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# Toward Sustainable Water Governance? Taking Stock of Paradigms, Practices, and Sustainability Outcomes

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## ABSTRACT

Governance is key to ensuring the sustainability of water systems in the long run. With the recognition of the complexities inherent in governing water resources, new and diverse governance models have started to emerge and be diffused to various contexts. This systematic review explores 223 cases from 165 studies on water governance and sustainability. We assess the cases based on water governance paradigms and how these paradigms relate to governance characteristics, water-related problématiques, and sustainability outcomes. Our results indicate a lack of knowledge cumulation and patterns connecting problématiques (e.g., "groundwater exploitation in agriculture") and paradigms (e.g., "community-based management"). We found that the "integrated approach to water management" was the most common paradigm, and paradigms might manifest with various governance characteristics, some of which may not fully align with the paradigm's fundamental principles. While certain paradigms, such as "integrated approach to water management," "participatory and collaborative governance," and "community-based management," are mostly associated with better sustainability outcomes, these successes should be interpreted cautiously due to the context-sensitive nature of paradigms and potential biases in the reviewed studies. These findings provide a basis for further diagnostic work and suggest the need for more nuanced approaches to water governance and sustainability.

## 1 | Introduction

The global water crisis, as argued by the Global Water Partnership (GWP 2000), as well as scholars and policymakers, is largely a crisis of governance. Governance is key not only to addressing water supply and demand misfits but also to ensuring the long-term well-being of water ecosystems (Hall 2003; Özerol et al. 2018; Pahl-Wostl et al. 2012; Rogers and Hall 2003; Tropp 2007). For several decades, scholars have aimed to address the social and ecological complexities of water via different governance solutions (Challies and Newig 2022; Pahl-Wostl 2019; Tropp 2007). The emphasis on sustainable development and resilience has led to a significant shift in water governance, from technocratic strategies neglecting complexities and human dimensions to more integrated approaches underpinning good governance (Jiménez et al. 2020).

The literature has also specialized in and explored water governance in light of different paradigms, problems, and sustainability outcomes. Despite the growing diversity of this body of literature and some theoretically targeted syntheses, there is no general overview that brings different paradigms

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and contexts together. Such a synthesis can contribute to a better understanding of the opportunities and limits of governance in the water context, and help identify gaps for further research.

This paper provides such an overview by systematically reviewing the body of empirical literature on water governance and its water-related sustainability outcomes. We understand water-related sustainability outcomes[1] in terms of the sustainable use of water resources and the well-being of freshwater ecosystems. Specifically, the aim of the paper is twofold: (a) to unveil the state of knowledge production in the literature by examining its socio-bibliometric characteristics and (b) to identify and explore water governance paradigms and their co-appearance with governance characteristics, water-related problématiques, and sustainability outcomes.

*Water governance*, following Pahl-Wostl (2015), regulates the development, management, and provision of water resources in light of diverse water-related issues or broader *problématiques* (i.e., the water-related context of the recurring "clusters" or "ensembles" of water-related issues), guiding water resources toward a sustainable state. A *water governance system* is an interconnected and dynamic ensemble of political, social, economic, and administrative elements—institutions, actors, and their interactions—that performs the function of water governance (Pahl-Wostl 2015). It encompasses the constellation of *characteristics* that indicate the ways in which governance is structured and implemented on the ground, how water resources are developed, managed, and provisioned, and which actors are involved and the interactions among them. In this paper, *governance characteristics* cover the role and involvement of actors (e.g., participation and collaboration), the governance mode (e.g., centralization, decentralization, partnership, and self-governance), the level of interaction (e.g., multi-level governance, sectoral integration, fragmentation, and polycentricity), scale (e.g., scale-adapted governance and governance on an administrative scale), the management of uncertainties and risks (e.g., adaptiveness), and information and knowledge management (e.g., evidence-based governance).

Water governance characteristics are often influenced by larger *paradigms*. For example, the "integrated approach to water management" emphasizes governance on a hydrological scale and sectoral integration, while "state-centric/command and control governance" emphasizes centralized decision-making and regulatory enforcement. Functioning as a symbolic and ideational device, paradigms can be understood as the frameworks of "normative-cognitive ideas" that focus attention on how problems are perceived, which policy goals to pursue, and which instruments to apply to attain these goals (Hall 1993; Challies and Newig 2022). Being important agenda-setters for political actions at all scales, water governance paradigms play a significant role in framing problems and providing solutions (Challies and Newig 2022). They also shape policy objectives and instruments by establishing and maintaining certain formal institutions, as well as the mandates that they work toward (Kern, Kuzemko, and Mitchell 2014). Paradigms also play an important role in which options are favored, disregarded, or ignored and which groups are empowered or sidelined (Molle 2008). Hence, paradigms may, in fact, "explain the enactment of certain local policies better than a functional necessity or the strategic considerations of involved parties" (Challies and Newig 2022, 513).

We address the paper's first objective by exploring the type of knowledge produced and analyzing how cumulative this knowledge is. To address the second objective of the paper, we present descriptive statistics on the distribution and co-appearance of water governance paradigms and their associated problématiques, governance characteristics, and sustainability outcomes across the literature. Problematizing the relationship between problématiques, governance paradigms, and sustainability outcomes allows this study to serve as an entry point for the diagnosis of water governance situations, to identify complementarities between these components, and to present informed hypotheses for further testing.

## 2 | Methods

To compile the relevant publications for our analysis, we conducted a systematic literature review, following the PRISMA guidelines (Moher et al. 2009), adapted to our research question. The review stages are illustrated in Figure A1 (see Appendix 4 in the Supplementary Material for additional figures).

We restricted our search to journal articles listed in Scopus, one of the most prominent peer-reviewed literature databases, providing broad coverage of the fields of environmental and social sciences (Frohlich et al. 2018). Focusing on international discourse, we searched for English-language articles that contained water and governance-related terms in the titles and terms in the titles or abstracts indicating empirical studies of sustainability outcomes (see Appendix 1 in the Supplementary Material for full search string).

Running our search string yielded a total of 8761 studies. Following manual screening of the abstracts and titles and eligibility assessments based on the exclusion criteria presented in Figure A1, we retained 165 papers, covering 1985–2020, for coding and analysis. We extracted the data from the included publications based on a coding scheme developed in consultation with existing literature on water governance and water governance scholars in the NEWAVE network.[2] The coding scheme covers six categories: bibliographic information, research framework, research design, case-related information, the characteristics of the water-related context and water governance, and sustainability outcomes (see Appendix 2 in the Supplementary Material).

The units of analysis in our systematic review were both the papers and the empirical cases within these papers. While the bibliographic information and information regarding the research frameworks and designs of the papers were assessed at the level of the papers, the remaining categories in our coding scheme were assessed at the level of the empirical cases reported in the papers. Within a paper, there could be separate (geographical) case studies, as well as distinct changes of governance within a geographically confined case; and we coded both as separate cases. We only included cases reporting



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sustainability outcomes linked to a water governance system. So, we excluded papers that did not provide any empirical information, qualitative or quantitative, on the sustainability outcomes observed in relation to the water governance system. For instance, Ananda, McFarlane, and Loh (2020) discuss institutional barriers to social learning in Western Australia without delving into how the governance system leads to specific sustainability outcomes. We also included cases in which the assessment of water governance impacts was based on the authors' interpretations, rather than any hard empirical evidence. We also did not include studies that lacked sufficient description of the water governance system, such as the governance structure, decision-making process, or overarching governance paradigm. One of the examples excluded with this criterion is the study by He et al. (2020) presenting the impacts of water transfer policy implementation on lake eutrophication on the Shandong Peninsula but does not provide information on the institutional arrangements governing water management in the region. As we were interested in real-world cases of water governance and their sustainability outcomes, hypothetical case scenarios were also excluded from the coding.

Finally, we restricted coding to six empirical cases per paper and included only the first six cases or those cases with complete information. In total, we identified 223 cases across the 165 studies (Bilalova, Newig, and Villamayor-Tomas 2024), with 23 studies reporting more than one case and one study reporting more than six, omitting five cases in total.

Following intensive test screening and coding by all authors, which showed high reliability for the test coding (r(WG) = 0.88), the final screening (i.e., to exclude non-valid papers) and coding were undertaken by the first author. To minimize the risk of reviewer bias and possible errors, trial steps were completed by all authors during all stages of the review process, until a common understanding had been reached regarding the exclusion criteria and coding scheme.

## 3 | State of Knowledge Production

Our systematic literature review reveals several underlying issues connected to knowledge production. After presenting a general overview of the included studies, we will discuss these in terms of two major questions: (1) what type of knowledge is produced? (2) how cumulative is the produced knowledge?

Examining the publications, we observe a substantive increase in the number of empirical articles reporting on the sustainability outcomes of water governance, increasing from one or fewer up to 1995 to 18 in 2020. The papers included in the review are published in 93 different journals. A quarter of these journals ($n = 23$) are water-specific, accounting for 41% ($n = 67$) of the included papers. The three most frequently observed journals are water-related: *International Journal of Water and Resources Development* (11 publications), *Water Policy* (9 publications), and *Water International* (7 publications). For non-water journals, the *Journal of Environmental Management* (6 publications), *Environmental Management* (3 publications), *Environmental Science and Policy* (3 publications), the *International Journal of Environmental Research and Public Health* (3 publications), *Land Use Policy* (3 publications), and the *Natural Resources Forum* (3 publications) are the most frequently observed, each with three or more publications included in our review.

Concerning the knowledge producers, the sex composition for the publications in our systematic review is notably skewed. Only 32% of the first authors are female ($n = 52$), while 63% of the papers are led by male authors ($n = 104$). An assessment of the countries of the first authors' affiliated institutions revealed that the top six countries—the USA, China, Canada, Germany, India, and the UK—accounted for more than half of the papers ($n = 87$). In terms of countries where empirical cases are located, almost half of all cases (43%; $n = 126$) relate to seven countries: the USA, China, India, Canada, Germany, Thailand, and Spain. We also observe a difference in relation to the geographical locations of the first authors' institutions and the locations of the empirical cases. Following Gupta (2012), we treated all OECD members as the "Global North" and all non-OECD countries as the "Global South." Our data show that in both regions, more countries are cited in empirical cases than are identified as the locations of the first authors' institutions. However, in the Global South, this difference ($n = 111$) is twice that seen in the Global North ($n = 20$). Despite this difference, there is a diverse distribution of both publications and cases across world regions, including North America, Europe, Asia, Africa, South America, and Oceania.

### 3.1 | Type of Produced Knowledge

Regarding the type of knowledge produced, the literature is dominated by "evaluation" and "description"—as opposed to "explanation" questions (Table 1). The considerable share of papers presenting evaluative research hints at the potential usefulness of the studies for policymakers. The question of "what works (or does not work) to achieve a particular desired outcome or condition," which is also important for scholars and practitioners with strong instrumental policy orientations (Sanderson 2002), is only evident in 8% of the papers. The reviewed papers with evaluative, descriptive, and "what works" questions predominantly focus on effectiveness and impact as their evaluative criteria. Generally, effectiveness ($n = 113$) and impact ($n = 52$) are the two most frequent evaluative criteria used in the reviewed publications (Figure A2). In comparison, the resilience and adaptive capacity of water systems as evaluative criteria are less prevalent among the reviewed studies, with each identified in only 7% of the reviewed publications.

### 3.2 | Cumulative Nature of the Produced Knowledge

To become policy-relevant, knowledge produced by water governance scholarship should be cumulative—meaning that the research builds on the findings of older research, such that the understanding of water governance research advances by either challenging, confirming, or adding nuance to previous research—for example, by specifying the context under which a



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**TABLE 1** | Governance-related research questions, frameworks, methods, and data used across the included studies. [Correction added on 28 October 2024, after first online publication: Table 1 has been reformatted.]

| | Number of papers |
|---|---|
| Governance-related research questions | |
| Evaluation of a (or multiple) governance system(s) | 134 |
| Thick description of a governance system(s) | 117 |
| Explanation of the genesis of a governance system(s) | 42 |
| What works to achieve a particular desired outcome or condition | 13 |
| Look for patterns in data, or build a typology | 4 |
| Analytical frameworks | |
| No clear framework | 106 |
| Using a pre-existing framework (i.e., with or without adaptation) | 46 |
| Developing a framework through a deductive approach | 13 |
| Methods | |
| Qualitative observational method | 87 |
| Other/Not clear | 58 |
| Quantitative observational method | 53 |
| Systematic review/meta-analysis | 4 |
| Set-theoretic method | 2 |
| Experimentation | 1 |
| Data | |
| Primary | 108 |
| Secondary | 77 |
| Not clear | 40 |

previously studied governance intervention might work (Newig and Rose 2020).

To assess whether the knowledge in the reviewed literature was cumulative, we conducted a network analysis of citations and co-authorship. Using VOSviewer (van Eck and Waltman 2010), we performed a citation analysis based on the bibliographic data of the included studies, using documents as units of analysis. Clusters were determined based on the number of times that the documents cited each other. The analysis reveals 16 clusters of just 52 documents, comprising 32% of all publications (Figure 1). The results point toward a relatively high level of fragmentation in the studied set of empirical water governance publications.

This fragmentation in the citation networks suggests a lack of knowledge cumulation (as found by Goyal and Howlett (2018) for a different research community). This may be driven by the fact that many studies draw on narrow case-based analyses that are too contextually specific to be applied to other contexts (Cox et al. 2020). A related explanation could be that there is no intuitive way of making comparisons across studies due to a lack of common understanding of key concepts and sets of variables, which leads to inconsistencies in the selection and measurement of these variables (Cox et al. 2020, 2021).

A similarly fragmented pattern is observed in the co-authorship networks. Co-authorship analysis, determined by the number of co-authored documents, was performed with VOSviewer, with the authors as units of analysis. As presented in Figure 1, the analysis reveals seven clusters, accounting for just 14% ($n = 55$) of all authors. Looking closely at these clusters of co-authorship (Figure A3), we identified some factors that accounted for each cluster, including shared knowledge of an empirical case, a shared governance paradigm, and a shared conceptual framework. The analysis also reveals one cluster with no common theme between its two papers; instead, the cluster was formed through an institutional affiliation.

The fragmented pattern detected in co-authorship analysis provides further support for the argument that there is limited potential for knowledge cumulation. This shows that while scholars have studied diverse water governance systems in different contexts and reported on their sustainability outcomes, there is a lack of sustained collaborative work that would allow us to identify the core concepts and move the research forward within the field (Goyal and Howlett 2018).

Another piece of evidence pointing to the lack of knowledge cumulation is that only 59 studies in our sample employ an analytical framework to conceptualize a relationship between water governance and its sustainability outcomes. Frameworks organize relevant variables according to general relationships and can, for this reason, be instrumental when comparing cases and cumulating knowledge (Ostrom 2009). Of the few analytical frameworks used by the papers in our sample, only three are applied more than once: Elinor Ostrom's Institutional Analysis and Development (IAD; $n = 11$), the Socio-ecological Systems (SES) framework ($n = 2$), which builds on the IAD framework (Schlager and Villamayor-Tomas 2013), and the Integrative Framework for Collaborative Governance ($n = 2$) by Emerson, Nabatchi, and Balogh (2012). The dominance of the IAD framework hints at Elinor Ostrom's influence on water governance and her focus on sustainability outcomes. Nonetheless, the absence of commonly used analytical frameworks adds to the overall impression of a relatively fragmented field of research.

In summary, our systematic review uncovers significant issues in knowledge production within water governance scholarship. Despite a notable increase in empirical studies on sustainability outcomes, the literature remains dominated by evaluative and descriptive research, with limited attention to explanatory questions. Moreover, our analysis suggests a lack of cumulative knowledge, as evidenced by fragmented citation and co-authorship networks, as well as the limited use of analytical frameworks.



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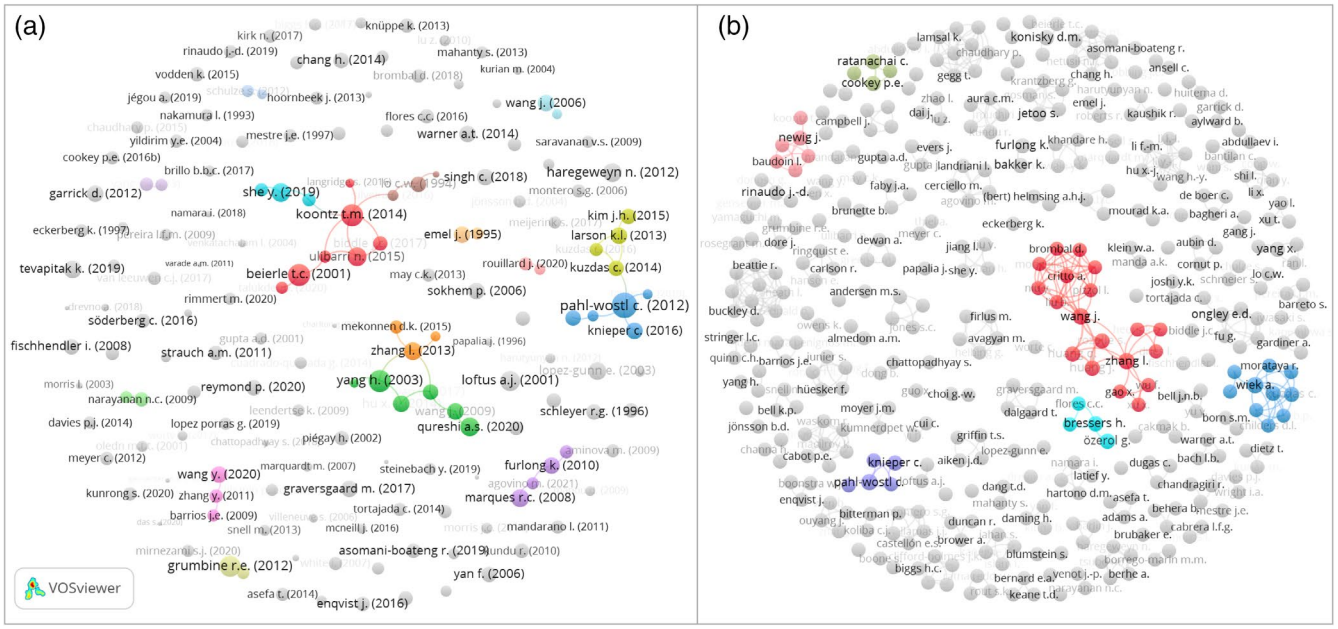


**FIGURE 1** | (a) Citation analysis (unit of analysis: Documents; weights: Total number of citations) and (b) co-authorship analysis (unit of analysis: Authors; weights: Documents) of the included studies.

## 4 | Water Governance Paradigms, Governance Characteristics, Water-Related problématiques, and Sustainability Outcomes

### 4.1 | Overview of Water Governance Paradigms

The water governance paradigms were coded according to a predefined list, based on inputs from the water governance scholars in the NEWAVE network and the existing literature on water governance. If we encountered paradigms not on our list during coding, we added them to the list (i.e., new public management). We observed during coding paradigms that most authors did not explicitly mention or address water governance paradigms. In such cases, we interpreted the papers based on our common knowledge of the specific characteristics of the paradigm, rather than seeking explicit naming. Therefore, the co-appearance of paradigms, governance characteristics, problématiques, and sustainability outcomes—discussed below—should be interpreted as artifacts of the coding process.

The distribution of these paradigms across papers varies, with some being more commonly discussed than others (Figure A4). For example, the "integrated approach to water management" was prevalent in 23% of cases ($n = 52$), while "resilience" was only present in 4% ($n = 9$). This could be attributed to several factors, potentially including the wide promotion of certain paradigms in policy and/or scientific spaces (e.g., IWRM and river-basin management [RBM]).

We also identified several patterns relevant to the paradigms, pointing to the dynamic, adaptable, and context-sensitive nature of water governance paradigms. First, 57% of the cases with a paradigm ($n = 101$ out of 176) observe more than one paradigm, with certain paradigms appearing more prone to combinations than others (Figure A5). For instance, "adaptive (co-)management or governance" co-appears with other paradigms in 96% of the cases ($n = 26$). In 65% of these cases ($n = 17$), more than two paradigms co-appear. Similarly, the "state-centric/command and control governance" paradigm co-appears with other paradigms in 75% of the cases, 62% of which ($n = 13$) have more than two paradigms.

The presented results might hint at the adaptable nature of paradigms, including their complementary (i.e., reinforcing each other) or competing (i.e., balancing each other) features (Halbe et al. 2013). However, the co-appearance of paradigms might also result from "just" the discursive or metaphorical application of certain paradigms. For instance, Biswas (2008) argues that, due to its fuzziness, IWRM is subject to various interpretations, and many people and institutions have used it just to obtain additional funds and greater acceptability and visibility, while continuing to pursue their existing practices. While these findings suggest the adaptable nature of paradigms, further in-depth analysis and interpretation are necessary to fully unpack their nuances and implications.

Regional differences are also observed, with certain paradigms being more common in cases from specific regions (Figure A6). For example, paradigms like "integrated approach to water management," "river-basin/catchment management," and "water as a common good and/or heritage" are more prevalent in European cases, while "community-based management" and "water as a resource seen by engineers" are more common in cases from Southern Asia (Figure A6). The observed patterns in the geographical distribution of certain paradigms might be related to policy enactment (e.g., RBM being a central tenet of mainstream water policies, such as the water-framework directive) or the long-standing existence of traditional and informal systems (e.g., community-based management).

Looking at the temporal prevalence of paradigms from the 1980s until the 2010s, we found that no paradigm once introduced, had



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completely disappeared from the reviewed water governance literature (Figure 2). Different paradigms dominated during different periods, with shifts occurring over time. For instance, from 1980 to 1990, "community-based management" was the dominant paradigm, which was followed by "governance with diffusion of authority." Subsequently, "market environmentalism" prevailed from 1995 to 2000, after which the "integrated approach to water governance" dominated from 2000 to 2010. "Adaptive (co-)management or governance" was prominent for the next half-decade, and from 2015 to 2020, "participatory and collaborative governance" became the leading paradigm.

## 4.2 | Governance Characteristics Observed Across Water Governance Paradigms

As presented in the Introduction, each paradigm, once introduced, comes with governance characteristics, in line with

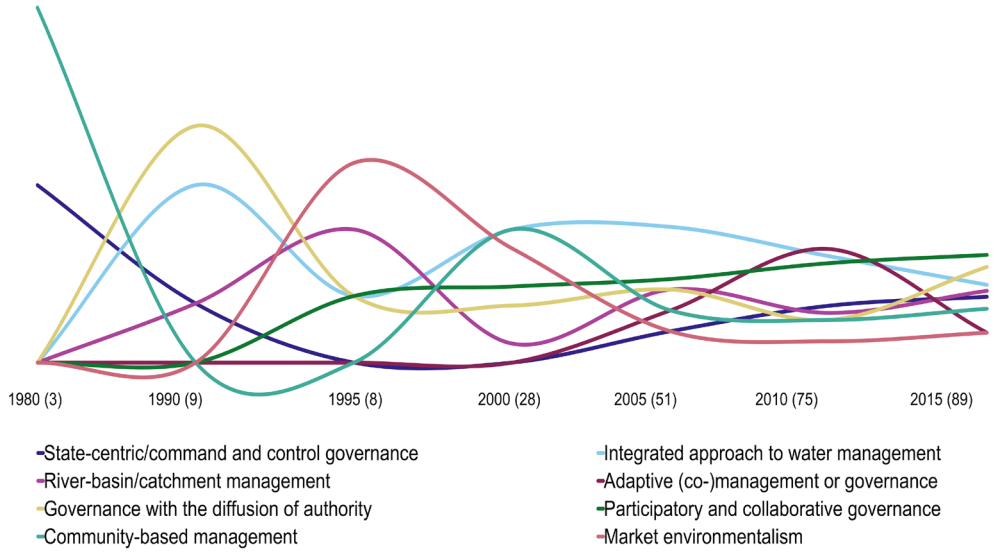


**FIGURE 2** | Temporal dynamics of the studied water governance paradigms. Vertical (y-axis) and horizontal (x-axis) axes represent years and number of cases, respectively. For every half-decade, the relative shares of the paradigms are depicted. The numbers in brackets correspond to the total number of paradigms mentioned in that half-decade.

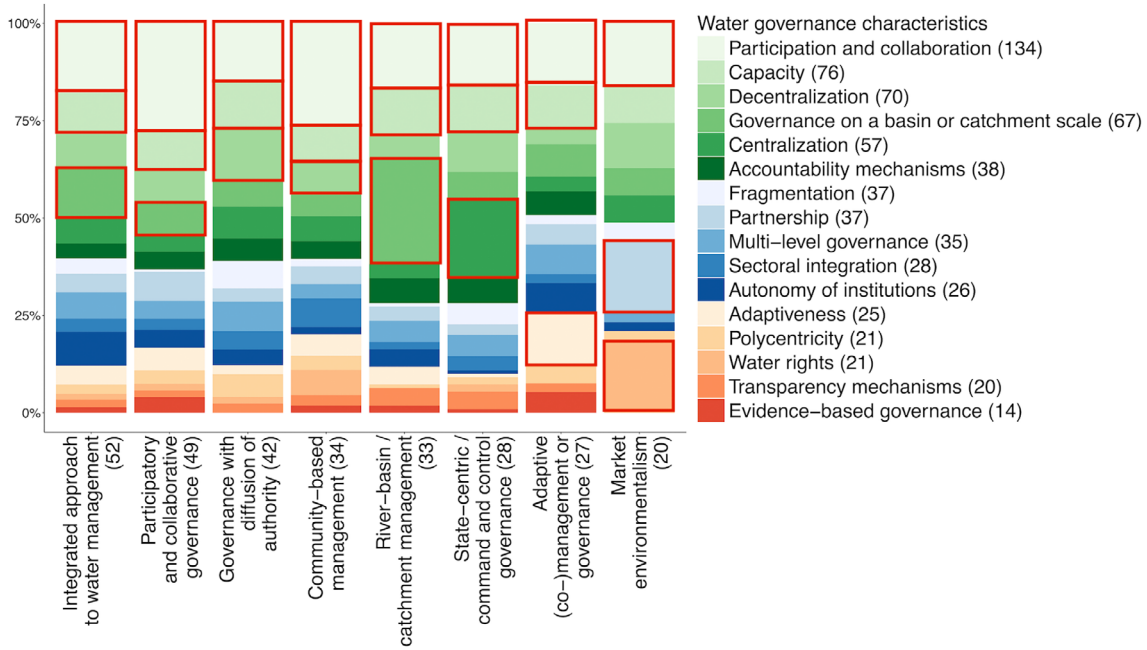


**FIGURE 3** | Governance characteristics by water governance paradigms. The numbers in brackets correspond to the numbers of cases with the respective governance characteristics or paradigms. The red rectangles in the figure indicate the three most frequently observed paradigms for each governance characteristic. A gradient color scale was chosen to improve the readability of the figure, especially for those with color blindness. The colors in the figure do not correspond to variations in values. [Correction added on 28 October 2024, after first online publication: Figure 3 caption has been updated.]



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certain principles they promote (Figure 3). For instance, the paradigms emphasizing participation and collaboration, like "participatory and collaborative governance" (36%; $n = 48$) and "integrated approach to water governance" (28%; $n = 37$), are consistently associated with these characteristics, reflecting their emphasis on involving stakeholders in decision-making. Similarly, capacity-building is most frequently coded together with the "integrated approach to water governance" (29%; $n = 22$) and "governance with the diffusion of authority" (28%; $n = 21$), as well as in more than half of the cases with "adaptive (co-)management" (58%; $n = 15$). This observation is as expected given the recognition of water system complexities (i.e., scalar or system) by these paradigms. Another example is water rights, which is identified as a common characteristic in the cases with the paradigms of "market environmentalism" and "community-based management," while 38% of the cases ($n = 8$) with water rights also have one of these paradigms. Both of these paradigms include water rights for their users.

However, the results also indicate that while each paradigm may have specific principles, their implementation in practice often leads to diverse governance arrangements. These arrangements are comprised of various governance characteristics, some of which may not fully align with the paradigm's fundamental principles. For example, we identified participation and collaboration in more than half of the cases for all paradigms, except "market environmentalism," where this governance characteristic is observed in 40% of the cases (n=7). This shows that most water governance cases involve a certain degree of participation, irrespective of how centralized a governance structure might be (e.g., "state-centric/command and control governance"). A larger share of participation and collaboration is expected, considering the steady increase in participatory, deliberative, and collaborative approaches to water governance implemented by governments, international donors, and organizations with different goals (van Buuren, van Meerkerk, and Tortajada 2019).

The diversity within each paradigm may stem from how institutional changes happen when a new paradigm is introduced. Streek and Thelen (2005) identified four types of changes: displacement (i.e., replacement of old institutional elements with new ones), layering (i.e., attaching new institutional elements to old ones), drift (i.e., keeping old elements by neglecting the changes in circumstances that alter their effects), and conversion (i.e., re-interpretation of old elements). The constellation of diverse governance characteristics within a paradigm may be attributed to the latter three of these four types of changes. This means that when a new paradigm arises, old institutional elements may continue alongside new ones or be reinterpreted in light of them.

A similar pattern is observed in the distribution of policy instruments. Despite network-style governance paradigms, like the "integrated approach to water management," being prevalent, regulatory policy instruments—associated more with hierarchical governance—are more commonly used across cases (Figure A7). Regulatory instruments are also dominant across all paradigms, with the exceptions of "market environmentalism" and "grassroots 'empowerment' (or commoning)."

### 4.3 | Water Governance Paradigms in Relation to Water-Related problématiques

We draw water-related problématiques from the cluster analysis of 155 empirical cases, excluding those without any

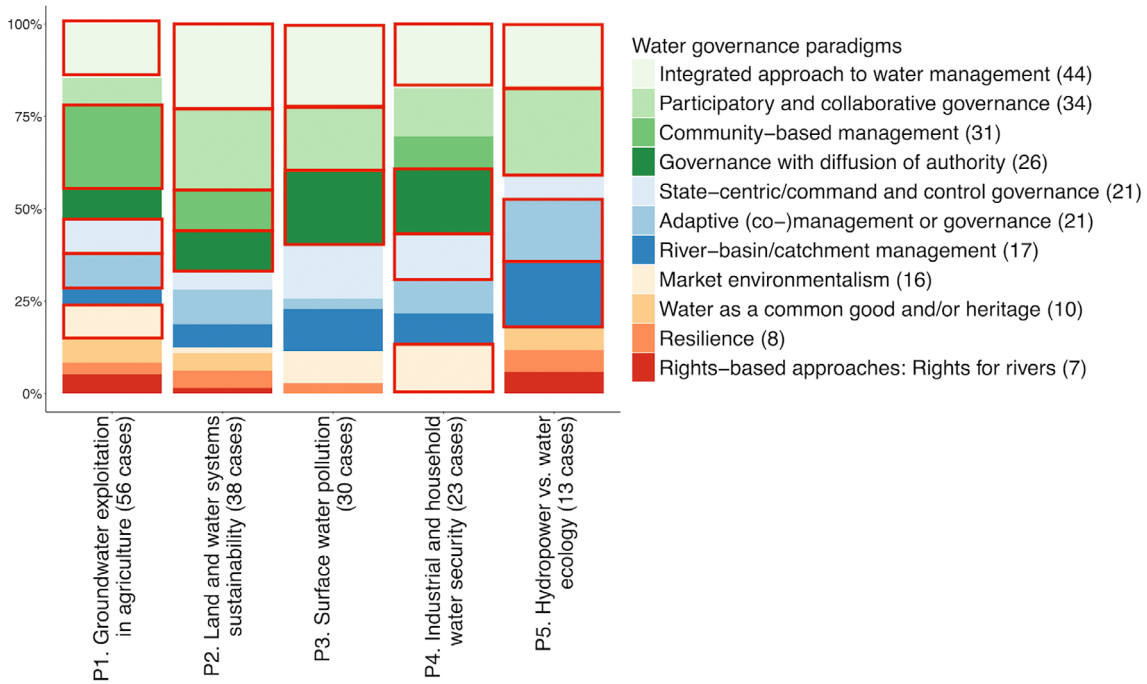


**FIGURE 4** | Distribution of paradigms across problématiques. Red rectangles in the figure indicate the most frequently observed three paradigms for each problématiques. The colors in the figure do not correspond to variations in values. A gradient color scale is chosen to improve the readability of the figure and make it easier to be read by those with color blindness.



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information on water resources, water use, or water-related sustainability issues (Bilalova et al., unpublished manuscript). Using agglomerative hierarchical clustering with Euclidean distance and Ward's method, we identified five distinct problématiques: "groundwater exploitation in agriculture," "land and water systems sustainability," "surface water pollution," "industrial and household water security," and "hydropower vs. water ecology." The largest problématique, "groundwater exploitation in agriculture," comprises 35% of cases and focuses on groundwater quantity associated with agricultural water use. "Land and water systems sustainability" includes 24% of cases and encompasses a broad range of sustainability issues and diverse water uses, addressing landscape development or ecosystem conservation. "Surface water pollution" covers 19% of cases, primarily addressing the water quality issues of surface water bodies linked to the discharge of pollutants. "Industrial and household water security" and "hydropower vs. water ecology" represent 14% and 8% of cases, respectively, with the former focusing on water supply for industrial and household uses and the latter on the impacts of hydropower production on water resources, including impacts on aquatic biodiversity and water quantity.

Figure 4 shows the distribution of water governance paradigms across the five problématiques, revealing some hotspots and gaps. While 65% of cases (22 out of 34) with the paradigm of "community-based management" fall within "groundwater exploitation in agriculture," no cases of that particular paradigm fall into the category of "surface water pollution." Additionally, our findings suggest that problématiques might motivate the employment of particular water governance paradigms (Figure 4). For instance, in "land and water systems sustainability" and "hydropower vs. water ecology," the participatory and collaborative governance paradigm is much stronger than in the other problématiques. One explanation might be that these problématiques deal with the complexities of water systems, which require both horizontal and vertical collaboration.

Such patterns across problématiques might indicate the responsiveness of governance paradigms to water problématiques. However, as presented in the introduction, paradigms play an important role in problem definition, so the explanation could also go the other way around. For instance, a lower share of cases with the "state-centric/command and control governance" paradigm in the "land and water systems sustainability" problématique could result from the paradigm's sole focus on water resources and its lack of holistic approach to comprehending water systems. In contrast, the cases in this problématique have a larger share of governance in the "integrated approach to water management" paradigm, which encourages a holistic and comprehensive approach to water governance through cross-sectoral integration.

Distinct governance characteristics are also evident across problématiques (Figure A8). For instance, in the "hydropower vs. water ecology" problématique, governance is characterized by capacity (43%; $n = 3$), governance on a basin or catchment scale (43%; $n = 3$), and multi-level governance (43%; $n = 3$). Governance in this particular problématique had no characteristics—such as water rights or sectoral integration—that might support the main argument that transboundary governance does not integrate with local agendas (Schulze 2012). The results also show that the "land and water systems sustainability" issue is mostly observed with the cases (13 out of 38) of governance on the basin and catchment scale across all problématiques. Additionally, we observe that decentralization is most prevalent in the "surface water pollution" problématique, likely due to the need for action on multiple scales, depending on the extent of the problem. Finally, we found that the "industrial and household water security" problématique lacks evidence-based governance structures, revealing a gap in evidence-based urban water governance.

### 4.4 | Sustainability Outcomes in Relation to Water Governance Paradigms

To assess the cases in terms of their sustainability outcomes, we coded each case as to whether the study authors reported it predominantly as a "success" (i.e., positive impact of governance on sustainability) or a "failure" (negative impact or failure of governance to adequately address a sustainability issue). We coded the ambiguous cases (not positive, negative, or mixed) as "neutral/mixed." About 42% ($n = 94$) are identified as "success" cases, 32% ($n = 72$) as "failure" cases, and 26% ($n = 57$) as neutral. The cases in the publications are well-distributed across the three types of outcome indicators that we coded.

The findings in this section must be interpreted with care, given that few of the studies (18%; $n = 41$) in our sample provide very detailed information about the impacts of water governance/interventions on sustainability outcomes by presenting qualitative/quantitative data on outcome results. However, this observation is not specific to our sample, as most studies reporting on the outcomes of water governance focus on outputs (e.g., program or plan), rather than impacts, primarily because a longer time horizon is required to study the impacts of certain governance or interventions (Akhmouch et al. 2022). Moreover, assessing how and to what extent governance affects sustainability is a daunting task, as actual changes in water ecosystems depend on a variety of environmental, social, political, historical, economic, institutional, and administrative factors (Akhmouch et al. 2022). These factors can also go beyond hydrological boundaries (Luetkemeier et al. 2021; Yang et al. 2016). Overall, there is no universal or harmonized set of measuring indicators that could capture all these complexities (Akhmouch et al. 2022), which raises a question about the measurability of the impacts of water governance.

Generally, we observe that certain paradigms, such as "participatory and collaborative governance," "integrated approach to water management," "adaptive (co-)management or governance," and "community-based management," among others, have been reported to result in better sustainability outcomes (Figure 5). For instance, Pereira, Barreto, and Pittock (2009) show how participatory river-basin management in the Sao Joao River basin in Brazil, implemented as a response to a eutrophication problem, has helped to address pollution and other environmental challenges. Another example could be the study by Brombal et al. (2018), discussing the integrated watershed management (IWM) program in China. The study shows how the implementation of the IWM program, coordinating water



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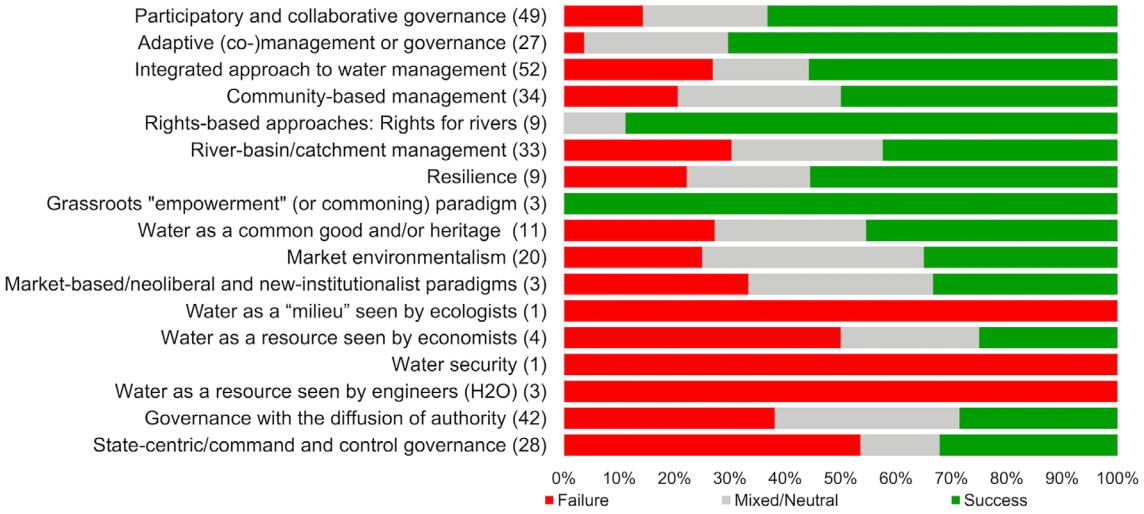


**FIGURE 5** | Water-related sustainability outcomes across water governance paradigms. The numbers in brackets correspond to the number of cases with the respective governance characteristics.

environmental management measures with urban planning, resulted in better environmental outcomes in terms of water quality (Cong et al. 2020).

Finally, we were also interested in intermediate outcomes in our cases, particularly their relation to paradigms. Intermediate outcomes are the short-to medium-term effects or changes that occur as a result of a governance intervention before the sustainability outcomes are realized and serve as important precursors to the sustainability outcomes. Examining their distribution, we note that an enabling (or challenging) environment and enhanced (or weakened) coordination and cooperation were major determinants of sustainability outcomes across all paradigms (Figure A9). Notably, we found no instances of behavioral change as an intermediate outcome in the "state-centric/command and control governance" paradigm.

In summary, our analysis of water governance paradigms highlights the prevalence of certain paradigms over others and reveals how they are mostly observed in combination. While each paradigm is linked to specific governance characteristics, they may sometimes be observed with characteristics diverging from their fundamental principles. Moreover, our findings suggest that paradigms exhibit responsiveness to water-related challenges. Finally, certain paradigms demonstrate better sustainability outcomes, although these outcomes are sensitive to other contextual factors.

## 5 | Conclusions and Ways Forward in the Scientific Understanding of Water Governance

Assessing 223 cases published in 165 academic papers, this study provides the first large-scale attempt to take stock of the multitude of water governance paradigms and how they relate to governance characteristics, problématiques, and outcomes. Although most of the studies in the reviewed literature are predominantly evaluative, which is useful for policymakers, the literature is largely fragmented, and many studies did not use explicit analytical frameworks, both of which hinder knowledge accumulation. The review also reveals how paradigms align with diverse governance arrangements and interact with water-related problématiques. Additionally, we found that paradigms like "integrated approach to water management," "participatory and collaborative governance," and "community-based management" are associated with better sustainability outcomes. Based on these findings and other reflections, we identify four areas where further research could enhance knowledge production in the water governance literature.

The review reveals that the research question concerning "what works (or does not work) to achieve a particular desired outcome or condition," which has a great potential to support evidence-based policymaking (Sanderson 2002), has received only limited attention in the studied literature. However, a better understanding of which configurations of governance systems have enhanced water availability, quality, and ecosystem well-being could inform policymakers about the policy actions to take. Further investigation into the 41 cases with detailed sustainability outcomes could provide valuable insights into the factors contributing to successful or unsuccessful outcomes in water governance.

Our results reveal that some paradigms, such as "integrated approach to water management," "participatory and collaborative governance," and "community-based management," are mostly associated with successful outcomes. However, this does not imply that these paradigms should be applied indiscriminately, as doing so would fall into the panacea trap argued by Ostrom, Janssen, and Anderies (2007), where one-size-fits-all solutions are inappropriately applied to diverse problems. We are also aware that the identified patterns in the sustainability outcomes of governance may be subject to biases, including a tendency to publish more statistically significant results or to seek out, interpret, and publish results that align with one's existing beliefs, viewpoints, and hypotheses (i.e., confirmation bias; Zvereva and Kozlov 2021). Also, it is



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important to emphasize that our study maps the literature on these governance paradigms and their reported sustainability outcomes without delving deeply into the context-specific details of each case. Therefore, while we observe positive outcomes, it is possible that our findings reflect some biases inherent in the studies reviewed. As such, this study's results should be further examined by comparing a set of these cases, using in-depth qualitative analyses. Such analysis should also consider interactions between governance configurations and contextual factors that might influence sustainability outcomes (Gupta, Pahl-Wostl, and Zondervan 2013). One potential approach is to employ qualitative comparative analysis to break down water governance into its constituent building blocks, identifying governance configurations and contextual factors that are necessary but not sufficient for achieving sustainable outcomes.

Furthermore, it is important to emphasize that governance characteristics not only emerge from the rational responses of actors but also result from political struggles over different interests, as power asymmetries substantially shape the process by influencing rule-setting, issue problematizing, and policy implementation (Morrison et al. 2019; Schlager and Blomquist 2008). To this end, integrating political-economic interests, discourse, institutional entrepreneurship, and power dynamics into the dialogue—and situating them within a historical context—would certainly enhance understanding of how water governance operates and whether it ensures the wellbeing of water systems (Clement 2010; Méndez, Amezaga, and Santamaría 2019; Sehring 2009).

As a way forward, this work offers a starting point for the development of a "diagnostic approach" (Cox 2011; Ostrom 2007) to identify a combination of governance characteristics that lead to certain sustainability outcomes under diverse contextual factors. Unlike overly simplified prescriptions for environmental problems, the diagnostic approach recognizes the nestedness of socio-ecological systems and the contextual nature of generalizations (Cox 2011; Pahl-Wostl et al. 2010). It identifies the causes of a particular outcome in the case by exploring the conditions that could lead to it and devises theories, hypotheses, and prescriptions that are generalizable or specific to one set of cases by comparing them to others (Cox 2011). Thus, future studies could explore interlinkages among the four elements presented in this paper—water-related problématiques, paradigms, governance characteristics, and sustainability outcomes—and incorporate them into a diagnostic assessment of the sustainability outcomes of water governance systems. These elements could be further unpacked into multiple conceptual tiers, depending on guiding policy or empirical questions (Ostrom 2007).

Finally, the case repository of this systematic review and the data extracted from the review of the included studies present an opportunity for researchers working on similar issues or interested in the in-depth exploration of certain cases and meta-research. The repository allows the examination of a diverse range of cases, such as those with positive and negative sustainability outcomes, as well as governance operating in similar and different water-related contexts and cases with water governance systems that have experienced shifts. Overall, we hope that this review and the case repository will contribute to an improved understanding of water governance and its outcomes, which will ultimately be central to water governance practitioners and researchers alike.

### Author Contributions

**Shahana Bilalova:** conceptualization (equal), data curation (lead), formal analysis (lead), investigation (equal), methodology (equal), visualization (lead), writing – original draft (lead), writing – review and editing (lead). **Jens Newig:** conceptualization (equal), investigation (equal), methodology (equal), supervision (equal), writing – review and editing (supporting). **Sergio Villamayor-Tomas:** conceptualization (equal), investigation (equal), methodology (supporting), supervision (equal), writing – review and editing (supporting).

### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The datasets generated and/or analyzed during the current study will be available after the paper published in the Leuphana University repository, https://doi.org/10.48548/pubdata-235.

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### Endnotes

[1] Throughout the paper, we will refer to "water-related sustainability outcomes" as "sustainability outcomes."

[2] NEWAVE is an EU Horizon 2020-funded project that aims to develop and implement a cutting-edge research agenda addressing crucial water governance priorities and future trends. The project also focuses on providing extensive interdisciplinary training to early-stage researchers (ESRs) (NEWAVE n.d.).

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