established policy regimes and leveraging broader landscape-level changes to advance to more sustainable socio-technical, socio-ecological and socio-economic systems (Loorbach et al., 2017;Köhler et al., 2019). For the purposes of the GOVAQUA case study analyses, we use the notion of **policy intervention points**, which are particular conditions in which a policy is applied and are central to advancing a more sustainable system (Kanger et al., 2020). By focusing on these governance conditions, the case studies can reveal commonalities and patterns of the role of different policy interventions for sustainable water governance transitions in Europe.

The policy intervention points approach has a key benefit: it is not tied to a single form of innovation, but instead enables the study of different technological, societal, and political interventions. The QCA complements the approach by focusing on generalisable commonalities and patterns related to innovative cases. The framework is informed by the so-called Multi-level Perspective (MLP) heuristic, which distinguishes systemic change into three main levels of system change, development and stimulation of sustainable innovations in **niche level**, overcoming unsustainable practices, technologies and policies of existing **regime level**, and developing broader societal pressure for change in the **landscape level** (Kanger et al., 2020) (Figure 2). The main benefit of the MLP is that it reveals the complexity of transitions, as often individual interventions fall short of supporting water governance transitions.

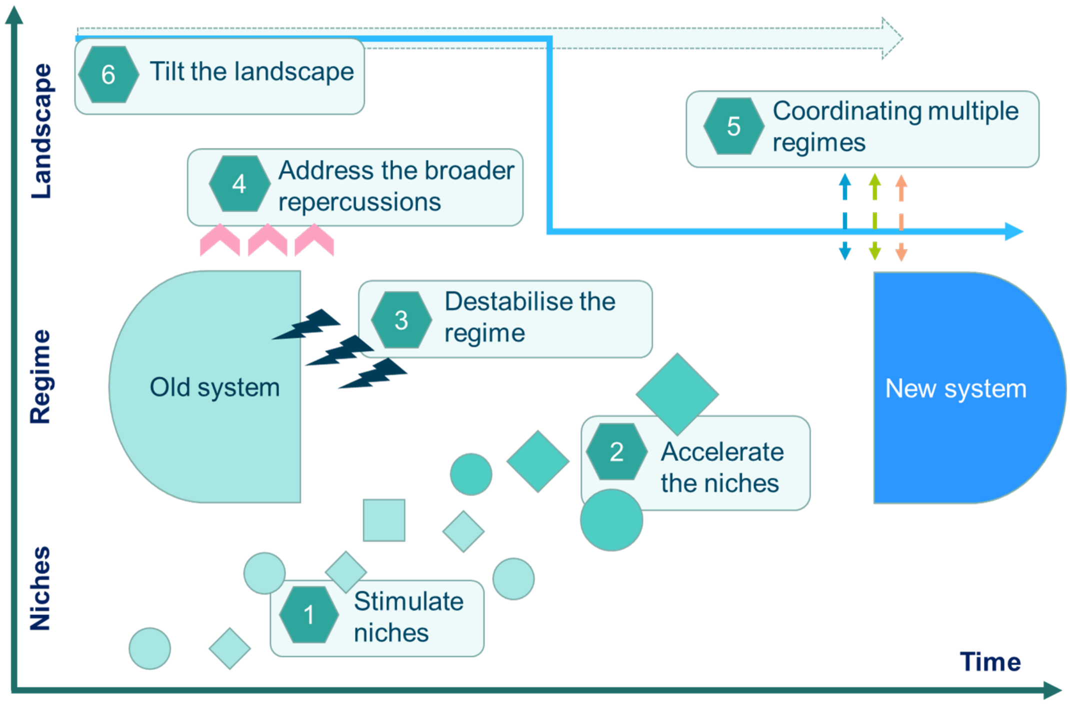

Figure 2. Six policy intervention points (Kanger et al., 2020)

The six intervention points taken as a starting point of our evaluation are as follows: (1) *Stimulating niches* reveals whether the context of innovations, such as Living-Labs, is supportive of sustainable and equitable innovations, (2) *accelerating the niches* discusses on conditions enabling to expand or multiply good governance innovations, (3) *destabilising the regime (current system)* focuses on measures to remove unsustainable and transition-hindering elements of the existing regimes, (4) *addressing the broader repercussions of regime destabilisation* shows whether there are conditions in place to explicitly address sustainability and equitability of water governance transitions, (5) *coordinating multi-regime interactions* reveals whether the governance conditions enable interaction and alignment between interconnected sectors, and (6) *tilting the landscape* focuses on the role of broader conditions, such as framework policies or societal pressures, in advancing the governance innovations. The main contribution of intervention points is in revealing how the conditions for the water governance transitions are emergent and contextually different, thus enabling drawing patterns of how the enabling and hindering conditions for transitions appear differently in the different kinds of innovation cases.

Collectively, the policy interventions are aimed to support a systemic change. In the case of water transitions, the intervention points in this project are understood as follows:

1. **Stimulating niches.** Involves supporting different emerging alternatives through different types of measures such as R&D funding schemes, foresight exercises to create future visions, or innovative decentralised practices for e.g. wastewater treatment, rainwater or water reuse.
2. **Accelerating the niches.** Focuses on helping innovations to scale up or accelerate. This can be done with platforms to share innovations, water innovation hubs, support for entering markets, and advice programs for water utilities, the agricultural and industrial sectors.
3. **Destabilising the regime**. Innovations can involve weakening of the old system, and this can happen by making the older system less attractive or more difficult to maintain. For example, creating taxes (higher water tariffs), banning specific technologies and practices, reducing subsidies, or involving experienced people, experts/consultants who can provide innovative ideas.
4. **Addressing the broader repercussions of regime destabilisation**. Systems are not in isolation; even the weakened old system is linked to infrastructure, local economies and cultural identity. For the water sector, this can be achieved via the utilisation of open data, data accessibility, financial and/or educational support, or facilitating regional diversification of industrial and/or agricultural activities.
5. **Coordinating multi-regime interactions**. Since systems are interconnected, they reinforce each other and, therefore, require coordinated interventions. This can be done by aligning policies among agricultural, industrial, energy and water service systems and urban planning, which can be at (sub-)basin, regional and national levels.
6. **Tilting the landscape**. Transitions can also be influenced by high-level frameworks that can change conditions across regimes. Some examples include the European frameworks, which serve as binding agreements for changing water management practices, such as the European Water Framework Directive or at the international level, the Sustainable Development Goals.

In the following systematic comparison of cases, the policy intervention points provide analytical lenses for several issues. First, they help us identify what the recurring positive policy conditions are in the water governance innovation cases in different geographical areas and different types of innovations. This should, in principle, help coordinate governance activities by utilising the appropriate governance practices more broadly. Second, they reveal the missing and hindering policy conditions, which help understand why there are constraints considering water governance sustainability and equity in different governance contexts. Combined with the QCA approach, this will provide patterns (a combination of policy interventions) that could enable more sustainable and equitable water use.

3. Qualitative comparative analysis: a methodology for comparing governance innovations

3.1. Description of QCA in the context of water governance

To answer our comparative research question (See Section 1), we selected a QCA approach. Generally speaking, QCA combines the strengths or qualitative, case-oriented and quantitative, variable-oriented approaches (Rihoux, 2006). It was selected since it is a highly suitable method for identifying patterns across a medium to large number of cases where causal complexity is likely. Causal complexity implies that 1) the same outcome may be explained by different patterns, 2) the focus is not on individual factors but on how they are combined and 3) whether an outcome is present or absent requires separate analyses (Schneider and Wagemann, 2012). As such, QCA does not assume correlation or simple causation but a set-theoretic relation. In other words, cases are seen through the lens of “a set with certain attributes”, which is also referred to as a configuration (Pahl-Wostl et al., 2021).

Our methodological choices are inspired by a systematic review of water governance studies that employ QCA. For this review, we used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), a protocol that provides a structure for how systematic reviews and meta-analyses should be documented and reported to ensure transparency (See Annex 1 for details). Through the review, we identified 31 scientific articles that employed QCA to study water governance. Geographically, the compared cases are mostly located in China (9), India (8), the Netherlands (8), Spain (7), and South Africa (7). We found that the most common number of cases compared was 20 across three papers (Busscher et al., 2019; Chai & Schoon, 2016; Cui & Yi, 2020), while the minimum number of cases was 8 (Huntjens et al., 2011), and the highest was 248 (Shin, 2022). Based on this finding, we aimed for a selection of cases within such a range.

To ensure ethical data collection and processing, the interview process and guide were developed in accordance with the project data management plan (D8.4) before contacting potential interviewees. We provided participants with information about the project, the interview process, including how their data would be used, and offered them the chance to withdraw at any time. Interviews, lasting around 60 minutes, were conducted online via Microsoft Teams.

Data collection for each case study followed a semi-structured interview protocol with an expert or stakeholder who led the implementation of water governance innovation. The 18 interviews (Section 3.2) were conducted online and lasted approximately one hour. To facilitate the data collection, these were recorded and transcribed. The interviews were supported by a questionnaire (see Annex 2) that focused on assessing whether the innovation was successful in terms of ecological sustainability and equitable water management and structured around the six policy intervention points.

We considered an innovation successful when it contributed to improving water quality (ecological sustainability) and fair allocation of water (equitable water use). When this is the case, the outcome is (mostly) present in the QCA. When an innovation did not contribute to improving sustainable and equitable water use, the outcome is (mostly) absent. In QCA, the analysis of the absence of the outcome is referred to as an analysis of the “negated” outcome. Each policy intervention point was regarded as a condition. The analysis focused on whether the absence or presence of policy intervention points can be associated with the absence of presence of the outcome. In theoretical terms, the analysis identified logically simplified statements that associate the presence or absence of (combinations of) conditions with the presence or absence of the outcome (Pappas & Woodside, 2021).

In practical terms, QCA involves running an algorithm that studies relations between conditions and outcomes. Through an analysis of sub-sets, super-sets, unions, and intersections, the necessity and sufficiency of conditions can be identified (Schneider & Wagemann, 2010). A **necessary condition** refers to a compulsory, basic requirement: if the outcome occurs, this condition must always be present. Meanwhile, **a sufficient condition** does not need to be present in every successful case. Yet, when present, it guarantees the outcome. Therefore, QCA helps us understand the policy interventions present in successful water governance innovations, as well as their configurations (combination of policy interventions).

Within the QCA methodology, there are three main types of analysis: 1) Crisp set, 2) Fuzzy set and 3) Multi-value (Pappas & Woodside, 2021). We have selected fuzzy-set QCA (fsQCA) because it allows cases to be compared based on their degree of membership in conceptually defined sets, rather than treating conditions and outcomes as simple yes/no variables. In fsQCA, both conditions and outcomes are understood as sets (for example, the set of cases with a strong policy impact), and each case can belong to these sets to different degrees. This membership is expressed on a continuum ranging from 0 (full non-membership) to 1 (full membership), with intermediate values (e.g. 0.8 or 0.3) capturing partial or weak membership. This approach makes fsQCA particularly suitable for analysing nuanced and complex concepts, such as the degree to which policy interventions contribute to sustainable and equitable water use, where clear-cut thresholds are rarely appropriate. This flexibility makes fuzzy-set analysis particularly useful for representing nuanced or "fuzzy" concepts, such as the degree of impact (Cronqvist & Berg-Schlosser, 2009) of policy interventions towards a sustainable and equitable water use in Europe. The choice of fsQCA is also supported by our systematic literature review, which found that it is the most commonly employed QCA approach in water governance research. This is understandable since water governance processes are complex, outcomes are not dichotomous, and the scale allows for nuances.

3.2. Case selection

The selection of cases was based on a review of cases and good practices conducted in GOVAQUA on legal and regulatory approaches (GOVAQUA D2.1 and D2.2), participatory and collaborative approaches (GOVAQUA D3.1 and MS10), economic and financial instruments (GOVAQUA D4.1 and D.2) and digital solutions for information sharing (GOVAQUA D5.1 and D5.2). The selected cases are distinguishable in advancing equitable and sustainable water use in Europe through innovative approaches. A good water governance practice exemplifies an innovative instrument, approach or arrangement that contributes to achieving water-related policy goals and targets sustainably and equitably. As mentioned in Section 2, we distinguish between four types of innovations, which are aligned with the thematic focuses of GOVAQUA: 1) Legal or regulatory (WP2), 2) Participatory or collaborative (WP3), 3) Economic or financial (WP4), and 4) Digital (WP5). Each governance innovation has been tested in practice, assessed and validated by stakeholders and independent evaluators in a specific context against specific principles and criteria.

Cases were initially identified through comprehensive thematic reviews conducted across the GOVAQUA project work packages. These reviews produced a broad pool of governance innovations that were potentially relevant to the project's analytical focus. At this stage, the objective was to identify candidate cases rather than to finalise the sample.

In a subsequent step, meetings were scheduled with Work Package (WP) leaders to discuss and refine the list of potential cases emerging from the thematic reviews and good practices. These meetings focused on identifying which governance innovations should be considered for inclusion, based on their relevance, maturity, and empirical richness. WP leaders also facilitated contact with experts, practitioners or stakeholders whom they considered most suitable to participate in the case-level semi-structured interviews, given their direct involvement and knowledge of the innovation. The final selection of cases was made in close collaboration with the international expert groups involved in the different WPs.

The interviewees were primarily with experts, practitioners or stakeholders directly involved in the governance innovations under study. Based on GOVAQUA experts' knowledge one person was selected as the representant for the case. The interviews provided essential contextual detail and clarification of implementation processes that are typically not available through document analysis alone. This process resulted in a final selection of 18 cases (see Table 1), consistent with the number of cases commonly used in fsQCA studies of water governance. The sample includes four legal or regulatory innovations (L1–L4), four economic or financial innovations (E1–E4), six participatory or collaborative innovations (P1–P6), and four digital innovations (D1–D4). Table 1 provides a description of each case.

Table 1. Selected governance innovation cases for QCA

Code	Case name	Location	Innovation type	Description
L1	Prioritisation of ecological minimum flows	Austria	Legal or regulatory	A prioritisation strategy to implement measures for the ecological flows, considering the hydropower sector.
L2	User based allocation in collective irrigation	France	Legal or regulatory	A nationwide regulation introduced to manage the collective use of irrigation across hydrological boundaries.
L3	International Water Stewardship Standard	European industry	Legal or regulatory	Private site-level standard and certification system for companies.
L4	Water National Decree to address water imbalances	France	Legal or regulatory	A national water decree operationalized at the basin level to address water imbalances.
E1	Water bank to address aquifer overexploitation	Tablas de Daimel, Spain	Economic or financial	The creation of a water bank to address the overexploitation of aquifers in the area.
E2	Water bank to address water scarcity	Guadiana River, Spain	Economic or financial	A water bank created to address water scarcity issues.
E3	Water pricing to address water overextraction	Italy	Economic or financial	A regional innovation designed to address over-extraction of water from the agricultural sector.
E4	Private payment for environmental services	Aquas De Vittel, Spain, France	Economic or financial	Provision of private financial subsidies to farmers to improve water quality.
P1	Watershed vision to reconcile water uses	Oulujoki River, Finland	Participatory or collaborative	An extensive stakeholder collaboration to reconcile various water uses and develop a shared vision and goals for the river basin.
P2	Water council to address pollution	Sweden	Participatory or collaborative	Establishment of a water council to improve the participation and collaboration of different actors to address pollution issues.
P3	River catchment partnerships to enhance water quality	England	Participatory or collaborative	Partnerships developed around the river catchment approach in England to enhance the quality of water.
P4	Watershed vision for water quality improvement	Iijoki River, Finland	Participatory or collaborative	An extended collaboration of different stakeholders to improve water quality and for environmental restoration.
P5	Local community participation to improve water access	Romania	Participatory or collaborative	Innovative approach led by the local community to improve the aquatic ecosystem and access to water.
P6	Citizen involvement in water planning	France	Participatory or collaborative	A citizen engagement process for water planning aimed at reducing water consumption and incorporating local voices.
D1	Monitoring network for water management	Italy	Digital	Monitoring network of hydrology and rainfall for water management and to determine how to use water effectively.
D2	Online data package for catchment-based approach	England	Digital	Development of an online data package (200 different digital layers with info about water and land) to support a catchment base approach
D3	WWF Water Risk Filter	European industry	Digital	A tool that gives free access to companies to assesses three types of water-related risks: physical, regulatory, and reputational.
D4	GIS-based tools for understanding water demand	Spain	Digital	Digitalisation of information to understand users' water demand and satisfy them with alternative water resources employing integrated infrastructure.

3.3. Analysis of the cases using fsQCA

For our analysis, we conceptualised each of the six policy intervention points as a potentially relevant condition for advancing sustainable water governance transition: niche stimulation (C1), niche acceleration (C2), regime reform (C3), addressing repercussion (C4), coordinating multiple regimes (C5), and landscape-level pressure (C6). If present, interviewees were asked to score each policy intervention point on a Likert scale from 6 to 10 (See interview questionnaire in Annex 2). The interview transcripts served as the primary basis for assessing the extent to which the intervention points were present in practice. To assess the outcomes of the innovations, interviewees were asked to rate, using a Likert scale, the extent to which the innovation was successful in terms of 1) ecological sustainability and 2) equitable water management. As the cases showed limited variation across these two dimensions, we used the average of the two scores to determine each case's overall outcome score (See Annex 3, Table A3.1). Data values for conditions and outcomes were transformed into values between 0 and 1 (Table 2).

Table 2 – Data matrix showing how the cases (Table 1) score on the conditions, the six policy intervention points (C1-C6) and on the outcome of interest, sustainable and equitable water use (O). Cells with relatively low scores (<0.5) are shaded red and cells with relatively high scores are shaded green (>0.5). In the outcome column of the table, based on the QCA, there are three cases that despite being innovative are not considered successful as the resulting outcome was lower than .6. These cases are L2, E3, and P3.

Table 2. Data matrix showing how the cases score on the conditions.

Innovation type	Case code	C1. Niche stimulation	C2. Niche acceleration	C3. Regime reform	C4. Addressing repercu-ssions	C5. Coordinating multiple regimes	C6. Landscape-level pressure	Outcome
Legal or regulatory	L1	0	0.8	0.6	0	0.8	0.8	0.6
	L2	0	1	0.8	0.8	0.8	0.6	0.4
	L3	0.6	1	0	0	0	0.4	0.6
	L4	0	0	1	1	0	1	0.6
Economic or financial	E1	0	0	0.2	1	0	0.6	1
	E2	0	0	0.8	0.6	0	0	0.6
	E3	0	0	0.8	0	0	0.4	0.2
	E4	0	1	1	1	0	0	0.9
Participatory or collaborative	P1	1	0	1	0	0.2	0	0.6
	P2	0.8	0.8	0.6	0.8	0	0.8	0.6
	P3	0	0.4	0	0	0	0.8	0.3
	P4	1	0	1	1	0	0.6	0.7
	P5	1	0	0	0.6	0	1	0.8
	P6	1	0.4	1	0.4	0	0.4	0.9
Digital	D1	0.2	1	0	1	0	1	0.6
	D2	0	0.2	0	0.6	0.4	0.4	0.6
	D3	1	1	0.6	0.6	0	0.8	0.85
	D4	0.6	0	0	0	0	0	0.7

The data matrix was analysed using QCA package (Duşa, 2019) and the SetMethods package (Oana & Schneider, 2018) in RStudio. First, we verified whether any condition or any combination of conditions (superset) was necessary for the outcome. This is the case when the condition always has a higher score than the outcome; in other words, it is a superset of the outcome. We concluded that this was not the case. Next, we conducted an analysis of sufficiency. This analysis aims to identify (combinations of) conditions that are always present when the outcome occurs, but the outcome can also occur without them. For this analysis, we first created a so-called “truth table” that lists all logically possible combinations of conditions (with 6 conditions, $2^6 = 64$ configurations are logically possible). This truth table (Annex 3 Table A3.2) is then used to investigate which combinations of conditions are sufficient for the outcome to occur.

In the sufficiency analysis, the software basically assists with identifying what combinations of conditions can be associated with an outcome. A typical result of the analysis is that one pattern of conditions is associated with a successful outcome for one group of cases and another pattern for another group of cases. These patterns jointly make up a so-called solution. QCA software can identify different types of solutions. The most conservative solution is usually more complex as it includes more solutions and more conditions. It is calculated by only considering the empirically observed patterns and is in this sense conservative. In addition, the software can calculate the most parsimonious solution. To create this solution, the software makes assumptions to overcome the problem of “limited diversity”, i.e. not all 64 configurations that are theoretically possible are observed in practice with 18 cases only. The parsimonious solution serves as the basis for the results section. In contrast to the complex solution, it also considers configurations that are not empirically observed and usually include fewer conditions.

In most analyses, researchers also include an intermediate solution that is based on theoretical expectations about the absence or presence of conditions. In our study, we do not have such “directional expectations” since we expect that the presence of the outcome is unlikely to be associated with the presence of all conditions. Rather, we expect that when one condition is absent (indicated with ~C), another one needs to be present (indicated with C). The QCA is meant to reveal such combinations. We repeated the same analyses for the negated outcome (i.e. the absence of sustainable and equitable water use). Throughout the analysis, we applied consistency and coverage thresholds as suggested by Schneider & Wagemann (2010). Annex 3 provides detailed information about all steps of the analysis, including how data were transformed into values between 0 and 1, the truth table, threshold values that were applied, and conservative and parsimonious solutions.

4. Results of the comparative analysis

This section presents the results of our systematic comparison of 18 governance innovations implemented in Europe. The section is divided into three parts. First, we provide an overview of the patterns identified through a systematic comparison of all cases, providing a general outline. Next, the results are clustered by innovation type. Finally, we analyse the role and relevance of each policy intervention point with reference to relevant cases.

4.1. Patterns identified through systematic comparison

We systematically compared the cases to identify whether specific combinations of the six intervention points (Section 2) are associated with certain outcomes. In this analysis, these combinations are referred to as patterns, meaning recurring configurations of intervention points observed across cases. Table 3 presents the synthesis of identified patterns, including cases that match each of them.

Four of these patterns are associated with successful governance innovations, defined here as contributing to more sustainable and equitable water use, while two patterns are associated with unsuccessful outcomes. The most common pattern is niche innovation stimulation (eight cases), where policy support and protection of innovations is an explanatory condition for good outcomes (pattern 1). Moreover, the presence of adaptive governance to address broader repercussions related to equity and justice in the water governance innovations was sufficient with the absence of regime reform (pattern 2) or landscape-level pressure (pattern 3). One legal case is explained by the presence of regime reform and landscape-level pressure combined with the absence of adaptive governance measures to address wider repercussions (pattern 4). On the one hand, the absence of several intervention points provided conditions for successful governance innovations (pattern 5), while on the other, the absence of niche stimulation was combined with a strong focus on other intervention points (pattern 6). Additionally, from a QCA perspective, the legal case, of Water National Decree to address water imbalances (L4), could not be analysed as it was inconsistent with the rest of the data (For more information, see Analysis on Sufficiency in Annex 3, subsection 3.4) .

Table 3. Synthesis of identified patterns (parsimonious solution in fsQCA)

Pattern	Outcome	Policy intervention points associated with the outcome	Legal or regulatory innovations	Economic or financial innovation	Participatory or collaborative innovations	Digital innovations
1	Present	Presence of niche innovation stimulation (C1)	International Water Stewardship Standard (L3)		Watershed visions to reconcile water uses and to improve water quality (P1, P4), Water council to address pollution (P2), Local community participation to improve water access (P5), Citizen involvement in water planning (P6)	WWF Water Risk Filter (D3), GIS-based tools for understanding water demand (D4)
2	Present	Presence of adaptive governance (C4) and absence of regime reform (~C3)		Water bank to address aquifer overexploitation (E1)	Local community participation to improve water access (P5)	Monitoring network for water management (D1), Online data package for catchment-based approach (D2)
3	Present	Presence of adaptive governance (C4) and absence of landscape pressure (~C6)		Water bank to address water scarcity (E2), Private payment for environmental services (E4)		Online data package for catchment-based approach (D2)
4	Present	Presence of regime reform (C3) and landscape pressure (C6) and absence of addressing repercussions (~C4)	Prioritisation of ecological minimum flows (L1)			
5	Absent	Absence of niche innovation stimulation (~C1) and acceleration (~C2) and addressing repercussions (~C4)		Water pricing to address water overextraction (E3)	River catchment partnerships to enhance water quality (P3)	
6	Absent	Absence of niche innovation stimulation (~C1) and presence of four other policy intervention points (C2, C3, C4 and C6)	User based allocation in collective irrigation (L2)			
	NA	Not included in analysis of sufficiency	Water National Decree to address water imbalances (L4)			

* the presence of a condition indicated as C and the absence as ~C, cases with multiple explanations are underlined

4.2. Comparison with respect to innovation types

This section presents the results by grouping the 18 cases according to the four innovation types: 1) Legal or regulatory, 2) Participatory or collaborative, 3) Economic or financial, and 4) Digital. Rather than assuming that all governance innovations follow a uniform causal logic, the analysis traces how the same policy intervention points support different configurations across the governance innovation. This approach makes visible how different interventions drive success depending on the innovation's context.

4.2.1. Legal or regulatory innovations

According to the QCA analysis, the legal or regulatory innovations gain quite low outcome scores in terms of advancing the water governance transition. They also show a high variety. However, there are also several interesting insights related to innovation dynamics. The Alliance for Water Stewardship International **Water Stewardship Standard** (L3) demonstrates that niche stimulation can be associated with the successful outcomes in legal-regulatory settings without destabilising established institutions – rather, they can support existing policy implementation. By contrast, the case of **ecological minimum flows** in Austria (L1) succeeds despite moderate regime destabilisation, reinforcing a selective reform pattern: targeted rule change can work, though it is not typical among the successful cases. The success can be associated with the joint local collaborations and the disruption that the reform created to align the energy and water sectors.

The failed performance of **collective irrigation** in France (L2) highlights the limits of relying on coordination or reform alone. While the case scores high on multi-regime coordination, it registers a low outcome score, suggesting that extensive institutional alignment does not guarantee success without complementary mechanisms for addressing repercussions or niche stimulation. The **water decree** in France (L4) is a special case as it could not be explained through the QCA. While this case seems very unique, a closer inspection reveals that it's similar to one of the economic cases, the **water bank** in Spain (E2). Yet, the water decree has a high score on the intervention point on tilting the landscape, while the water bank does not. In combination with high scores on regime reform and addressing broader repercussions, these policy intervention points seem to explain the relative success of this case.

Across legal-regulatory cases, the results indicate that innovation success is more likely when rule changes support, rather than destabilise, ongoing governance arrangements, unless radical regime change is capable of coordinating sectors and includes local aspects.

4.2.2. Economic or financial innovations

Successful cases in this category, such as **water banks** (E1 and E2) and **payments for environmental services** (E4) in Spain, suggest that for this innovation type, the intervention point on addressing repercussions is more important than niche stimulation. Economic instruments work when actors plan for how new incentives (monetary and non-monetary) affect existing water rights, budgets, and behavioural norms. These innovations focus less on experimentation and more on embedding financial designs within existing rules.

Economic cases vary in niche acceleration and regime destabilisation; yet these intervention points are rarely decisive. As shown by the analysed cases, water banks can succeed despite different values on acceleration, showing that economic instruments can occur independently of scaling processes. This might be related to the nature of economic or financial reforms, which tend to occur at the regime level. The water bank cases also demonstrate that landscape pressure may provide a supportive context, yet it is not a condition that consistently distinguishes success from failure in economic cases. Overall, economic innovations can happen at the regime level, and they do not require an institutional disruption. Their success depends on designing economic and financial tools that consider existing governance structures while encouraging resource users to adopt different behaviours.

4.2.3. Participatory or collaborative innovations

Participatory or collaborative innovations show the clearest link between niche stimulation and successful outcomes. Cases such as **watershed visions** in Finland (P1 and P4), **water council** in Sweden (P2), and **community and citizen initiatives** in Romania and France (P5 and P6) all score rather high on niche stimulation. These cases focus on local knowledge, shared problem definitions, and iterative planning processes. They demonstrate that participatory innovations succeed through the creation of shared spaces for learning and experimentation rather than through formal institutional change at the regime level.

Acceleration contributes to water governance transitions selectively. The **water council** in Sweden (P2) and the **citizen initiative** in France (P6) show clear tendency on niche stimulation and acceleration in their success. Meanwhile, the **watershed vision** in Finland (P1) and **community initiative** in Romania (P5) succeed without measurable acceleration. This shows that participatory innovations remain viable even when scaling mechanisms are weak. As such, niche acceleration strengthens participatory governance innovations but does not define them; the extent of participation is also important. However, limited or locally focused participation means innovations are not diffused and can remain fragmented.

Addressing repercussions is present in some, but not all, successful participatory cases. Projects that anticipate conflicts, clarify stakeholder roles, and link new objectives to existing responsibilities tend to be successful. This was shown in the cases on watershed vision (P4) and community initiative (P5). On the other hand, low values on addressing repercussions do not automatically prevent participatory projects from succeeding as long as niche stimulation remains strong. Overall, the participatory innovation pattern is defined by bottom-up approaches rather than systemic restructuring.

4.2.4. Digital Innovations: success requires absorption capacity

Digital innovations provide the clearest illustration of adaptive governance through addressing repercussion. High-performing cases such as the **monitoring network** in Italy (D1), the **online data package** in England (D2), the **WWF Water Risk Filter** (D3), and the **GIS-based tools** in Spain (D4) tend to embed digital solutions within existing decision processes, allowing institutions to absorb new information without conflict. In other words, this shows the relevance of embedding technology considering participatory processes and within regimes that can support them.

Niche stimulation can support digital innovations. In the tool-oriented cases (D3 and D4), it provides opportunities for collaborative learning and shared interpretation of monitoring data. In the other cases, addressing repercussions is more defining, indicating that digital innovations succeed when actors plan how the new information will be used, who will maintain it, and how it aligns with administrative responsibilities. Acceleration appears as a facilitating condition when present but does not differentiate among the different outcomes. Cases with low scores on acceleration can still perform well if the digital innovation responds to a clearly identified problem and if repercussions are well managed. Digital innovations can rely on incremental integration rather than disruptive reforms.

4.3. The role and relevance of policy intervention points

The results in this subsection are structured around the six policy intervention points that can be relevant for transitioning towards sustainable and equitable water use. For each point, we provide insights into the role and relative importance, both individually and, where relevant, in combination with other points.

4.3.1. Stimulating niches

This intervention point is the strongest and most consistent condition of success in the studied cases. Moreover, it is typically absent in less successful cases. The successful cases, associated with this intervention point, span three innovation types: legal, participatory and digital, and they share a clearly defined set of innovations. The cases include the Water Stewardship Standard (L3), watershed vision processes in Finland, the water councils in Sweden, community-based and citizen-led initiatives in Finland, Romania and France (P1; P2; P4; P5; P6), and two digital tools one at the European level (D3) and one in Spain (D4). The core feature of these cases is that they create or sustain opportunities for actors to experiment, test ideas, and build shared understanding around water governance practices. For the legal case of collective irrigation in France (L2), the absence of niche innovation stimulation – though in combination with the presence of other policy intervention points - is also associated with a low score on facilitating sustainable and equitable water use.

Some cases, such as the digital innovation on GIS-based tools in Spain (D4), suggest that niche stimulation can support positive outcomes even in the absence of other policy interventions. However, it is important to note that regime reforms were implemented earlier to enable this digital innovation. The cases in France, Sweden and Germany combine niche stimulation with different types of enabling policy interventions, including acceleration, aspects of regime destabilising, or mechanisms to address wider repercussions. The common thread is that niche stimulation indicates settings where learning, collaboration, and iterative problem-solving stay active throughout the innovation process.

The analysis also reveals that niche stimulation is not strictly necessary, as several economic innovations succeed without strong niche stimulation. However, the presence of niche stimulation is a highly reliable indicator of successful innovations. At the same time, there are limitations. Many of the niche stimulation cases have complementary policy interventions, such as further acceleration or explicit focus on repercussions. Niche innovation tends to produce local improvements rather than broader governance change. In other words, stimulating niches is a powerful policy intervention for initiating and sustaining innovations locally, but they can become fragmented at the system level without the presence of other innovation points.

4.3.2. Accelerating niche innovations

Various cases have high scores on accelerating niche innovations. This policy intervention point is present in all innovation types, including two legal cases, the collective irrigation in France (L2), and the Water Stewardship Standard (L3), two digital cases, the monitoring network in Italy (D1), and the WWF Water Risk Filter (D3), an economic case of payment for ecosystem services in France (E4), and a collaboration case, the water council in Sweden (P2). These cases share some interesting features, as they illustrate how facilitation platforms, knowledge-sharing networks, and technical services can amplify ongoing experimentation. On closer inspection, we observe that accelerating niches appears as a secondary or "booster" condition. For example, the water council collaboration combines the stimulation and acceleration of niche innovations to move participatory efforts beyond isolated local projects toward basin-level practices and shared governance routines. The WWF Water Risk Filter (D3) shows a similar logic:

digital risk assessment tools help institutionalise learning processes and mainstream new practices among water users. In none of these cases, accelerating niches appear as a crucial driver of success, as niche stimulation appears to be sufficient.

Moreover, the data includes several cases that perform well on sustainable and equitable water use and niche innovation stimulation without a high score on acceleration. This applies, for example, to participatory innovations in Finland and Romania (P1, P5). These examples reinforce that acceleration is not a sufficient explanation for an innovation to contribute to sustainable and equitable water use. Still, acceleration can make successful outcomes at the niche level more scalable and durable when present.

The absence of niche innovation acceleration explains low scores on sustainable and equitable water use. For these cases, this intervention point is combined with the absence of niche innovation stimulation and the absence of addressing broader repercussions. This is the case for water pricing in Italy (E3) and river catchment partnerships in the UK (P3).

4.3.3. Destabilising the regime

The analysis shows that destabilising existing rules and institutions alone is hardly a defining feature of successful water governance innovations. The ecological minimum flow reform in Austria (L1) is the only example where destabilisation features clearly within a successful configuration. Yet even in this case, the policy interventions supporting destabilisation are specific and do not generalise to other settings. The collective irrigation scheme in France (L2) illustrates the opposite scenario, where attempts to alter existing rules are present, but the outcome remains weak, even though the case scores highly on many other policy intervention points.

Meanwhile, several cases with high outcome scores, indicating strong contribution to advancing sustainable water governance transition, have low or zero score on regime reform. This includes the Water Stewardship Standard (L3), the water bank in Tablas de Daimiel, Spain (E1), local community participation in Romania (P5), and several digital tools such as the monitoring network in Italy (D1), the online data package in England (D2), and the GIS-based tools in Spain (D4). These cases demonstrate that innovation can emerge without efforts to disrupt or dismantle governing arrangements. Their success is driven by learning processes, practical problem-solving, and collaboration rather than institutional confrontation.

At the same time, the presence of a regime reform does not guarantee positive results. A few innovations show higher scores, such as water pricing schemes or basin-level planning processes. These results suggest that innovation in water governance does not depend on destabilising established regimes. Rather than overturning existing systems, most successful cases work with them. They introduce targeted changes, create new spaces for cooperation, and use shared information to support decision-making. In practice, this represents a form of reconfiguration rather than disruption. Regime change in this study is most effective when it is selective and combined with adaptive governance strategies, rather than when it seeks to restructure water governance from the top down.

4.3.4. Addressing repercussions

Addressing the repercussions of change emerges as a recurrent feature of successful innovations, but not in all of them, nor in the same way. Several cases score high on this policy intervention point, including the water banks in Spain (E1 and E2), the payment for environmental services scheme in Spain (E4), the Water Council collaboration in Sweden (P2), the watershed vision in the Iijoki River in Finland (P4), the community initiative in Romania (P5), and several digital tools such as the monitoring network in Italy (D1), the online data package in England (D2), and the WWF Water Risk Filter (D3). QCA results show that the presence of this intervention point is rarely decisive on its own. It appears in only one participatory case (the community initiative in Romania, P5), suggesting that its relevance becomes apparent with the absence of other intervention points. In particular, successful outcomes occur when addressing broader repercussions is combined with either the absence of regime reform or the absence of landscape-level pressure.

First, the repercussions are addressed and regimes are not reformed, applies to four cases: the water bank in Tablas de Daimiel (E1), the community-based initiative in Romania (P5), the Italian monitoring network (D1), and the English catchment data hub (D2). Each of them introduces new practices, whether digital tools, local ecological action, or economic instruments, without challenging the central structures of water governance. Instead, their success stems from how they incorporate adaptive measures that help authorities and users interpret new information, negotiate adjustments, and address distributional impacts as they arise. In E1, for example, the water bank is embedded within the existing water rights system. It succeeds because its design explicitly manages tensions between agricultural users, and environmental obligations. P5 relies on local leadership and shared learning to introduce ecological improvements without provoking institutional conflict. D1 and D2 demonstrate how digital infrastructures can extend monitoring capacity and support decision-making when they are integrated into the existing governance regime. Across these cases, addressing innovations allows innovations to take hold in settings where institutional stability is maintained and where actors adapt collectively to new tools or practices.

Second, in other cases same adaptive quality is connected to low landscape pressure. This pattern applies to three cases: the Guadiana water bank (E2), the French payment for environmental services scheme (E4), and again in D2. These innovations do not emerge as a response to external pressure but to internal pressure. For example, in E2, the aim was to solve the aquifer water crisis in the short term. Meanwhile, for D2, while the WFD played a role in developing a participatory and basin management, this pressure is not directly related to the development of the digital innovations.

In other words, the innovation occurred in comparatively stable contexts, where actors introduce innovations that serve a recognised governance need. Their success rests on planning, iterative design, and anticipating consequences rather than on external pressure. The environmental payment scheme in E4, for instance, is structured to incentivise environmental practices while avoiding conflict with farmers' existing livelihoods. E2 adapts to long-standing scarcity challenges without fundamentally altering governance structures, and D2 enhances planning processes by providing shared data in a manner that is compatible with existing institutional arrangements.

Taken together, the cases demonstrate a form of non-disruptive innovation. Water governance systems, in these cases, do not undergo fundamental restructuring, nor are they pushed into transformation by external shocks. Instead, innovation proceeds through managed adaptation. Addressing repercussions provides the procedural and organisational capacity to absorb new practices, adjust them to local realities, and negotiate their implications. Whether regimes remain stable or external pressures are low, strong repercussion management enables innovations to be accepted, operationalised, and sustained.

The broader implication is that successful water governance innovations need not rely on destabilising existing institutions or waiting for landscape-level drivers. Innovations can emerge and thrive when governance actors focus on the practical work of integrating new tools, economic instruments, and participatory approaches that address local needs and can be integrated into established structures. In the selected cases, the most effective path to success is not disruption, but deliberate and adaptive alignment.

Overall, this intervention point appears less as a trigger and more as a stabiliser. It does not by itself explain why innovations start, but it helps to keep them politically and socially acceptable. In successful cases, this intervention point is used to clarify responsibilities and to adapt implementation. Thus, it is a central ingredient to embed water governance innovations in the governance system.

4.3.5. Coordinating multiple regimes

This intervention point is quite rare in the selected cases. It does not play a role in any of the identified patterns, neither for the successful nor for the unsuccessful cases. Our first analysis suggested that the absence of this intervention point could be necessary for a successful outcome to occur. This is theoretically unlikely and further inspection confirmed this is not the case: this intervention point is present in two legal innovations, both with a different outcome: the ecological minimum flow reform in Austria (L1) and the collective irrigation regulation in France (L2). Both are legal and regulatory interventions that explicitly engage multiple sectors or administrative levels; the first one is slightly more successful than the second one. Other cases have low scores on this intervention point. In other words, respondents did not perceive that multi-regime coordination facilitated the transition. In all highly successful cases, multi-regime coordination was considered absent. This includes the community initiative in Romania (P5), the water bank in Tablas de Daimiel, Spain (E1), the monitoring network in Italy (D1), and the WWF Water Risk Filter (D3). Their coordination efforts are mostly contained within a single regime or governance level, and yet they achieve relatively high outcome scores.

The pattern above indicates that extensive, formalised coordination across regimes is not a necessary policy intervention for innovation success in the water sector across different European regions. It can matter in specific legal-regulatory reforms, where aligning basin authorities, ministries, and user groups is intrinsic to the intervention, as in L1 and L2. But most of the successful economic, participatory and digital innovations in the selected case studies rely instead on problem-focused cooperation and institutional linkages. Therefore, this intervention point plays a limited, contextual role. Where a reform is explicitly multi-scalar and multi-sectoral, strong coordination can be a valuable resource and may help avoid fragmentation. At the same time, the relative failure of L2, despite high score on multi-regime coordination, and the success of many low-scoring cases, underline that multi-regime coordination is neither sufficient nor required for positive outcomes. Additionally, from an empirical perspective, the cases suggest that multi-regime coordination is difficult to achieve at the regime level. However, at the local level, coordination can be easier.

4.3.6. Landscape-level pressure

This intervention point appears with a mixed profile in the results. Some successful cases, including legal-regulatory cases of minimum flows in Austria (L1), and the collective irrigation (L2) and water decree (L4) in France, gain high scores on landscape-level pressure, in particular regarding the existence of framework legislation that has enabled these innovations. However, in most cases, this intervention point is absent or low. For example, the Guadiana water bank in Spain (E2), the payment for environmental services scheme in France (E4), and the catchment data package in England (D2) have been successful despite limited or no landscape-level pressure. Meanwhile, several other cases, such as the water council in Sweden (P2) and the river catchment partnerships in England (P3), in which higher landscape-level pressure values coexist with moderately successful or unsuccessful outcomes.

Overall, landscape pressure is a background condition rather than a direct driver of water governance innovations. The cases show that cultural or regulatory pressures do not automatically translate into more effective governance innovations. In some instances, broader policy debates, European directives, or public attention create a favourable climate, but the decisive work is shaped by how actors organise niches, manage repercussions, and, in a few legal reforms, align different governance levels. The QCA results point to a picture in which innovations in water governance can emerge both with and without strong landscape pressure, and where external forces tend to support opportunities rather than determine outcomes.

5. Conclusion

This deliverable systematically compares governance innovations to better understand which (combinations of) policy intervention points can support a transition towards sustainable and equitable water use in Europe. Building on the good practices identified in the GOVAQUA project, we collected and analysed data on 18 cases: four legal or regulatory innovations, six participatory or collaborative innovations, four economic or financial innovations, and four digital innovations. Based on the QCA results, we discern four key findings.

The first key finding is that **no single pattern guarantees success across all contexts**. Instead, the results point to a small number of recurring patterns consistently associated with stronger outcomes. Two intervention points stand out as more relevant than the others. First, stimulating niche innovations is the most robust and consistent signal of success. In practice, successful cases create or sustain spaces for experimentation, learning, and collective problem-solving, which implies the relevance of contextualised policies. This intervention point is sufficient to explain a substantial subset of successful cases, particularly among participatory innovations, and it also helps differentiate unsuccessful cases, where the absence of niche stimulation repeatedly coincides with low performance. Second, addressing regime repercussions is a key driver of successful innovation. The results show that water governance innovations often succeed not because they destabilise existing institutions, but because actors anticipate and manage distributional impacts, clarify responsibilities, and adjust implementation as tensions emerge. This pattern is especially evident in economic and digital innovations, where introducing new incentives or data infrastructure requires institutional capacity to be successful.

The second key finding is that **acceleration of niches, regime reform, multi-regime coordination, and landscape pressure do matter in some individual cases, but they are rarely decisive in determining success or failure across the full set of cases**. Acceleration appears primarily as a supportive factor that can help consolidate and spread practices, but it does not consistently distinguish successful from unsuccessful cases. Regime reform can contribute to success in specific circumstances, yet it is neither necessary nor sufficient. Landscape pressure similarly acts more as a contextual factor than a direct driver: some innovations succeed with low landscape pressure, while others perform modestly despite high pressure. Multi-regime coordination is particularly noteworthy, as it receives low scores in most cases and does not appear as a core element in the sufficient configurations. This does not imply that coordination is unimportant, but it suggests that it is difficult to achieve at the regime level and may not be perceived by respondents as a decisive driver of sustainability and equity outcomes, as operationalised in this study. The way in which success was defined and measured may have influenced how this intervention point is reflected in the empirical calibration.

The third key finding is that **innovation types are associated with distinct causal patterns**. Legal or regulatory innovations are the most heterogeneous. Their outcomes depend strongly on how rule changes interact with sectoral coordination and implementation dynamics, and legal reform alone does not guarantee success. Participatory or collaborative innovations are most consistently associated with niche stimulation and bottom-up learning processes; they facilitate change primarily through local engagement rather than systemic restructuring. By contrast, economic and digital innovations are more strongly shaped by addressing repercussions: they tend to perform best when new instruments and technologies are embedded in routines and responsibilities that enable institutions and users to work through consequences and trade-offs.

Finally, the fourth key finding tackles the **hybrid nature of governance innovations**. While the results focus on four distinct types of innovations, additional data gathered during the interviews showed that, across 16 of the 18 cases, the innovations were not isolated. Participatory or collaborative governance appeared frequently as a secondary innovation type, occurring in nine cases, followed by legal-regulatory elements in five cases, and economic and digital elements in three cases each. All four legal innovations include participatory components as secondary innovations, underscoring the importance of stakeholder engagement in translating formal rules into practice. Economic innovations combine financial instruments with participatory or legal elements, while participatory or collaborative innovations themselves are the most hybrid, frequently being accompanied by legal, economic, and digital tools. Digital innovations also show strong complementarities, most often combined with participatory arrangements, and occasionally with legal or economic instruments. This pattern suggests that participation and collaboration function as connective mechanisms across innovation types, supporting legitimacy, learning, and implementation. Taken together, these findings indicate that transitions towards sustainable and equitable water use are not driven by a single instrument or a single configuration. Instead, they unfold through combinations of complementary governance approaches. Niche stimulation and addressing repercussions emerge as central engines of transition, while other intervention points play more conditional and context-dependent roles. The prominence of secondary governance innovations further suggests that effective policy mixes should be designed to encourage interaction between different types of instruments, rather than treating them separately. Overall, the analysis points towards a transition pathway characterised by managed adaptation and sustained experimentation rather than disruptive restructuring. While this pathway enables progress across diverse institutional contexts, it also produces a fragmented transition landscape in which success depends on institutional readiness and the capacity to integrate new practices into existing governance systems. Strengthening this capacity, therefore, remains a key challenge for advancing water governance innovation across Europe.

In the following stages of the GOVAQUA project, the governance innovation patterns identified in this report will be utilised for the evaluation of transition pathways in the European water governance. The innovation patterns will be reflected in relation to the in-depth lessons from the case studies and good practice analyses, as well as the assessment of Living-Lab experimentation to develop an understanding of diverse governance pathways. The water governance pathways will be analysed in terms of stakeholder dynamics, geographical contexts, and sectoral water issues to distinguish governance pathways that build on the innovation patterns. Therefore, qualitative comparative analysis presents a key step between individual governance innovations and generalisable transition pathways on different aspects of water governance in Europe.

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Annexes

Annex 1. Overview of the QCA literature review

This annex presents the results of a targeted literature review mapping how QCA has been applied in water governance research and identifying empirical cases of governance innovation discussed in that body of work. The review was conducted in 2023 using two major bibliographic databases, Web of Science and Scopus, to ensure broad coverage of peer-reviewed literature. Our two queries for title, keyword and abstract were “Water”, “Governance”, “QCA”, and “Water”, “Governance”, “Qualitative Comparative Analysis”. The final review included 31 articles, and we employed the COVIDENCE platform to extract information from the articles. Fig. A1.1 shows the selection process.

Fig. A1.1. Selection process of QCA research on water governance.

Fig. A1.2. Map at the national level of studied cases that were part of QCA studies in the selected articles of the 2023 literature review.

Annex 2. Interview protocol

Interview protocol to identify innovations for sustainable water governance in Europe

This annex presents the semi-structured interview protocol used in the GOVAQUA to collect comparable qualitative data across case studies on innovations for sustainable water governance in Europe. The protocol supports the project's comparative analysis of transition pathways by assessing which combinations of six policy intervention points are present in each case and the extent to which they are perceived to drive innovation. The protocol combines descriptive questions with structured assessments, including two 1–5 Likert ratings of perceived success (ecological sustainability and equity) and a yes/no screening plus a 6–10 "driving role" rating for each intervention point. Interviews typically take 30–45 minutes. Participation is voluntary, and no personal data are collected; any identifying contact details are replaced with the case name for reporting and analysis.

Brief background of the research

To gain a deeper understanding of innovative pathways for sustainable water governance in Europe, the **GOVAQUA** project focuses on four distinct types of innovations: **legal, economic, stakeholder engagement, and digital**. These innovations are categorised into three levels: **niche** (radical novelties), **regime** (business as usual), and **landscape** (exogenous impacts) (Kanger, 2021). These levels are further subdivided into six policy intervention points, which serve as a bridge between policy instruments and goals. These points include:

1. Promote various alternatives for system change
2. Scale up single niches and align different niches to each other
3. Weaken incumbent regime structures hindering the transition
4. Anticipate and manage broader societal impacts resulting from system change/transition
5. Ensure complementary input-output relations between the regimes
6. Alter broader framework conditions enabling change in the directionality of locally bounded sociotechnical systems (Kanger et al., 2020).

Examples of these policy intervention points can be found in question 10.

This interview is part of a GOVAQUA task, with which we aim to answer the following question: **What combinations of policy intervention points in the implemented innovations are driving the transition pathway for advancing a sustainable and equitable water governance system in Europe?**

L. Kanger, et al. Research Policy 49 (2020) 104072

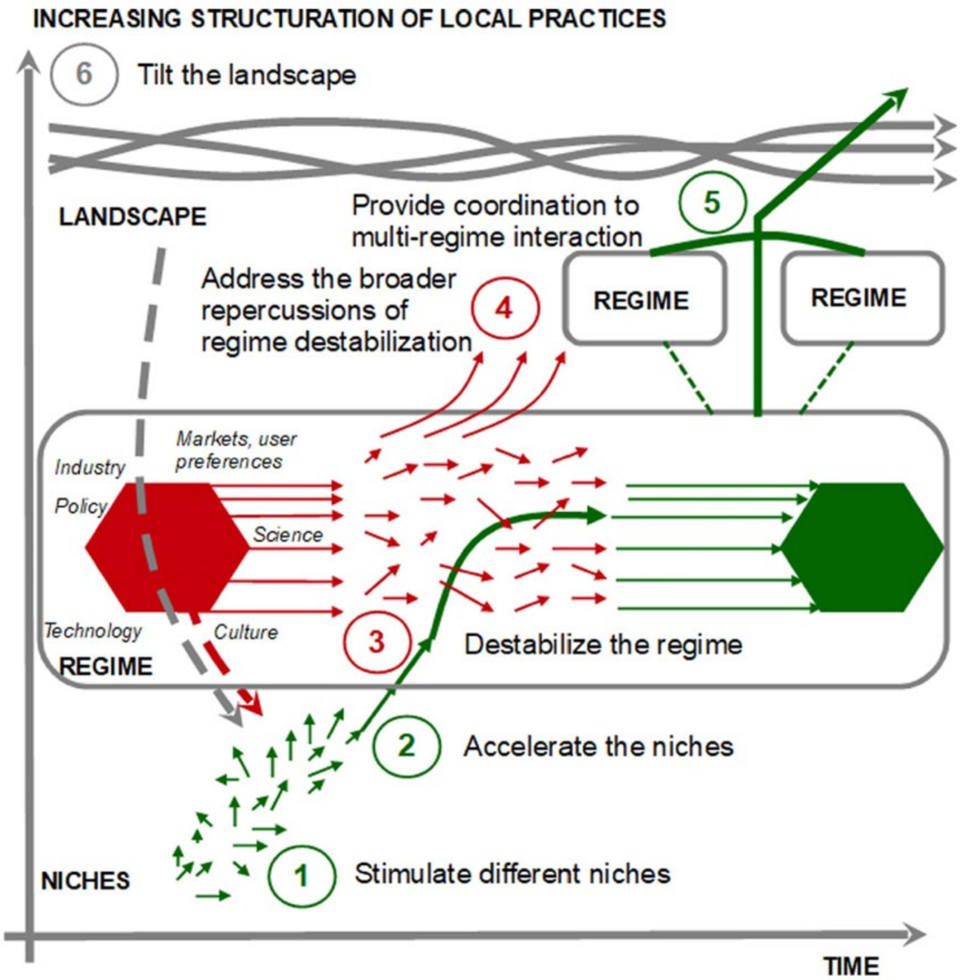

Fig. 1. Six intervention points for systems change (based on Geels and Schot, 2007: 401).

Figure A2.1. Six intervention points for systems change

Questionnaire

1. What water issue was addressed by the innovation?
2. Can you briefly describe what the innovation was about?
3. What was the basin/administrative scale of the innovation (sub-basin, basin, local, regional, national, European)?
4. Which of the four types of innovations do you think was the most important in your case?

a) legal	b) economic	c) stakeholder engagement	d) digital for sharing knowledge

5. Is there a secondary innovation that you consider relevant to your case?

a) legal	b) economic	c)stakeholder engagement	d) digital for sharing knowledge

6. Do you consider the innovation **fully** successful, and why? In this research, an innovation is considered **fully** successful when it contributes to the transition to a sustainable water governance system in Europe. This means the innovation improved the ecological water status and supported equitable (just) water management. By ecological status, we mean that the innovation contributed to improving the water quality and by equitable water management, we mean that the innovation contributed to

improving water allocation more fairly. The innovation is considered **partially** successful if the innovation only helped one of the two objectives.

7. Using the Likert scale from 1 to 5 (with five being the highest), to which degree do you think the innovation was successful in terms of ecological sustainability? If it was not successful, do not mark it.

1	2	3	4	5

8. Using the Likert scale from 1 to 5 (with five being the highest), to which degree do you think the innovation was successful in terms of equitable water management? If it was not successful, do not mark it.

1	2	3	4	5

9. To what extent did the innovation consider all water users, including the environment?

10. Considering each intervention point (first column) (Kanger et al., 2020), answer the question YES or No. If **YES**, please mark the degree to which you think the intervention point is driving the innovation pathway. In this Likert scale, 6 is **limited driving role**, and 10 is **high driving role**. You can mark more than one intervention point.

Intervention point	**Question**	**Examples**	**Answer**		**Example**
1. Stimulate different niches	Was the intervention point facilitating the transition by stimulating the innovation at different niches?	As an R&D funding scheme, foresight exercises to create future visions, innovative decentralised practices for wastewater treatment, rainwater or water reuse.	Yes No/Do not apply >.5	10 9 8 7 6	
2. Accelerate the niches	Was the intervention point facilitating the transitions via acceleration of innovation niches?	There were platforms to share innovations, water innovation hubs, support for entering markets, advice programs for water utilities, agricultural and industrial sector	Yes No/Do not apply >.5	10 9 8 7 6	
3. Reform the regimes	Was the intervention point facilitating the innovation via changes in the regime?	Creating of taxes (higher water tariffs), banning of specific technologies and practices, reducing subsidies, or involvement of experienced people, experts/consultants that can provide innovative ideas.	Yes No/Do not apply >.5	10 9 8 7 6	
4. Address the broader repercussions	Was the intervention point facilitating the	It was facilitated by supporting changes at the regional, social and global level in terms of	Yes	10	

of regime reforms	innovation by mixing various changes at multiple levels?	infrastructure, skills, networks, etc. Some examples are campaigns to change water intensive uses or behaviours. Via open data, data accessibility, financial and/or educational support or facilitating regional diversification of industrial/agricultural activities.	No/Do not apply >.5	9 8 7 6	
5. Provide coordination to multi-regime interaction	Was the intervention point facilitating the innovation by mutually reinforcing developments in multiple systems?	It was supported by aligning policies between agricultural, industrial, energy, water service systems and urban planning. This can be at (sub)basin, regional and local level.	Yes No/Do not apply >.5	10 9 8 7 6	
6. Tilt the landscape	Was the intervention point facilitating the innovation through exogenous forces?	It was supported by international or European frameworks that work as binding agreements for changing water management practices. For example, the European Water Framework Directive or the SDGs.	Yes No/Do not apply >.5	10 9 8 7 6	

11. How easily can the innovation be applied in other parts of Europe?
12. From your perspective, can the innovation have an impact in the long term? Why?
13. When looking at the starting point of the case, in your conclusion, how successful has the innovation been?
14. Do you have any additional comments that could be relevant to this research?

Annex 3. QCA of necessary and sufficient conditions

This section introduces the approach, language, parameters of fit, and case numbers that were used when conducting the analysis with the QCA package (Duşa, 2019) and SetMethods package (Oana & Schneider, 2018) in RStudio. First, we present the raw data and then explain the necessity and sufficiency analysis.

As recommended in the literature, we conducted an analysis of necessity prior to the analysis of sufficiency. Furthermore, we conducted separate analyses for the outcome and the absence of the outcome (the negated outcome, indicated with ~O). The negated outcome is 1 minus the outcome's score. In other words, if an outcome has a score of 0.7, the negated outcome is 0.3.

In this annex, conditions and solutions are presented in Boolean algebra. The absence of a condition is indicated with a tilde (~), e.g., ~C1 implies that C1 is absent. An asterisk (*) denotes a logical AND, and a plus (+) a logical OR.

As QCA is a set-theoretic method, each case is assigned a membership score for the presence and for the absence of each condition and the outcome. When conducting a QCA, choices must be made regarding thresholds for "parameters of fit". This includes consistency parameters, which indicate to what extent a condition is a subset or superset of an outcome, and coverage parameters, which measure how much of the outcome is covered by a sufficient condition or how trivial or relevant a necessary condition is. The information and formulas that are presented in this annex are derived from and further explained by Schneider and Wagemann (2012).

In the software-based analysis that is presented in this annex, cases are given a number that matches their order. To match the cases with these numbers, please refer to the concluding table (Table A3.10), which presents both the cases as they are referred to in the main text and the number that is used here in the annexe. Finally, in the process of conducting the QCA, we experimented with various thresholds and with removing conditions and cases. None of the analyses yielded more consistent results than the ones presented in this annex.

A3.1. Raw data

Table A3.1 shows the raw scoring data derived from the interview questionnaire across all cases included in the analysis. For each case (rows), the table records the interviewee's assessment of the six intervention points. These intervention points cover: stimulating different niches, accelerating niches, reforming regimes, addressing broader repercussions of regime reforms, coordinating multi-regime interactions, and tilting the landscape. Scores for the intervention points are on a 5–10 scale, where higher values indicate that the interviewee perceived the intervention point as playing a stronger role in driving the case's innovation.

In addition, the table includes two outcome ratings provided by interviewees: Sustainable Outcome and Equitable Outcome, each scored on a 5–10 scale (higher values indicate higher perceived performance) when being identified as positive. Outcome Average is the arithmetic mean of the two outcome scores for each case. The table is presented as raw data (i.e., without normalisation, weighting, or aggregation across cases) to ensure transparency and enable replication of subsequent comparative analyses.

Table A3.1. Raw data from interviews

Case	C1. Niche stimulation	C2. Niche acceleration	C3. Regime reform	C4. Addressing repercu-ssions	C5. Coordinating multiple regimes	C6. Landscape-level pressure	Sustainable Outcome	Equitable Outcome	Outcome Average
L1	5	9	8	5	9	9	8	8	**8**
L2	5	10	9	9	9	8	6.5	7.5	**7**
L3	8	10	5	5	5	7	8	8	**8**
L4	5	5	10	10	5	10	8	8	**8**
F1	5	5	6	10	5	8	10	10	**10**
F2	5	5	9	8	5	5	8	8	**8**
F3	5	5	9	5	5	7	7	5	**6**
F4	5	10	10	10	5	5	10	9	**9.5**
S1	10	5	10	5	6	5	8	8	**8**
S2	9	9	8	9	5	9	9	7	**8**
S3	5	7	5	5	5	9	7	6	**6.5**
S4	10	5	10	10	5	8	8	9	**8.5**
S5	10	5	5	8	5	10	9	9	**9**
S6	10	7	10	7	5	7	9	10	**9.5**
D1	6	10	5	10	5	10	8	8	**8**
D2	5	6	5	8	7	7	8	8	**8**
D3	10	10	8	8	5	9	10	8.5	**9.25**
D4	8	5	5	5	5	5	8	9	**8.5**

The raw data were transformed in a linear manner to values between 0 and 1 as presented in Table A3.2. For instance, an outcome value of 8.5 was transformed to 0.7.

Table A3.2. Transformation of raw data into fuzzy values between 0 and 1

Value of raw data	Fuzzy score in fsQCA
5	0
6	0.2
7	0.4
8	0.6
9	0.8
10	1.0

A3.2. Background on the analysis of necessary conditions

The analysis of necessity in fsQCA investigates whether membership in a condition is larger or equal to membership in the outcome across all cases. To determine the necessity of a certain condition, we first applied the following formulas and thresholds:

- Consistency of necessity (Cons. Nec) measures whether empirical information is in line with the statement of necessity (i.e., whenever the outcome is present, the condition is also present). Cons. Nec $(Yi \leq Xi) = \Sigma (\min (Xi, Yi)) / \Sigma (Yi)$. As recommended in the literature, we apply a high consistency threshold of 0.9 (cf. Knieper and Pahl-Wostl, 2016; Skaaning, 2011).
- Coverage of necessity (Cov. Nec) is a measure of the empirical relevance of a solution, i.e. how much smaller the outcome set Y is in relation to the condition set. High values indicate relevance whereas low values indicate trivialness Cov. Nec $(Yi \leq Xi) = \Sigma(\min (Xi, Yi)) / \Sigma (Xi)$

As recommended in the literature, for conditions that score high on necessity we made XY plots to visually inspect to what extent there are cases that contradict the statement of necessity (Duşa, 2019).

A3.3. Background on the analysis of sufficient conditions

For the analysis of sufficiency, cases are assigned to ideal-typical combinations of conditions (so-called configurations) in a truth table. For the construction of the truth table, condition values below 0.5 are changed to 0 and condition values larger than 0.5 are changed to 1. The truth table presents for each configuration the number of cases that is assigned to that combination and the measures of fit (i.e. consistency and coverage values). Only those configurations that pass certain thresholds are included in the calculation of the solution term. The parameters of fit and thresholds that are included in the analysis of sufficiency are:

- Consistency (incl) measures the degree to which a condition is a subset of the outcome, i.e. the inclusion rate. Incl $(Xi \leq Yi) =\Sigma(\min(Xi, Yi)) / \Sigma(Xi)$. Recommended and applied threshold: 0.8 or higher (cf. Knieper and Pahl-Wostl, 2016; Ragin, 2009)
- PRI Consistency (PRI) measures the Proportional Reduction in Inconsistency and expresses how much a condition is indeed a subset of the outcome rather than the negated outcome. PRI = $[\Sigma(\min(Xi, Yi)) – \Sigma(\min(Xi, Yi, \sim Yi))] / [\Sigma(Xi) – \Sigma(\min(Xi, Yi, \sim Yi))]$. For PRI consistency, there is no generally recommended threshold (cf. Knieper and Pahl-Wostl, 2016). We applied a flexible threshold that was determined on the basis of the truth table values.
- Raw coverage (cov.r) measures how much of the outcome is covered by a path. Raw coverage $(Xi \leq Yi) = \Sigma(\min(Xi, Yi)) / \Sigma(Yi)$
- Unique coverage measures how much of the outcome is covered by a unique path.

When constructing the truth table, it often happens that not all theoretically possible configurations are empirically observed. This is especially the case when the analysis includes a high number of conditions in comparison to the number of cases. All rows of the truth table that are not covered by cases are so-called “logical remainders”. These logical remainders can be dealt with differently, which may lead to different solutions. In the analysis of sufficiency, we report on two different solutions:

- The conservative or complex solution only includes those configurations that are empirically observed. Due to its complexity (i.e., many possible models and combinations), we did not use this solution in the presentation of results.

- The most parsimonious solution is based on software-generated assumptions about logical remainders so that the resulting solution term includes the fewest conditions and logical operators ("AND" and "OR"). This solution is presented in the results.

It is good practice to also report on an intermediate solution, which only takes into account logically remaining configurations that match the assumptions of the researcher. It is a (less complex) superset of the conservative solution and a (more complex) subset of the most parsimonious solution. As we did not have any theoretically informed directional expectations, this solution is not provided. Lastly, the analysis of sufficiency may result in different combinations that are all possible. This is also called model ambiguity. In such cases, we used parameters of fit (e.g. unique coverage) to determine which model is most likely to apply.

A3.4. Results of the analysis for necessity

The results for the analysis of necessity are presented in Table A3.3.

Table A3.3. Results of the analysis of necessity

Condition	Cons.Nec	Cov.Nec	RoN	Negated condition	Cons.Nec	Cov.Nec	RoN
C1	0.506	0.812	0.889	~C1	0.589	0.630	0.643
C2	0.472	0.734	0.775	~C2	0.615	0.683	0.697
C3	0.597	0.734	0.775	~C3	0.537	0.721	0.797
C4	0.658	0.809	0.827	~C4	0.485	0.651	0.758
C5	0.139	0.727	0.963	~C5	**0.948**	**0.693**	**0.312**
C6	0.632	0.760	0.785	~C6	0.589	0.810	0.857

Only one condition, ~C5 (absence of regime coordination), passes the conventional consistency threshold of 0.9 (0.948). For this condition, an XY-plot has been prepared (see figure A3.1).

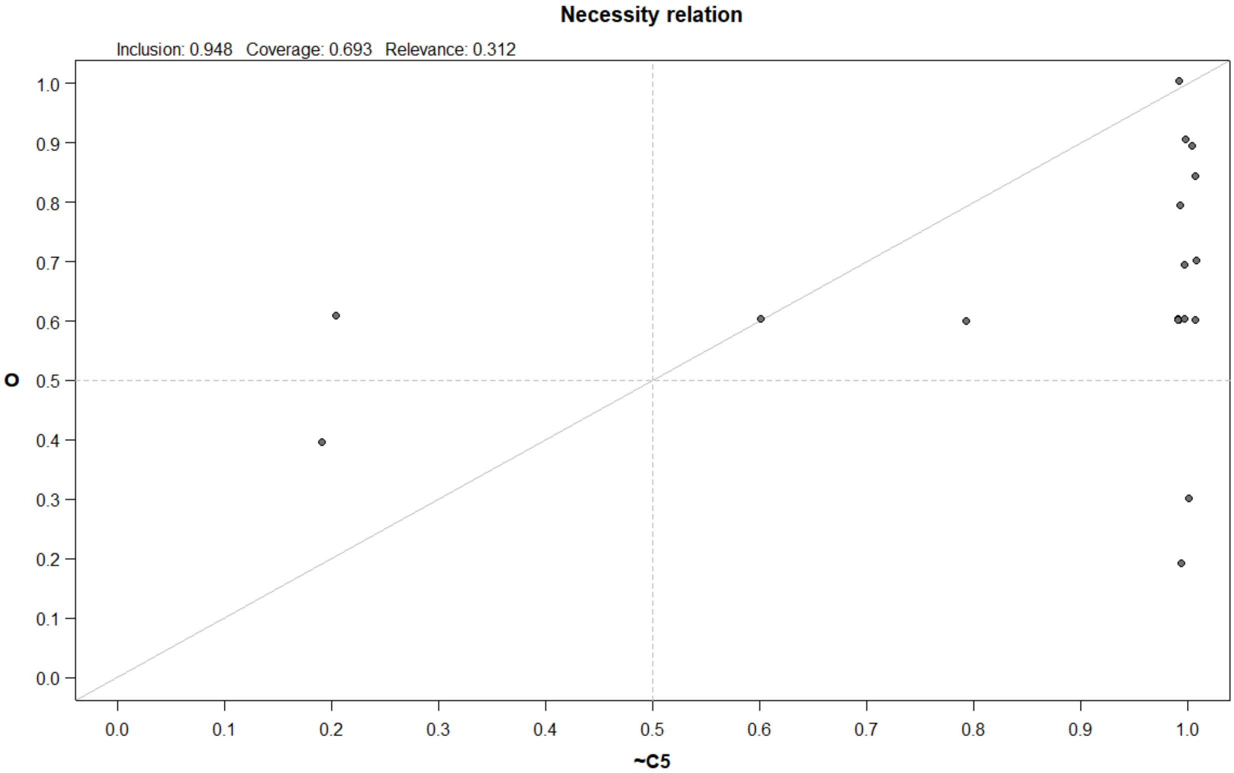

Figure A3.1. ~C5 (absence of regime-coordination), passes the conventional consistency threshold of 0.9.

The XY-plot illustrates that the relevance of necessity is low: most cases have a high score on ~C5. The plot also illustrates that two cases do not fit the statement of necessity; both are clearly above the diagonal line:

- L1 (outcome score of 0.6) can be found in the upper-left corner of the figure. Despite a relatively high score on the outcome, it has a rather low score on ~C5 (0.2). In the literature, this case is referred to as a deviation in kind (see (Duşa, 2019).
- L2 (outcome score of 0.4) can be found in the lower-left corner of the figure. In this case, the outcome is higher than condition value for ~C5. In the literature, this case is referred to as a deviation in degree (see (Duşa, 2019).

We reject that the absence of C5 is a necessary condition for the following reasons. First of all, the relevance of necessity is very low (0.312), which is logical since the majority of the cases have a low score on this condition. Second, a closer analysis reveals that the data includes two deviant cases (L1 in kind and L2 in degree). More importantly, multi-regime coordination is expected to support systemic change in complex socio-ecological systems. It would be counterintuitive to argue that a lack of regime coordination is required for positive governance outcomes.

We also analysed whether combinations of conditions would be necessary. The table below provides all combinations (analysis of supersets) that have a RoN that is higher than 0.5.

Table A3.4. Results of the analysis of supersets

Combination of conditions (supersets)	inclN	RoN	covN
C1 + C3 + ~C6	0.905	0.530	0.746
C1 + C4 + C5	0.948	0.596	0.793
C4 + C5 + ~C6	0.926	0.521	0.754

None of the SuperSets are actual combinations; they all contain OR combinations. For such large supersets (one condition, or another one, or another one), the statement of necessity is not very relevant. Hence, we also reject this as possible necessary combination.

A3.5. Results of the analysis for sufficiency

To analyse which combinations of conditions were sufficient for the presence of the outcome, we applied standard QCA procedures based on the calibrated data matrix and the truth table (Table A3.5). First, each case was assigned membership scores in the six conditions (C1–C6) and the outcome (O), as shown in the data matrix. The truth table was then constructed using a consistency threshold of 0.85 (indicated in the table with a thick line) to identify rows with a sufficiently strong empirical relation between the configuration of conditions and the presence of the outcome. Two cases are worth mentioning because they both have a low score on PRI Consistency, which indicates it's hard to determine to what extent a condition is indeed a subset of the outcome rather than not the outcome. Case 15 (D1) is included in the analysis since consistency is relatively high. Case 4 (L4) has been assigned a score of 0 on the outcome even though it has a 0.6 score. For the software, this case is apparently difficult to place into a configuration and hence the case is excluded from the analysis of sufficiency.

Table A3.5. Truth table for the analysis of sufficiency, sorted by PRI consistency and consistency. The numbers in the first column refer to a row number of the truth table. Empty rows are excluded from the table.

	C1	C2	C3	C4	C5	C6	OUT	n	incl	PRI	Cases
5	0	0	0	1	0	0	1	1	1	1	16
6	0	0	0	1	0	1	1	1	1	1	5
13	0	0	1	1	0	0	1	1	1	1	6
28	0	1	1	0	1	1	1	1	1	1	1
33	1	0	0	0	0	0	1	1	1	1	18
38	1	0	0	1	0	1	1	1	1	1	13
46	1	0	1	1	0	1	1	1	1	1	12
49	1	1	0	0	0	0	1	1	1	1	3
62	1	1	1	1	0	1	1	2	1	1	10,17
29	0	1	1	1	0	0	1	1	0.93	0.89	8
41	1	0	1	0	0	0	1	2	0.88	0.78	9,14
22	0	1	0	1	0	1	1	1	0.86	0.5	15
14	0	0	1	1	0	1	0	1	0.71	0.5	4
2	0	0	0	0	0	1	0	1	0.81	0	11
9	0	0	1	0	0	0	0	1	0.71	0	7
32	0	1	1	1	1	1	0	1	0.67	0	2

Figure A3.2 presents the **conservative solution** of the analysis. This solution consists of four possible models (M1, M2, M3, M4). Each model starts with the same six configurations (numbered 1 to 6) that explain one to three cases. The last part of each model differs (numbered 7 to 10). The only difference between the models in terms of parameters of fit is unique coverage: this is highest for model 1.

```
M1: ~C1*~C3*C4*~C5*C6 + ~C1*C3*C4*~C5*~C6 + C1*~C2*~C4*~C5*~C6 + C1*~C3*~C4*~C5*~C6 + C1*C3*C4*~C5*C6 +
    ~C1*C2*C3*~C4*C5*C6 + (~C1*~C2*~C3*C4*~C5 + C1*~C2*C4*~C5*C6) -> O
M2: ~C1*~C3*C4*~C5*C6 + ~C1*C3*C4*~C5*~C6 + C1*~C2*~C4*~C5*~C6 + C1*~C3*~C4*~C5*~C6 + C1*C3*C4*~C5*C6 +
    ~C1*C2*C3*~C4*C5*C6 + (~C1*~C2*~C3*C4*~C5 + ~C2*~C3*C4*~C5*C6) -> O
M3: ~C1*~C3*C4*~C5*C6 + ~C1*C3*C4*~C5*~C6 + C1*~C2*~C4*~C5*~C6 + C1*~C3*~C4*~C5*~C6 + C1*C3*C4*~C5*C6 +
    ~C1*C2*C3*~C4*C5*C6 + (~C1*~C2*C4*~C5*~C6 + C1*~C2*C4*~C5*C6) -> O
M4: ~C1*~C3*C4*~C5*C6 + ~C1*C3*C4*~C5*~C6 + C1*~C2*~C4*~C5*~C6 + C1*~C3*~C4*~C5*~C6 + C1*C3*C4*~C5*C6 +
    ~C1*C2*C3*~C4*C5*C6 + (~C1*~C2*C4*~C5*~C6 + ~C2*~C3*C4*~C5*C6) -> O

                                            --------------------------------
                         inclS   PRI   covS   covU   (M1)   (M2)   (M3)   (M4)   cases
--------------------------------------------------------------------------------------------
1    ~C1*~C3*C4*~C5*C6  0.909  0.800  0.173  0.052  0.052  0.052  0.069  0.052  5; 15
2    ~C1*C3*C4*~C5*~C6  0.955  0.923  0.182  0.078  0.113  0.113  0.078  0.078  6; 8
3   C1*~C2*~C4*~C5*~C6  0.909  0.833  0.173  0.069  0.069  0.069  0.069  0.069  18; 9,14
4   C1*~C3*~C4*~C5*~C6  1.000  1.000  0.139  0.052  0.052  0.052  0.052  0.052  18; 3
5      C1*C3*C4*~C5*C6  1.000  1.000  0.190  0.069  0.069  0.121  0.069  0.121  12; 10,17
6  ~C1*C2*C3*~C4*C5*C6  1.000  1.000  0.069  0.052  0.052  0.052  0.052  0.052  1
--------------------------------------------------------------------------------------------
7   ~C1*~C2*~C3*C4*~C5  1.000  1.000  0.156  0.017  0.035  0.035                16; 5
8   ~C1*~C2*C4*~C5*~C6  1.000  1.000  0.156  0.000                0.017  0.017  16; 6
9     C1*~C2*C4*~C5*C6  1.000  1.000  0.156  0.000  0.052         0.052         13; 12
10   ~C2*~C3*C4*~C5*C6  1.000  1.000  0.156  0.000         0.052         0.052  5; 13
--------------------------------------------------------------------------------------------
                    M1  0.948  0.908  0.788
                    M2  0.948  0.908  0.788
                    M3  0.947  0.905  0.771
                    M4  0.947  0.905  0.771
```

Figure A3.2. Overview of the conservative solution (screenshot from results in RStudio).

Table A3.6 provides an overview of which configuration of absent and present conditions can be linked to which cases. This overview, for example, shows that the absence or presence of C2 is irrelevant to explain most cases. Also, it shows that the absence of C5 is always part of an explanatory combination.

Table A3.6. Overview of how configurations are linked to cases including indication of absence (indicated by X) and presence (O)

Configuration	Cases	C1	C2	C3	C4	C5	C6
~C1*~C3*C4*~C5*C6	5; 15	X		X	O	X	O
~C1*C3*C4*~C5*~C6	6; 8	X		O	O	X	X
C1*~C2*~C4*~C5*~C6	18; 9,14	O	X		X	X	X
C1*~C3*~C4*~C5*~C6	18; 3	O		X	X	X	X
C1*C3*C4*~C5*C6	12; 10,17	O		O	O	X	O
~C1*C2*C3*~C4*C5*C6	1	X	O	O	X	X	O
~C1*~C2*~C3*C4*~C5 (model 1)	16;5	X	X	X	O	X	

The minimisation procedure also produced the most parsimonious solution (see Figure A3.3). Here again, the model is ambiguous with three combinations applying across different models. Three configurations are sufficient for the outcome to occur: 1) C1 (high niche stimulation alone is sufficient for the outcome); 2) the combination ~C3*C4 (absence of regime destabilisation combined with mechanisms for addressing repercussions) and 3) the combination C4*~C6 (strong repercussion management in combination with the absence of landscape pressure).

```
M1: C1 + ~C3*C4 + C4*~C6 + (C2*~C4) -> O
M2: C1 + ~C3*C4 + C4*~C6 + (~C4*C5) -> O
M3: C1 + ~C3*C4 + C4*~C6 + (C3*~C4*C6) -> O

                                         -------------------------
               inclS   PRI   covS   covU   (M1)   (M2)   (M3)   cases
--------------------------------------------------------------------------------------
1          C1  0.812  0.716  0.506  0.229  0.247  0.281  0.299  18; 13; 9,14; 12; 3; 10,17
2      ~C3*C4  0.905  0.822  0.329  0.069  0.069  0.069  0.069  16; 5; 15; 13
3      C4*~C6  0.976  0.953  0.355  0.130  0.130  0.130  0.130  16; 6; 8
--------------------------------------------------------------------------------------
4      C2*~C4  0.806  0.576  0.251  0.026  0.078                1; 3
5      ~C4*C5  0.875  0.500  0.121  0.000         0.052         1
6   C3*~C4*C6  0.909  0.789  0.173  0.017                0.069  1
--------------------------------------------------------------------------------------
           M1  0.804  0.695  0.905
           M2  0.832  0.739  0.879
           M3  0.835  0.739  0.896
```

Figure A3.3. Overview of the most parsimonious solution (screenshot from results in RStudio).

Only one case (L1) is not explained by the first part of the model. Unique coverage is highest for model 1, yet model 3 is more likely to apply since this model only explain case 1 whereas the other also explains case 3 (which is also explained by presence of C1). Table A3.7 provides an overview of which configuration of absent and present conditions can be linked to which cases. In this analysis, the absence or presence of C2 and C5 is not relevant for explaining the presence of the outcome. Eight cases are explained by the presence of C1. One case (16; D2) is explained by two different configurations.

Table A3.7. Overview of how configurations are linked to cases including indication of absence (indicated by X) and presence (O); cases explained by multiple configurations are in bold.

Configuration	Cases	C1	C2	C3	C4	C5	C6
C1	18; **13**; 9,14; 12; 3; 10,17	O					
~C3*C4	**16**; 5; 15; **13**			X	O		
C4*~C6	**16**; 6; 8				O		X
C3*~C4*C6 (model 3)	1			O	X		O

Results for the analysis of necessity (negated outcome)

The results for the analysis of necessity for the absence of the outcome are presented in Table A3.8.

Table A3.8. Results of the analysis of necessity

Condition	Cons.Nec	Cov.Nec	RoN	Negated condition	Cons.Nec	Cov.Nec	RoN
C1	0.380	0.340	0.695	~C1	0.791	0.472	0.558
C2	0.488	0.414	0.700	~C2	0.667	0.413	0.555
C3	0.628	0.431	0.616	~C3	0.612	0.459	0.669
C4	0.535	0.367	0.591	~C4	0.721	0.541	0.704
C5	0.248	0.727	0.963	**~C5**	**0.907**	**0.370**	**0.181**
C6	0.752	0.505	0.639	~C6	0.643	0.494	0.693

Again, only one condition, ~C5 (absence of multi-regime coordination), passes the conventional consistency threshold of 0.9 (0.907). For this condition, an XY-plot has been prepared (see figure A3.4). This time relevance of necessity is even lower and as the figure shows, L1 and L2 are deviations in kind and in degree. Hence, the statement of ~C5 as necessary condition is rejected.

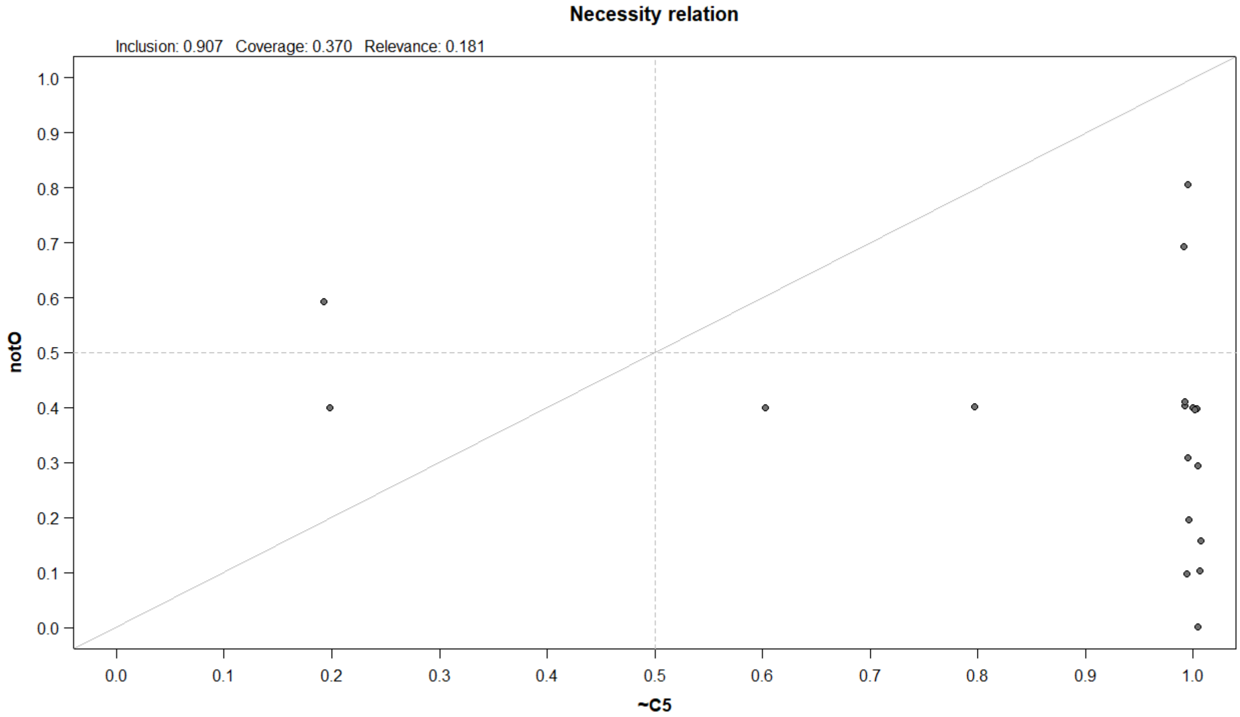

Figure A3.4. ~C5 (absence of regime-coordination), passes the conventional consistency threshold of 0.9

Results for the analysis of sufficiency (negated outcome)

To analyse which combinations of conditions were sufficient for the absence of the outcome, each case was assigned membership scores in the six conditions (C1–C6) and the negated outcome (~O). The truth table was then constructed. Only cases that are fully consistent are included (threshold indicated with a thick line) since all other cases fall below a consistency threshold of 0.75 and have been included already in the analysis of the outcome.

Table A3.9. Truth table for the analysis of sufficiency, sorted by PRI consistency and consistency. The numbers in the first column refer to a row number of the truth table. Empty rows are excluded.

	C1	C2	C3	C4	C5	C6	OUT (notO)	n	incl	PRI	cases
2	0	0	0	0	0	1	1	1	1	1	11
9	0	0	1	0	0	0	1	1	1	1	7
32	0	1	1	1	1	1	1	1	1	1	2
28	0	1	1	0	1	1	0	1	0.75	0	1
49	1	1	0	0	0	0	0	1	0.75	0	3
22	0	1	0	1	0	1	0	1	0.71	0	15
33	1	0	0	0	0	0	0	1	0.63	0	18
13	0	0	1	1	0	0	0	1	0.6	0	6
5	0	0	0	1	0	0	0	1	0.57	0	16
6	0	0	0	1	0	1	0	1	0.5	0	5
38	1	0	0	1	0	1	0	1	0.5	0	13
46	1	0	1	1	0	1	0	1	0.5	0	12
41	1	0	1	0	0	0	0	2	0.44	0	9,14
14	0	0	1	1	0	1	0	1	0.43	0	4
62	1	1	1	1	0	1	0	2	0.41	0	10,17
29	0	1	1	1	0	0	0	1	0.36	0	8

Figure A3.5 presents the **conservative solution** of the analysis. This solution contains three configurations, each of them explaining only one case. Noticeable here is that the absence of C1 is part of all configurations, but it is never a sufficient condition on its own. In the first and the third configuration (cases 7 and 11), C2 and C4 are absent. Yet, they differ in terms of presence of C3 and C6.

```
M1: ~C1*~C2*C3*~C4*~C5*~C6 + ~C1*C2*C3*C4*C5*C6 + ~C1*~C2*~C3*~C4*~C5*C6 -> notO

                          inclS   PRI    covS   covU   cases
-----------------------------------------------------------
1  ~C1*~C2*C3*~C4*~C5*~C6  1.000  1.000  0.217  0.124  7
2      ~C1*C2*C3*C4*C5*C6  1.000  1.000  0.093  0.093  2
3  ~C1*~C2*~C3*~C4*~C5*C6  1.000  1.000  0.248  0.155  11
-----------------------------------------------------------
                       M1  1.000  1.000  0.465
```

Figure A3.5. Overview of the conservative solution (screenshot from results in RStudio).

The most parsimonious solution (see Figure A3.6) provides four different models. Models 2 and 4 have the highest inclusion and PRI scores. In both models, C1 is absent; yet they differ in absence / presence of C2 and C4. For case 2 (L2), the presence of nearly all conditions is an explanation, this seems to be a unique case. For the other cases, model 2 seems most applicable: absence of C1, C2 and C4 is combined.

```
M1: C4*C5 + ~C1*~C2*~C4 -> notO
M2: C4*C5 + ~C1*~C4*~C5 -> notO
M3: ~C1*~C2*~C4 + ~C1*C2*C3*C4*C6 -> notO
M4: ~C1*~C4*~C5 + ~C1*C2*C3*C4*C6 -> notO

                                       ---------------------------------
                    inclS   PRI   covS   covU   (M1)   (M2)   (M3)   (M4)   cases
--------------------------------------------------------------------------------
1           C4*C5   0.833  0.500  0.155  0.000  0.093  0.062                2
2     ~C1*~C2*~C4   0.906  0.750  0.450  0.000  0.388         0.419         11; 7
3     ~C1*~C4*~C5   0.857  0.625  0.558  0.078         0.465         0.496  11; 7
4  ~C1*C2*C3*C4*C6  1.000  1.000  0.124  0.000                0.093  0.062  2
--------------------------------------------------------------------------------
               M1   0.875  0.688  0.543
               M2   0.833  0.600  0.620
               M3   0.921  0.786  0.543
               M4   0.870  0.667  0.620
```

Figure A3.6. Overview of the most parsimonious solution (screenshot from results in RStudio).

Summary of QCA findings

Table A3.10 contains the calibrated membership scores for all 18 cases across the six conditions (C1–C6) and the outcome (O) and reports, for each case, the solution pathway to which it is assigned. Dark-shaded entries represent negated conditions, while boxes indicate the presence of a condition. The table enables the analysis of the empirical diversity of the cases and their alignment with the configurations identified in the truth table. It also clarifies which cases contribute to each sufficient configuration and which cases display combinations that do not lead to the outcome. Together, Tables A3.2 and A3.3 provide a complete representation of the QCA process: the calibrated case data used in the truth table (Table A3.1), and the minimised solution terms that summarise the sufficient causal pathways.

Table A3.10. Data matrix and applicable solution pathways per case with present conditions in squares and negated conditions and outcome in grey-shaded cells. Dark-shaded entries represent negated conditions, while boxes indicate the presence of a condition.

Case	Nr	C1	C2	C3	C4	C5	C6	O	Solution pathway
L1	1	0	0.8	0.6	0	0.8	0.8	0.6	C3*~C4*C6
L2	2	0	1	0.8	0.8	0.8	0.6	0.4	difficult to explain; ~C1*C2*C3*C4*C6
L3	3	0.6	1	0	0	0	0.4	0.6	C1
L4	4	0	0	1	1	0	1	0.6	not included in analysis of O and ~O (contradicting E2)
E1	5	0	0	0.2	1	0	0.6	1	~C3*C4
E2	6	0	0	0.8	0.6	0	0	0.6	C4*~C6
E3	7	0	0	0.8	0	0	0.4	0.2	~C1*~C2*~C4
E4	8	0	1	1	1	0	0	0.9	C4*~C6
P1	9	1	0	1	0	0.2	0	0.6	C1
P2	10	0.8	0.8	0.6	0.8	0	0.8	0.6	C1
P3	11	0	0.4	0	0	0	0.8	0.3	~C1*~C2*~C4
P4	12	1	0	1	1	0	0.6	0.7	C1
P5	13	1	0	0	0.6	0	1	0.8	C1 OR ~C3*C4
P6	14	1	0.4	1	0.4	0	0.4	0.9	C1
D1	15	0.2	1	0	1	0	1	0.6	~C3*C4
D2	16	0	0.2	0	0.6	0.4	0.4	0.6	~C3*C4 OR C4*~C6
D3	17	1	1	0.6	0.6	0	0.8	0.85	C1
D4	18	0.6	0	0	0	0	0	0.7	C1