



Synthesis

Comparative studies of water governance: a systematic review

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ABSTRACT. Governance is key to tackling water challenges and transforming water management under the increasing pressures of competing water uses and climate change. Diverse water governance regimes have evolved in different countries and regions to regulate the development and management of water resources and the provision of water services. Scholars and policy analysts have been comparing these water governance regimes to analyze elements and processes, to assess performance, or to draw lessons. Although the number of such studies has increased since the 1980s, no comprehensive synthesis exists. We present such a synthesis by conducting a systematic review of the emerging field of comparative water governance studies, and we critically reflect on how water governance is defined, conceptualized, and assessed in different contexts. Based on the resultant insights, we identify four areas for future research: (1) improving the balance between small-, medium-, and large-*N* studies that are used in comparative studies of water governance; (2) conducting longitudinal comparisons of water governance to identify temporal governance trends and patterns; (3) expanding the geographical coverage of the comparisons to include underrepresented countries and regions, focusing more broadly on the global South; and (4) addressing the issues of justice, equity, and power, which are becoming increasingly important in tackling the water governance challenges that are exacerbated by the effects of climate change, industrialization, and urbanization.

Key Words: *comparative analysis; comparative studies; systematic review; water governance; water management; water policy*

INTRODUCTION

Water resources are under increasing pressure from competing uses and climate change (Rockström et al. 2009, IPCC 2014). Governance is acknowledged and investigated as a key challenge in achieving the long-term sustainability of this important resource (Rogers and Hall 2003, Bakker et al. 2008, OECD 2015, Pahl-Wostl 2017). Around the globe, diverse water governance regimes have evolved to regulate the development and management of water resources and the provision of water services (Hussey and Dovers 2007, Van De Meene and Brown 2009, OECD 2011). Scholars and policy analysts have responded by producing a broad body of literature comparing these water governance regimes to draw out diverse lessons (e.g., Benson and Jordan 2010, Pahl-Wostl et al. 2010, Herrala et al. 2012, Araral and Wu 2016). Here, we assess the state of scholarship on comparative water governance and its main characteristics. We identify trends, gaps, and ongoing issues to be resolved as the field progresses.

Varying perspectives exist on what defines water governance (de Loë and Kreuzwiser 2007, Woodhouse and Muller 2017). For our purposes, water governance is defined as “[...] the social function that regulates development and management of water resources and provisions of water services at different levels of society and guides the resource towards a desirable state and away from an undesirable state” (Pahl-Wostl 2015:25). This definition allows for the participation of nonstate actors but also encompasses situations in which actions and decisions are taken solely by state actors. Governance differs from the more

functional exercise of water management. Water management is defined as “the activities of analyzing and monitoring, developing and implementing measures to keep the state of a [water] resource within desirable bounds” (Pahl-Wostl 2009:355).

Comparisons of water governance serve several purposes. These include identifying the ways in which water governance is shaped across varied settings, assessing performance, and drawing out lessons on what works in which context and why (Wescoat 2009, Araral and Wu 2016). Comparisons often focus on certain elements of governance. These elements include, among others, laws and policies (e.g., Gemmer et al. 2011), performance (e.g., Scott 2015), intersectoral cooperation (e.g., Jager 2016), and public participation (e.g., Wehn et al. 2015). They also include related concepts such as integrated water resources management (e.g., Brown et al. 2003) and the water–energy–food nexus (e.g., Lawford et al. 2013). Diverse definitions and methods build the basis for comparing water governance concepts and regimes across cities, river basins, countries, sectors, and regions, as well as across political, institutional, and economic contexts.

Although the number of comparative studies in water governance is increasing, there has not yet been a synthesis of these studies. Moreover, little reflection has been conducted on the different governance elements, the methods that are chosen for comparison, and the implications of those comparative choices for different water problems (excepting Wescoat 2009). To bridge these knowledge gaps, we present a systematic review of the emerging field of comparative water governance studies. We critically reflect on how water governance is defined,

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Table 1. Overview of search strings used and resulting numbers of publications. Total $N = 214$ publications.

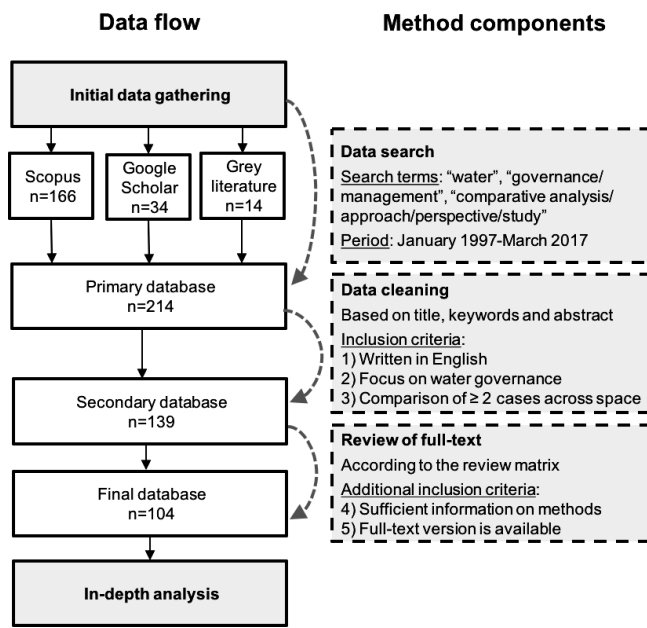
Search string	Number of publications from Scopus search engine	Number of additional publications from Google Scholar and knowledge repositories
1. “water” AND “governance” AND “comparative analysis”	80	11
2. “water” AND “management” AND “comparative analysis”	25	6
3. “water” AND “governance” AND “comparative approach*” OR “comparative perspective*” OR “comparative stud*” OR “comparison*”	61	31
Total	166	48

conceptualized, and assessed in diverse contexts, paying specific attention to the governance elements and methodologies used for comparative analyses. In doing so, we aim to provide researchers and practitioners with clear direction on how to advance the practice of comparative analysis in water governance.

REVIEW METHOD

To obtain a comprehensive overview of comparative studies of water governance, we conducted a social science systematic review (Petticrew and Roberts 2008). Systematic reviews are useful for synthesizing trends and abstracting findings from large bodies of information. The review approach and process were collaboratively designed and executed by a team of 12 international water governance scholars. All authors participated in regular online meetings to discuss the data gathering, review, and writing process. The review stages are detailed in Fig. 1 and described further below.

Fig. 1. Schematic representation of the systematic review process.



Data gathering and screening

The review focuses on publications that compare empirical cases for which data were collected by the authors of the publications or by other researchers. A “case” refers here to a delimited phenomenon, or a unit, observed at a single point in time or over some period of time (adapted from Gerring 2007:19). During the initial screening process, three inclusion criteria were applied:

1. The publication is written in English;
2. The publication contains a comparison of at least two empirical cases across geographical space;
3. The publication focuses on the governance of water resources or services (as defined earlier). Publications that compared cases from both water governance and other relevant topics such as environmental protection were included in the review (e.g., Newig and Fritsch 2009, Mahalingam et al. 2011).

During the data gathering stage, these criteria were translated into a search string that was designed to capture publications that address water governance and apply comparative approaches (Table 1). Both academic literature and professional publications were targeted. To identify peer-reviewed literature (i.e., scientific journals, books, book chapters, and conference proceedings), the search string was used to search the Scopus database. This search returned 166 publications that met the first three inclusion criteria. The search was limited to the period from January 1997 to March 2017. Scopus was selected because of its broad coverage of social sciences. We ran a parallel search in Google Scholar, focusing on the first 200 results. The Google search added 34 new publications to our database. To capture professional publications (“grey” literature), we searched the Organisation for Economic Co-operation and Development (<http://www.oecd-ilibrary.org>) and United Nations (<http://www.un-ilibrary.org>) repositories. These searches added 14 publications to the review process. After removing duplicates, bibliographic data from 214 publications were compiled in an online spreadsheet for analysis.

The abstract, title, and keywords of each publication were screened by two members of the review team (authors of publications were not allowed to review their own publications). If these three areas provided insufficient information to make a decision on inclusion, the full text of the publication was examined. After screening the 214 publications, 139 publications were retained for inclusion in the in-depth review. We are aware of several potentially relevant publications that were not captured

by the database scans. However, the final database is the result of the strict application of selection criteria and provides sufficient coverage of publications on comparative water governance to develop comprehensive insights.

In-depth review process

During the in-depth review process, two more inclusion criteria were applied in addition to the first three criteria:

1. The publication provides sufficient information to conduct an in-depth review of the parameters used for the comparison, data sources, data collection, and analysis methods;
2. The publication's full-text version is available to the review team.

One publication was excluded because the review team could not access the full text. Another 34 publications were excluded because they were conceptual rather than empirical ($N = 11$) or they did not focus on water governance or provide sufficient information to conduct an in-depth review ($N = 23$). The results presented here are based on the analysis of the final dataset of 104 publications (see Appendix 1 for the list of publications included in the in-depth review).

The review process was guided by a review matrix that contained entries for thematic and geographic scope, definition of water governance, comparative framework, governance elements that are being compared, unit of analysis, case selection rationale, case delineation, data collection and analysis methods, and comparative methods. An initial version of the matrix was developed based on existing reviews of water governance and management (e.g., Cook and Bakker 2012, González Tánago et al. 2016, Varady et al. 2016). This matrix was tested by the review team using the same four publications to ensure that all team members had a common understanding of the review categories. The matrix was refined based on feedback from team members. The refined matrix (Appendix 2) was then used to review the 104 full-text publications. Each publication was reviewed by two members of the review team. Each team member reviewed approximately 11 publications as first reviewer, and another 11 publications as second reviewer. Differences in interpretation were resolved through discussions between the two reviewers and, where necessary, with the larger review team.

Limitations

The final database of reviewed publications does not contain any professional studies, despite the initial aim to capture that literature. The selection criteria required sufficient information on the comparative framework and methods used to conduct an in-depth review using the review matrix. None of the professional publications returned in the searches provided sufficient information. Book chapters and introductions or conclusions to journal special issues were often excluded for the same reason. As well, given our interest in elements and methods of comparison, only publications that compared at least two empirical cases were included in the review. As a result, conceptual papers, which did not compare empirical cases, were excluded. Finally, review is a subjective process that involves many decisions regarding how to classify publications. We attempted to limit subjectivity through the review process described above. However, some variation in interpretation is inevitable.

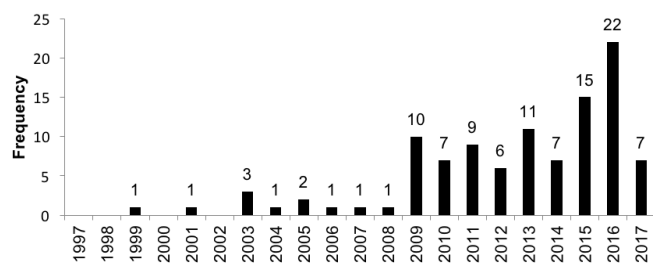
EMERGENCE AND CONCEPTUAL BASIS OF COMPARATIVE WATER GOVERNANCE STUDIES

Here, we provide a descriptive overview of the evolution of the comparative water governance field based on an analysis of the reviewed publications. We focus on how attention to comparative studies is evolving, how water governance is defined, what governance elements are compared, and which frameworks are used.

Comparative studies of water governance in the academic literature

To obtain a comprehensive overview of the scholarly literature on comparative water governance, we analyzed the number of publications over time and in different journals, the publications that were most widely cited, and the major issues on which the reviewed publications focused. Examining the number of publications over the past two decades (1997–2017) showed a gradual increase since 2009 (Fig. 2). Because the publications were selected through a systematic process, this is an indication that scholarly attention to comparing water governance across two or more case studies is growing.

Fig. 2. Number of publications each year meeting the search criteria (January 1997–March 2017).



Although the comparative studies on water governance are published in diverse outlets, the most popular journals were *Environmental Policy and Governance* (nine publications), *Ecology and Society* (seven publications), *Water Policy* and *Environmental Science and Policy* (six publications each), and *Regional Environmental Change* and *Water International* (four publications each). Further analysis of the most widely cited comparative water governance publications in Scopus (Table 2) shows that most of these publications were published in water- or environment-oriented journals in the period between 2009 and 2012. The number of cases compared as well as the methods used for comparison vary significantly. There is no correlation between a high number of citations and a specific journal or method, or a high or low number of cases. The first publication (Newig and Fritsch 2009), which stands out in terms of number of citations, is a meta-analysis of 47 cases on environmental governance, including cases on water governance.

Comparative water governance studies focus on a wide range of water-related issues (Table 3). The greatest proportion of the reviewed publications ($N = 25$) focuses on river basin management. Other issues that were frequently examined include agriculture ($N = 14$) and urban water services ($N = 13$). The majority of the agriculture-oriented publications are centered on

Table 2. Overview of the most-cited articles, receiving > 50 citations in Scopus until March 2017.

Times cited	Authors	Year	Title	Journal	Number of cases compared	Comparative method
256	Newig and Fritsch	2009	Environmental governance: participatory, multi-level and effective?	<i>Environmental Policy and Governance</i>	47	Statistical
76	Pahl-Wostl et al.	2012	From applying panaceas to mastering complexity: toward adaptive water governance in river basins	<i>Environmental Science and Policy</i>	29	Mixed: statistical and qualitative
71	Mukherji and Shah	2005	Groundwater socio-ecology and governance: a review of institutions and policies in selected countries	<i>Hydrogeology Journal</i>	4	Qualitative
56	Huntjens et al.	2010	Climate change adaptation in European river basins	<i>Regional Environmental Change</i>	4	Mixed: qualitative and formal comparative analysis
56	Srinivasan et al.	2012	The nature and causes of the global water crisis: syndromes from a meta-analysis of coupled human-water studies	<i>Water Resources Research</i>	22	Set-theoretic
55	Huntjens et al.	2011	Adaptive water management and policy learning in a changing climate: a formal comparative analysis of eight water management regimes in Europe, Africa and Asia	<i>Environmental Policy and Governance</i>	8	Mixed: statistical and set-theoretic
53	Meijerink and Huitema	2010	Policy entrepreneurs and change strategies: lessons from sixteen case studies of water transitions around the globe	<i>Ecology and Society</i>	16	Qualitative
52	Harris and Alatout	2010	Negotiating hydro-scales, forging states: comparison of the upper Tigris/Euphrates and Jordan River basins	<i>Political Geography</i>	2	Qualitative
51	Garrick et al.	2009	Water markets and freshwater ecosystem services: policy reform and implementation in the Columbia and Murray-Darling basins	<i>Ecological Economics</i>	2	Qualitative

irrigation (13 of 14). Six of these irrigation-centered publications investigate institutions or institutional reforms, and three investigate the functioning of water user associations. Within the category of urban water services, water supply ($N = 4$), water utilities ($N = 3$), and wastewater ($N = 3$) are the three main subissues examined. The remaining categories all contain between four and seven publications. Our selection includes 27 publications that did not fall within one of the predefined categories. These publications focus on diverse issues such as coastal recreational water quality, water quality in urban and rural areas, and comparison of user- vs. agency- vs. market-based governance.

Definition of water governance

For the selected publications, we analyzed whether and how water governance was defined. Of the 104 publications, 31 do not provide a definition of water governance or of a specific aspect or form of governance. Almost half of the reviewed publications ($N = 51$) provide a definition of a specific aspect or form of water governance, rather than a generic definition. The aspects that were most commonly defined are public participation or participatory governance ($N = 6$) and adaptive capacity or governance ($N = 5$). In addition, definitions of the following aspects or forms of governance were provided in three publications each: groundwater governance, multilevel governance, collaboration or collaborative governance, and integrated water (resources) management. The remaining publications in this category ($N = 28$) provide definitions for a wide range of governance aspects and forms.

Table 3. Categorization of the main governance issue compared across cases.

Main issue	Number of publications
River basin management	25
Agriculture	14
Urban water services	13
Flood risk governance	7
Groundwater governance	5
Transboundary water management	5
Environmental protection	4
Watershed management	4
Other	27
Total	104

Only two publications propose their own definition of water governance. First, Pahl-Wostl et al. (2012:25) define water governance as a system with “structural features and transient processes at both rule making and operational levels,” that “takes into account the different actors and networks that help formulate and implement water policy.” Araral and Yu (2013:5307) define water governance in terms of “various dimensions of water law, policies, and administration that have been commonly regarded in the literature as determinants of performance. These include water rights, pricing, decentralization, accountability, integration, private sector participation, user group participation, and organizational basis of water management, among others.”

From the reviewed publications, fewer than one-quarter of them ($N = 20$) refer to an existing definition of water governance. Only

one existing definition of water governance, which is the definition by the United Nations Development Programme (UNDP 1997), is cited in two publications. All other existing definitions (18 in total) are cited only once. In eight publications, two different references are cited when providing a definition of water governance. This result implies that there is no common approach to defining water governance within studies of comparative water governance. However, this situation may be partially explained by the emphasis of comparative studies on varying aspects or forms of governance, rather than a broad, encompassing definition of water governance.

Governance elements being compared

To understand what is being compared, we identified eight different categories of water governance elements (Table 4). These governance elements are based on Rogers and Hall (2003), one of the most-cited publications that elaborates on the principles and conditions of water governance. Rogers and Hall (2003) acknowledge the integrated nature of the principles and conditions for operationalizing normative or performance-oriented governance concepts such as “good” and “effective” water governance. We used these concepts as the basis for categorizing the multiple elements of water governance; however, we did not apply them to evaluate the governance systems. While scrutinizing the governance elements compared in the reviewed publications, we observed that most publications considered two or more governance elements ($N = 66$). The most common governance element is “legislation, instruments, and policies” ($N = 52$). For example, Lopez-Gunn (2003) compares the types of rules developed by different regional water authorities in Spain. Likewise, Erickson (2015) compares state-level water management and funding policies in USA.

Table 4. Theoretical concepts or governance elements that were assessed and compared in the publications.

Concept or element	Number of publications
Legislation, instruments, and policies	52
Participation and stakeholder involvement	41
Water or environmental management and outcomes	37
Cooperation and coordination	36
Governance qualities	35
Governance levels	29
Resources	28
Knowledge or expertise	17
Other	20

“Participation and stakeholder involvement” is often interpreted as a key component of water governance, as reflected in the high number of publications ($N = 41$) focusing on it. However, the issues investigated in relation to participation vary significantly. For example, Wehn et al. (2015) compare participation in flood risk management in the UK, Netherlands, and Italy. Benson et al. (2013) specifically compare the nature and quality of participation in their examination of the collaborative turn in water management across Europe, USA, and Australia. Publications focusing on “water or environmental management and outcomes” ($N = 37$) often look at the efficacy of water

governance. For example, Scott (2015) systematically compares physical water quality indicators to determine whether collaborative governance processes actually produce the improved environmental outcomes that they are assumed to create. The next most common category ($N = 36$) specifically compares “cooperation and coordination.” To illustrate, Pahl-Wostl et al. (2012) compare regimes varying in coordination and power distribution and determine that those with distributed power but effective coordination perform better than those without such characteristics. Other common categories were “governance qualities” such as transparency, inclusion, coherence, equity, accountability, efficiency, and adaptiveness ($N = 35$); “governance levels” ($N = 29$); “resources” such as power and finance ($N = 28$); and “knowledge or expertise” ($N = 17$). The publications in which the compared governance elements were not sufficiently captured by the eight predefined categories were assigned to the ninth category: “other” ($N = 20$).

Frameworks used to perform comparative analysis

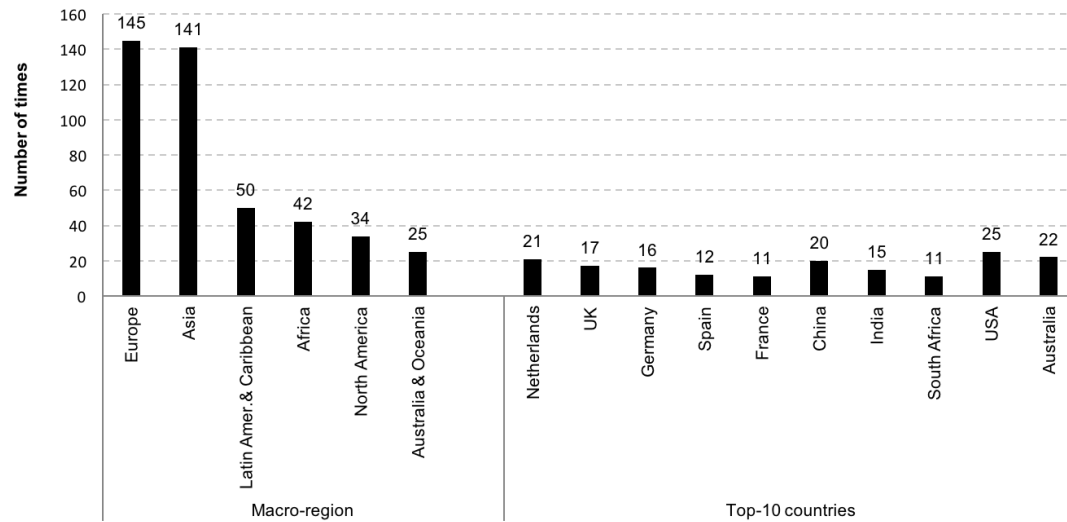
We expected frameworks to play an important role in comparative studies. Following Ostrom (1990:192), we define a framework as a “set of variables and the types of relationships among variables that need to be examined in conducting any theoretical or empirical study of a particular type of phenomenon.” The frameworks for performing comparative analysis fall into one of four categories: (1) application of an existing framework for the comparison of cases; (2) development of a new framework based on theory, which is then used for the comparison of cases; (3) inductive development of a new framework out of the comparison of cases; and (4) no or unclear framework.

Almost half of the publications ($N = 54$) develop their own framework from existing theory and then use it to compare cases. Of these, 32 publications created “original” frameworks that used diverse theory to construct a new framework for comparison. For example, Van Buuren et al. (2016) use theory on policy processes, power, and framing to develop a comparative framework that examines processes of “puzzling, powering, and framing.” The remainder of articles in this category ($N = 22$) create a new framework by building on a specific existing framework or approach.

About one-fifth of the publications ($N = 19$) use existing frameworks for comparison without making major modifications. Ostrom’s institutional analysis and design (IAD) and social-ecological system (SES) frameworks, both based on institutional design principles, are used most frequently ($N = 4$ each). Dinar and Saleth’s (2005) framework on water policies, laws, and administrations, and Bressers et al.’s (2013) water governance assessment tool are both applied twice. Other existing frameworks that were identified are all used just once. No single framework emerged that is widely used for comparative analyses of water governance in its original form.

There was significant diversity in the frameworks used after modifications or adaptations. Two frameworks were most often modified or adapted to build new frameworks, namely, Ostrom’s design principles ($N = 4$), and Pahl-Wostl’s framework for analyzing regime characteristics ($N = 3$). For example, Huntjens et al. (2010) integrate Pahl-Wostl’s (2007) framework with the river basin assessment framework of Raadgever et al. (2008) to develop a new framework for comparison.

Fig. 3. Number of cases located in a specific macroregion and country.



In seven publications, authors construct new frameworks through an inductive approach. In these cases, the comparative framework is developed as a result of the comparative analysis instead of using a predefined framework to guide comparisons. For example, Lebel et al. (2005) follow an inductive process to develop and test measures of “fit” relative to water governance regimes. These fit measures are then compared across geographical settings.

Upon in-depth examination, we found that almost one-quarter of the studies ($N = 24$) that made it through the first two rounds of screening do not clearly articulate their comparative framework, i.e., they did not explicitly show which specific governance elements they compared. These articles contained enough information for the review team to conduct a review, but required close reading of the study results to determine what authors were comparing. For example, Brown et al. (2006) summarize findings across three cases and provide lessons on impediments to the implementation of sustainable urban water management. However, they do so without clearly describing the elements they compared.

A cross-sectional analysis of the frameworks and the compared governance elements shows that when existing frameworks are used ($N = 19$), comparisons mainly focus on multilevel governance systems and institutions ($N = 3$ each). For papers that develop their own frameworks from existing theory ($N = 54$), comparisons focus mainly on actors, institutions, multilevel governance, and adaptive capacity.

CASES, DATA, AND METHODS USED FOR COMPARING WATER GOVERNANCE

Here, we focus on the empirical cases that are compared in the reviewed publications. We examine why the cases are selected, where they are located, what boundaries are used to delineate cases, and what data and methods are used.

Case selection rationale

During the review process, we collected qualitative information about the rationale behind the selection of empirical cases for

comparison. Four general, partly overlapping categories emerged as we refined the review matrix. The most frequent rationale ($N = 42$) is the selection of cases that are similar (in terms of key characteristics) or most similar (cases are very similar and only differ in the dependent variable). For publications in this category, the authors’ main goal is to examine and understand a specific issue in multiple, similar cases. For example, Brisbois and de Loë (2017) studied the actions, roles, and motivations of the natural resource industries involved in collaborative water governance in two case studies that involve active participation of both provincial government representatives and major natural resource industry actors. Silveira et al. (2016) selected cases from two river basins that are similar (industrialized, densely populated, and intense trade-offs) and thus likely to necessitate cross-sectoral collaboration. They compare two cases that are very similar (two sub-basins of the same river basin) as well as two sub-basins that are similar but differ in terms of physical and governance characteristics (European vs. Chinese catchments).

Another popular rationale ($N = 20$) is to study specific issues or to extract some critical findings by comparing diverse cases. For example, Mosello (2015) examine adaptive capacity across developed and developing country cases. Meijerink and Huitema (2010) compared 16 diverse cases to extract the change strategies of policy entrepreneurs in water transitions.

Data availability is also a frequent rationale for case selection ($N = 14$). For example, Lebel et al. (2013) and Knieper and Pahl-Wostl (2016) both use the data set that was created during the European Twin2Go project. However, most of studies that cite data availability as a case selection rationale also indicate other rationales. For example, Newig and Fritsch (2009) explain that, although completeness of information was their main selection criterion, they used a diversity of cases in terms of political issues, scales, and societal contexts as other criteria.

Lastly, almost one-quarter of publications ($N = 28$) do not provide a clear rationale for case selection. They refer to similarities and differences at the same time ($N = 8$) or simply focus on a specific

geographical area ($N = 20$). For example, Yu et al. (2016) studied two villages in the Shiyang River basin to explore whether water user associations can improve water governance in China. The reasoning for selecting these cases is not explained in the publication.

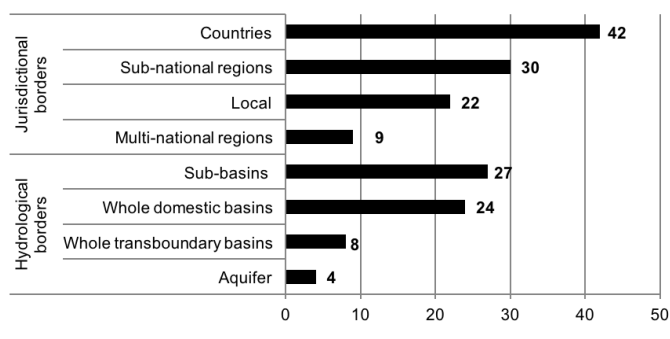
Locations and boundaries of cases

For all reviewed publications, we identified the locations of the compared cases in terms of their macroregions and countries (Fig. 3). From this analysis, it can be discerned that Europe (145 cases) and Asia (141 cases) are by far the most represented macroregions. In contrast, USA and Australia are the most-studied countries, with 25 and 22 cases, respectively, although they are both in other macroregions. The Netherlands is the most-studied country in Europe (21 cases), whereas China is the most-studied country in Asia (20 cases).

It is also worth noting that, in some publications, the European Union (EU) is treated as a single unit of analysis to compare it with federal political systems such as in USA and Australia (e.g., Benson and Jordan 2010, Benson et al. 2012, 2013). Also of interest is that the single states of the USA are sometimes compared with other countries. This means that there are some cases where the jurisdictional comparison is not between similar administrative units but, for example, between a subnational unit and a national unit, or a national unit and a multinational unit.

Publications were also analyzed with regard to the jurisdictional and hydrological boundaries applied to delineate cases. We found that 85 publications use jurisdictional boundaries, 18 publications use hydrological boundaries, and 31 publications use both hydrological and jurisdictional boundaries to delineate cases (Fig. 4). For example, Pahl-Wostl et al. (2013) delineate their cases by a combination of jurisdictional and hydrological boundaries (i.e., Hungarian Tisza basin, German Rhine basin, Dutch Rhine basin). In one publication (Edelenbos et al. 2015), it is unclear from the case descriptions whether the names of the selected cases represent hydrological or jurisdictional boundaries.

Fig. 4. Number of cases using different types of jurisdictional and hydrological boundaries.



From the publications that apply jurisdictional boundaries (either exclusively or in combination with hydrological boundaries), countries are used to define case boundaries in 42 of these publications. Subnational ($N = 30$) and local ($N = 22$) boundaries are also used. Multinational boundaries (9 publications) are the least common. In the set of publications using hydrological

boundaries, the type used most often are sub-basins of transboundary or domestic basins ($N = 27$) followed by whole domestic basins ($N = 24$; Fig. 4).

Case study data and methods

The number of cases compared varies widely, ranging between 2 and 233. Most publications include two ($N = 41$) or three ($N = 20$) case studies in their comparisons. More than 50 cases are compared in only three publications (Heikkila 2004, Scott 2015, Zingraff-Hamed et al. 2017).

We categorized the publications with regard to the use of primary and secondary data. Primary data implies that original data are collected directly by the researchers involved, e.g., through interviews, questionnaires, observations, or document analysis, to meet a specific research goal (Hox and Boeije 2005). Secondary data are gathered on the basis of previous studies; these data can include sources such as censuses, government reports, and previous projects that did not involve the authors (Ghauri and Grønhaug 2005). Many of the reviewed publications ($N = 59$) are based on primary data. For these publications, data were collected mainly using qualitative methods such as interviews and document analysis. In addition, a few publications are based on large- N surveys (e.g., Lebel et al. 2013, Kadirbeyoglu and Özertan 2015, Harris et al. 2017, Zingraff-Hamed et al. 2017). We also identified one publication for which the authors conducted field experiments (Ibele et al. 2017). Only seven publications are based exclusively on secondary data. These data were sometimes obtained for research purposes by other authors (Doorn 2017) or by the authors themselves (Pahl-Wostl and Knieper 2014, de Boer et al. 2016) within the context of previous research. In several publications, the authors use data that were collected by others for organizational purposes (Herrala et al. 2012) or within the context of cyclical reporting (Jager 2016). Finally, 24 publications used both primary and secondary data, whereas 15 publications did not provide detailed information about how data, most notably documents, were collected and analyzed.

To obtain an improved understanding of the methods that are used in comparative water governance analysis, we made a distinction among three broad categories of methods: (1) qualitative methods, (2) quantitative methods, and (3) set-theoretic methods (Table 5). Set-theoretic methods are studied as a separate category because they focus on membership scores of elements in sets. These methods are particularly useful when comparison aims to draw attention to complex causal patterns. One of the most well-known set-theoretic methods applied in water governance research is qualitative comparative analysis. It is often applied to the analysis of a mid-sized number of cases, but can also be used to analyze a large number of cases (Schneider and Wagemann 2012).

A majority of the analyzed publications ($N = 76$) compares cases using qualitative methods only. Most of these qualitative studies ($N = 56$) compare only two or three cases. In 17 publications, four to six cases are compared. Three publications compare a mid-sized number of cases (11–16). Three-quarters of the exclusively qualitative studies ($N = 56$) compare cases on the basis of descriptive information only. To allow for a more systemic approach or comparison, authors sometimes use systematic coding of data (e.g., Brisbois and de Loë 2016) or present their results in tables (e.g., Vink et al. 2015) or visuals (Pahl-Wostl et

al. 2013). In addition, comparisons are sometimes made using categories to rank the cases systematically (e.g., absence or presence; measurement scales; low, medium, or high; none, little, or strong).

Table 5. Number of publications using qualitative, quantitative (statistical), or set-theoretic methods as a single analysis method or in combination with another method.

Method	Used as a single method	Used with another method
Qualitative	76	12
Quantitative	7	15
Set-theoretic	6	3
Total	89	15†

†In mixed-method approaches, quantitative methods are used together with qualitative or set-theoretic methods. Therefore, quantitative methods are counted twice, and the total number sums to 15.

Quantitative methods are used to compare cases in 22 publications, but only a minority ($N = 7$) of these studies solely applies quantitative methods. The quantitative methods that are applied include descriptive statistics (e.g., weighted mean, standard deviation), statistical analysis (e.g., regression or correlation analysis, measures of fit), and other quantitative methods such as economic models or data envelopment analysis (a programming methodology to measure the efficiency of multiple decision-making units). For example, Chai and Schoon (2016) use data envelopment analysis to measure the efficiency of government spending, and use qualitative comparative analysis to compare data for 20 counties in south China.

In 12 publications, both quantitative and qualitative methods are used. For example, Huntjens et al. (2010) combine formal comparative analysis with qualitative information to compare cases. Pahl-Wostl et al. (2012) combine linear regression analysis with case-sensitive analysis and clustering. Zingraff-Hamed et al. (2017) compare cases using methods for statistical analysis and qualitative textual analysis. We also identified three publications that combine quantitative methods with methods for qualitative comparative analysis. Publications that rely on statistical methods alone are relatively uncommon ($N = 5$).

In five publications, quantitative methods are used to compare a large number of cases (> 40). For example, Scott (2015) uses hierarchical linear regression modeling to compare 233 collaborative watershed groups. Dinar and Saleth (2005) use descriptive statistics to compare water institutions across 43 countries. Newig and Fritsch (2009) present a meta-analysis of 47 participatory governance cases. In seven publications, quantitative methods are also used when authors compare a very small number of cases. For example, Araral and Ratra (2016) compare water governance in India and China, and Harris et al. (2017) compare urban settlements in Ghana and South Africa with respect to gender issues. In both publications, data were collected using a survey questionnaire and were analyzed using statistical methods. The two countries were then compared on the basis of the resulting quantitative figures. Thus, the actual comparison was not done using statistical analysis.

DISCUSSION

Our review reveals a number of findings that help characterize the field of comparative water governance, and illuminates directions for improvement and future research. We highlight three important issues.

Emergence of comparative water governance studies as a new field

The analysis of reviewed publications shows several general trends in the practice of comparative water governance. In particular, the comparative study of water governance is a relatively recent phenomenon. Most comparative studies of water governance have been published since 2009. This finding is likely reflective of the fact that water governance itself is a fairly young field (Pahl-Wostl 2015). Discussions of “governance,” as opposed to “government,” arose in the 1980s amid increasing political and institutional reforms that introduced market-focused as well as participatory mechanisms. Private companies and civil society organizations were increasingly seen to have a role in making and executing decisions that had formerly been the sole purview of governments (Rhodes 1996, Peters 2001). Studies that examine water governance have proliferated since the late 1980s (Woodhouse and Muller 2017). As the literature has expanded, it is logical that scholars have begun to focus on what generalizable findings can be gleaned by comparing across multiple cases. We expect that there will be more emphasis on comparing water governance across different settings in the coming years.

Conceptual basis of comparative water governance studies

Definitions of water governance are very distinct or diffuse, and there is no agreement on a common definition. Similarly, there is no single framework that is widely used for comparative analyses of water governance. More than half of researchers substantially modified existing frameworks, or developed their own framework from existing theory, and then used this to compare cases (e.g., Heikilla 2004, Erickson 2015). Nevertheless, digging more deeply into the frameworks that are used as base material to create modified frameworks, the influence of Elinor Ostrom on the field of comparative water governance becomes clear. Ostrom’s own work (e.g., Ostrom 1990) is directly cited only eight times across publications that either made use of her framework directly or modified it. However, many of the other frameworks that are cited draw upon Ostrom’s design principles or the IAD framework. For example, the management and transition framework of Pahl-Wostl et al. (2010) builds upon the “action situation” concept in the IAD framework (Ostrom 2005), and the water governance assessment tool of Bressers et al. (2013, 2016) references Ostrom’s design principles and ideas.

More generally, there appear to be three distinct substreams within the research community. In the first substream, researchers focus on building databases and abstracting findings based on comparisons that use broad frameworks in a systematic manner to make more defensible claims (e.g., Knieper and Pahl-Wostl 2016). This idea can be traced back to the SES framework (Ostrom 2007), which allows sophisticated analyses and comparisons of SESs to overcome the promotion of panaceas in resources management. Publications using the management and transition framework provide another example of this substream (e.g., Knieper et al. 2010, Pahl-Wostl et al. 2013). The second substream builds upon existing theory to fill gaps in the understanding of

water governance dynamics, even if it is only through small-*N* studies. This group appears to be interested in pushing the conceptual boundaries as they try to account for the complexity of water governance by using different ideas, concepts, and frameworks drawn from diverse disciplines and experiences (e.g., Gemmer et al. 2011, Clarvis and Engle 2015). Unlike the first substream, these studies do not abstract from case studies, but instead try to make profound descriptions of specific governance concepts. For instance, Kadirbeyoglu and Özertan (2015) elaborate on the role of power in irrigation management decentralization in Turkey by linking their assessment to the IAD framework. Finally, the third substream focuses on understanding case- or place-based problems. These studies may not always contribute substantially to theory building but provide valuable observations and insights on the situations under study. For example, Mahalingam et al. (2011) studied three coordination agencies that were involved in water and sanitation projects in India and observed their performance through five parameters that were not linked to any specific theoretical framework. Findings from the second and third substreams, if sufficiently established, are often taken up by the first, and more rigorously established through systematic analysis. For example, as McGinnis and Ostrom (2014) argue, the IAD framework was mainly shaped based on multiple case studies analyzed by the Indiana University Bloomington Workshop in Political Theory and Policy Analysis.

The wide range of conceptual approaches used in designing and adapting analytical frameworks indicates that water governance is a topic of broad relevance that cuts across disciplinary boundaries. Approaches that use new or modified frameworks to fill gaps in the understanding of water governance are extremely important. For example, Clement's (2010) use of power theory to modify the IAD framework (Ostrom 1990, 1999, 2005) provides a valuable, refined tool that helps to account for the ways that power shapes governance processes and defines outcomes. Likewise, large-*N* studies have the ability to test theoretical propositions and generate findings that can be applied across contexts. For example, Knieper and Pahl-Wostl (2016) show that good environmental status in river basins seems to depend primarily on the overall level of pressure from human use rather than the quality of water management. Just as small-*N* studies are unable to claim broad generalizability, large-*N* studies often paint with a very broad brush that needs to be contextualized to be applicable to local contexts. However, together, the two approaches appear to be contributing to a robust system of knowledge generation.

Our analysis of the frameworks also revealed that almost one-quarter of the reviewed publications did not establish a clear comparative framework. This finding means that they did not scrutinize the relationships among the different variables that they used for comparing the multiple cases and, thus, lacked the theoretical or empirical foundation for making sound comparisons. The high prevalence of such publications indicates that there is significant room for improvement for researchers, journal editors, and reviewers in producing strong, clearly defined results from comparative research.

Empirical basis of comparative water governance studies

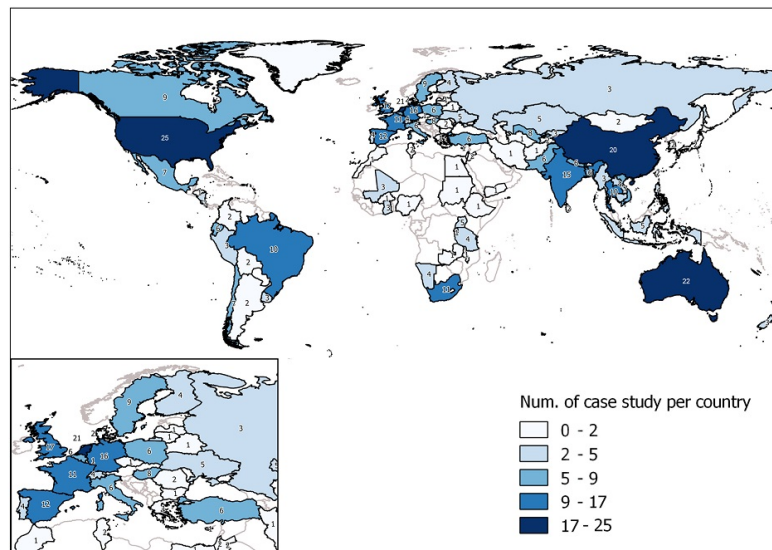
Despite the expansion of comparative studies, the number of cases compared remains fairly low. Studies that compared more

than five cases were relatively infrequent ($N = 28$). This result likely reflects the largely qualitative approach that has been taken in studies of water governance ($N = 76$). Examining large-*N* studies using qualitative methods can be extremely time and resource consuming. For this reason, it is logical that large-*N* qualitative studies are rare. However, publication rates of studies based on large-*N* studies have been increasing in recent years. This trend may lead to a new class of generalizable findings that can contribute to the understanding of water governance. For example, Zingraff-Hamed et al. (2017) analyzed 75 urban river restoration projects and found that the role of macrolevel governance is often limited. Instead, factors such as the relationships between nature, people, and the river, which are expressed through microlevel governance, are often more important in shaping governance outcomes. Using these methods, such findings can be more reliably applied to other contexts.

The compared cases are unevenly distributed across the globe (Fig. 5). This pattern reflects the uneven distribution of global resources, including within the research community (Salager-Meyer 2008). High concentrations of studies in Europe and Asia, and particularly, in USA, Australia, the Netherlands, and China, reflect a bias in the distribution of global wealth, combined with those countries that have particularly pressing water issues such as sea-level rise in the heavily dyked Netherlands and water supply and distribution in drought-prone Australia. Although the overrepresentation of USA, China, and Australia can also be explained by their size, the Netherlands constitutes an exception, given its relatively small area. Scholars publishing on water issues in developing countries may also be more likely to frame their research according to development challenges, rather than using water governance terminology. Such publications would not be captured by our review's search criteria.

The majority of reviewed publications uses jurisdictional boundaries for case delineation. Since the late 1990s, there has been a strong push to use hydrological boundaries as management and governance units (e.g., Rogers and Hall 2003). This trend is reflected in national and international water governance strategies such as the Canadian *Water for Life* policy (i.e., watershed-based protection and advisory committees), the Australian *Catchment and Land Protection Act* (i.e., catchment management authorities), and the EU *Water Framework Directive* (i.e., river basin districts). However, our findings indicate that it is often more relevant to examine water governance initiatives according to the boundaries within which relevant laws and regulations are enacted, or using a combination of administrative and watershed boundaries. De Loë and Patterson (2017) argue that the focus on watersheds has the potential to limit the uptake and utility of water research by framing out many of the issues that fundamentally shape governance processes and outcomes. In this regard, Mollinga et al. (2007) also use the term "problemshed," instead of watershed, to emphasize the importance of inherent political characteristics and the plurality of actors, institutions, and objectives in water governance. The importance of jurisdictions is also reflected in the focus of the reviewed publications on "legislation, instruments, and policies," the most commonly compared category of governance elements. This finding is consistent with recent arguments that, despite the purported "retreat of the state," governments and their formal policies and legislation are still very much integral to the practice of water governance (Newig and Koontz 2014). Related to this,

Fig. 5. Number of case studies located in each country.



the second most common governance element examined is “participation and stakeholder involvement.” The prevalence of publications in our review that study participation is likely linked to the enactment of the EU Water Framework Directive in 2000. The Water Framework Directive contains significant and challenging requirements for public participation. This characteristic made it one of the most popular themes for researchers that examined the implementation of the Directive (Boeuf and Fritsch 2016).

Regarding the use of primary vs. secondary data, we observe that most of the reviewed publications are based on primary data collected by the researchers themselves. This means that there is significant room to exploit these primary data and synthesize insights from studies in diverse contexts. At present, there are very few large-*N* studies that compare across cases. However, it should be acknowledged that the diversity of governance frameworks used is challenging when attempting to use existing data to populate large-*N* comparative studies. Established frameworks such as the IAD framework (Ostrom 2005) and the SES framework (McGinnis and Ostrom 2014) might be helpful in preparing a base for a rigorous combination of the outputs from available small-*N* studies into large-*N* studies.

CONCLUSIONS

The overarching finding of our systematic review is that there is incredible variability in the field of comparative water governance studies. This variability may simply be a characteristic of a relatively young field that has yet to consolidate. To integrate the insights from our review into recommendations for future research, we first briefly sketch out a picture of the field of comparative water governance, and then identify four research areas to develop the field in a manner that maximizes its academic and practical potential.

Our review reveals that, consistent with the larger body of work on water governance, the definition of the concept of water

governance used in comparative studies is contested. Various definitions of the concept, as well as its specific aspects and forms, are adopted in comparisons. Furthermore, water governance is often studied through subelements of governance such as legislation and public participation, which are given relatively high importance for the implementation of water policies. The emphasis on specific subelements is an indication of the policy relevance of comparative water governance studies, which often examine contemporary changes in water policies that address certain elements. Many scholars use analytical frameworks that are rooted in the work of Elinor Ostrom. Beyond this, there is little consistency in the frameworks applied, which can also be explained by the diversity of disciplinary backgrounds of the researchers that conduct comparative studies of water governance. Compared to the definitions, elements, and frameworks, there is relatively more consistency in the methods and approaches used. Comparative studies are often qualitative and small-*N*, although there is an increasing number of quantitative and large-*N* studies that aim to synthesize findings across different settings. The number of comparisons that apply multiple research methods is limited; studies mostly rely on qualitative methods. Comparisons are also largely based on cases defined according to jurisdictional boundaries or according to both jurisdictional and hydrological boundaries. In terms of the data types, most of the reviewed publications rely on primary data for comparisons.

We identify four future research areas to improve the theoretical and empirical foundations of comparative water governance studies. First, the field would benefit from a better balance of small-, medium-, and large-*N* studies. Although small-*N* studies are useful for explorative purposes and are able to capture the complexity of water governance regimes, they seldom allow the derivation of more general insights or patterns. In contrast, large-*N* studies run the risk of resulting in simplistic blueprints or panaceas because they fail to do justice to the contextual

specificity and complexity of water governance regimes. Diagnostic approaches that consider context and problem characteristics are therefore particularly promising (Ostrom 2007, Pahl-Wostl and Kranz 2010, Ingram 2011). Our review includes several studies in which authors systemically compare a moderate number of cases (e.g., Huntjens et al. 2010, Pahl-Wostl et al. 2012). To allow for the systemic comparison of carefully selected cases, the consistency in methods and elements analyzed should be improved to build data sets with secondary data that can be used in comparative analysis.

Second, our review was restricted to comparisons across geographical space. It would also be interesting to examine longitudinal studies that compare across time while holding geographical space constant. Longitudinal comparative studies can enable the identification of temporal governance trends and patterns by observing water governance phenomena over long periods. Such large-scale, longitudinal studies can be supported by small-scale studies that are conducted for shorter times, using consistent frameworks and case delineations. However, similar to large-*N* studies, the financial and technical challenges of conducting longitudinal studies should be taken into account.

Third, the geographical distribution of comparative studies should be expanded significantly to include countries from the global South. Whereas geographic bias is often a consequence of funder requirements, data availability, and language barriers, the geographic coverage of comparative studies should be improved by concentrating efforts to improve the range of comparisons where possible. Such efforts could include holding conferences and funding governance-related research in the global South, and promoting water governance research networks with the global South. Resolving issues of geographic bias will also help to address the relatively limited focus on issues of justice, equity, and power (Lu et al. 2014).

These concepts bring us to the fourth and final future research area. Our review revealed that justice, equity, and power have received limited attention in comparative water governance studies. This finding contradicts with the fact that addressing issues of power, equity, and justice is becoming increasingly important in tackling the water governance challenges that are exacerbated by the effects of climate change, industrialization, and urbanization (Perreault 2014, Perreault et al. 2018, Zwarteveen and Boelens 2014). Moreover, such issues have crucial effects in less democratized countries in the global South (Allan 2007, Zeitoun et al. 2012, Molle et al. 2018). Thus, the third and fourth future research areas are highly interrelated. Widening the comparative studies to represent better the global South is likely to improve knowledge about justice, equity, and power issues in water governance.

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/issues/responses.php/10548>

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Appendix A. Publications included in the in-depth review

ID	Authors	Year	Publication title	Source title
P001	Araral E., Ratra S.	2016	Water governance in India and China: comparison of water law, policy and administration	Water Policy
P002	Araral E., Yu DJ.	2013	Comparative water law, policies, and administration in Asia: evidence from 17 countries	Water Resources Research
P003	Argento D., Grossi G., Thomasson A.	2011	Governance and control of externalized water service management: comparing solutions adopted in Italy and Sweden	Corporate Ownership and Control
P004	Benson D., Gain A.K., Rouillard J.J.	2015	Water governance in a comparative perspective: from IWRM to a 'nexus' approach?	Water Alternatives
P005	Benson D., Jordan A.	2010	The scaling of water governance tasks: a comparative federal analysis of the European Union and Australia	Environmental Management
P006	Benson D., Jordan A., Smith L.	2013	Is environmental management really more collaborative? A comparative analysis of putative 'paradigm shifts' in Europe, Australia, and the United States	Environment and Planning
P007	Benson D., Jordan A., Huitema D.	2012	Involving the public in catchment management: an analysis of the scope for learning lessons from abroad	Environmental Policy and Governance
P008	Bettini Y., Brown R.R., de Haan F.J.	2015	Exploring institutional adaptive capacity in practice: examining water governance adaptation in Australia	Ecology and Society
P009	Beucher S.	2009	National/local policy tensions in flood risk management: an international comparison	Environmental Hazards
P010	Blomquist W., Dinar A., Kemper K.E.	2007	Comparative analysis of case studies	Integrated River Basin Management through Decentralization
P011	Bohn N., Goetten W.J.	2015	Groundwater Governance in the States of São Paulo, Paraná, Santa Catarina and Rio Grande Do Sul: An Analysis from the Instruments of the National Water Resources Policy	Proceedings - 2015 9th International Conference on Complex, Intelligent, and Software Intensive Systems

ID	Authors	Year	Publication title	Source title
P012	Borowski I., Le Bourhis J.-P., Pahl-Wostl C., Barraqué B.	2008	Spatial misfit in participatory river basin management: Effects on social learning, a comparative analysis of German and French case studies	Ecology and Society
P013	Bréthaut C.	2016	River management and stakeholders' participation: The case of the Rhone River, a fragmented institutional setting	Environmental Policy and Governance
P014	Brisbois M.C., de Loë R.C.	2017	Natural resource industry involvement in collaboration for water governance: influence on processes and outcomes in Canada	Journal of Environmental Planning and Management
P015	Brown C.	2015	Scale and subnational resource management: Transnational initiatives in the salish sea region	Review of Policy Research
P016	Brown C., Ruiz J.L.C., Lowery N., Wright R.	2003	Comparative analysis of transborder water management strategies: case studies on the US-Mexican border	The U.S.-Mexican Border Environment: Binational Water Management Planning
P017	Brown J.	2014	Evaluating participatory initiatives in south africa: Not just processes but outcomes too	SAGE Open
P018	Brown R.R., Sharp L., Ashley R.M.	2006	Implementation impediments to institutionalising the practice of sustainable urban water management	Water Science and Technology
P019	Chai Y., Schoon M.	2016	Institutions and government efficiency: Decentralized irrigation management in China	International Journal of the Commons
P020	Cuadrado-Quesada G.	2014	Groundwater governance and spatial planning challenges: examining sustainability and participation on the ground	Water International
P021	da Costa Silva G.	2011	Assessing environmental justice of community-based watershed management: A tool to build adaptive capacity in Latin America?	Local Environment
P022	de Boer C., Vinke-de Kruijf J., Özerol G., Bressers H.	2016	Collaborative Water Resource Management: What makes up a supportive governance system?	Environmental Policy and Governance
P023	Dinar A., Saleth R.M.	2005	Can water institutions be cured? A water institutions health index	Water Science and Technology: Water Supply
P024	Dombrowsky I., Hagemann N., Houdret A.	2014	The river basin as a new scale for water governance in transition countries? A comparative study of Mongolia and Ukraine	Environmental Earth Sciences

ID	Authors	Year	Publication title	Source title
P025	Doorn N.	2017	Allocating responsibility for environmental risks: A comparative analysis of examples from water governance	Integrated Environmental Assessment and Management
P026	Eberhard R., Margerum R., Vella K., Mayere S., Taylor B.	2017	The practice of water policy governance networks: An international comparative case study analysis	Society and Natural Resources
P027	Edelenbos J., Meerkerk I., van Leeuwen C.	2015	Vitality of complex water governance systems: Condition and evolution	Journal of Environmental Policy and Planning
P028	Erickson A.	2015	Efficient and resilient governance of social–ecological systems	Ambio
P029	Fournier M., Larrue C., Alexander M., Hegger D., Bakker M., Pettersson M., Crabbé A., Mees H., Chorynski A.	2016	Flood risk mitigation in Europe: How far away are we from the aspired forms of adaptive governance?	Ecology and Society
P030	Franks T., Bdliya H., Mbuya L.	2011	Water governance and river basin management: Comparative experiences from nigerian and Tanzania	International Journal of River Basin Management
P031	Garrick D., Siebentritt M.A., Aylward B., Bauer C.J., Purkey A.	2009	Water markets and freshwater ecosystem services: Policy reform and implementation in the Columbia and Murray-Darling Basins	Ecological Economics
P032	Gemmer M., Wilkes A., Vaucel L.M.	2011	Governing climate change adaptation in the EU and China: An analysis of formal institutions	Advances in Climate Change Research
P033	Grossi G., Thomasson A.	2011	Jointly owned companies as instruments of local government: Comparative evidence from the swedish and italian water sectors	Policy Studies
P034	Hamidov A., Thiel A., Zikos D.	2015	Institutional design in transformation: A comparative study of local irrigation governance in Uzbekistan	Environmental Science and Policy
P035	Harris L., Kleiber D., Goldin J., Darkwah A., Morinville C.	2016	Intersections of gender and water: comparative approaches to everyday gendered negotiations of water access in underserved areas of Accra, Ghana and Cape Town, South Africa	Journal of Gender Studies

ID	Authors	Year	Publication title	Source title
P036	Harris LM, Alatout S	2010	Negotiating hydro-scales, forging states: Comparison of the upper Tigris/Euphrates and Jordan River basins	Political Geography
P037	Heikkila T.	2004	Institutional boundaries and common-pool resource management: A comparative analysis of water management programs in california	Journal of Policy Analysis and Management
P038	Herrala M.E., Huotari H., Haapasalo H.J.O.	2012	Governance of Finnish waterworks - A DEA comparison of selected models	Utilities Policy
P039	Hill Clarvis M., Engle N.L.	2013	Adaptive capacity of water governance arrangements: a comparative study of barriers and opportunities in Swiss and US states	Regional Environmental Change
P040	Holley C., Sinclair D., Lopez-Gunn E., Schlager E.	2016	Conjunctive management through collective action	Integrated Groundwater Management: Concepts, Approaches and Challenges
P041	Hughes S.	2013	Authority Structures and Service Reform in Multilevel Urban Governance: The Case of Wastewater Recycling in California and Australia	Urban Affairs Review
P042	Huntjens P., Pahl-Wostl C., Grin J.	2010	Climate change adaptation in European river basins	Regional Environmental Change
P043	Huntjens P., Pahl-Wostl C., Rihoux B., Schlüter M., Flachner Z., Neto S., Koskova R., Dickens C., Kiti I.N.	2011	Adaptive water management and policy learning in a changing climate: A formal comparative analysis of eight water management regimes in Europe, Africa and Asia	Environmental Policy and Governance
P044	Hurlbert M.	2009	Comparative water governance in the four western provinces	Prairie Forum
P045	Hurlbert M.A., Diaz H.	2013	Water governance in Chile and Canada: A comparison of adaptive characteristics	Ecology and Society
P046	Ibele B., Sandri S., Zikos D.	2016	Endogenous Versus Exogenous Rules in Water Management: An Experimental Cross-country Comparison	Mediterranean Politics
P047	Jacobs J.W.	1999	Comparing river basin development experiences in the Mississippi and the Mekong	Water International
P048	Jager N.W.	2016	Transboundary Cooperation in European Water Governance – A set-theoretic analysis of International River Basins	Environmental Policy and Governance
P049	Kadirbeyoglu Z., Özertan G.	2015	Power in the Governance of Common-Pool Resources: A comparative analysis of irrigation management decentralization in Turkey	Environmental Policy and Governance

ID	Authors	Year	Publication title	Source title
P050	Kayser G.L., Amjad U., Dalcanale F., Bartram J., Bentley M.E.	2015	Drinking water quality governance: A comparative case study of Brazil, Ecuador, and Malawi	Environmental Science and Policy
P051	Keessen A.M., van Kempen J.J.H., van Rijswijk M., Robbe J., Backes C.W.	2010	European river basin districts: Are they swimming in the same implementation pool?	Journal of Environmental Law
P052	Keskinen M., Guillaume J.H.A., Kattelus M., Porkka M., Räsänen T.A., Varis O.	2016	The water-energy-food nexus and the transboundary context: Insights from large Asian rivers	Water
P053	Knieper C., Holtz G., Kastens B., Pahl-Wostl C.	2010	Analysing water governance in heterogeneous case studies-Experiences with a database approach	Environmental Science and Policy
P054	Knieper C., Pahl-Wostl C.	2016	A Comparative Analysis of Water Governance, Water Management, and Environmental Performance in River Basins	Water Resources Management
P055	Knüppe K., Pahl-Wostl C., Vinke-de Kruijf J.	2016	Sustainable Groundwater Management: A Comparative Study of Local Policy Changes and Ecosystem Services in South Africa and Germany	Environmental Policy and Governance
P056	Larrue C., Bressers N., Bressers H.	2016	Towards a drought policy in north-west European regions?	Governance for Drought Resilience: Land and Water Drought Management in Europe
P057	Lawford R., Bogardi J., Marx S., Jain S., Pahl-Wostl C., Knüppe K., Ringler C., Lansigan F., Meza F.	2013	Basin perspectives on the water–energy–food security nexus	Current Opinion in Environmental Sustainability
P058	Lebel L., Nikitina E., Pahl-Wostl C., Knieper C.	2013	Institutional fit and river basin governance: A new approach using multiple composite measures	Ecology and Society
P059	Lieberherr E., Truffer B.	2015	The impact of privatization on sustainability transitions: A comparative analysis of dynamic capabilities in three water utilities	Environmental Innovation and Societal Transitions

ID	Authors	Year	Publication title	Source title
P060	Lopez-Gunn E.	2003	The role of collective action in water governance: A comparative study of groundwater user associations in La Mancha aquifers in Spain	Water International
P061	Lowry W.R.	2009	Policy changes on Canada's rivers: Different but not isolated	Review of Policy Research
P062	Mahalingam A., Devkar G.A., Kalidindi S.N.	2011	A comparative analysis of public- private partnership (PPP) coordination agencies in India: What works and what doesn't	Public Works Management and Policy
P063	Mees H., Suykens C., Crabbé A.	2017	Evaluating Conditions for Integrated Water Resource Management at Sub-basin Scale. A Comparison of the Flemish Sub-basin Boards and Walloon River Contracts	Environmental Policy and Governance
P064	Mees H.L.P., Driessen P.P.J., Runhaar H.A.C.	2014	Legitimate adaptive flood risk governance beyond the dikes: The cases of Hamburg, Helsinki and Rotterdam	Regional Environmental Change
P065	Meijerink S., Huitema D	2010	Policy Entrepreneurs and Change Strategies: Lessons from Sixteen Case Studies of Water Transitions around the Globe	Ecology and Society
P066	Montaña E., Diaz H.P., Hurlbert M.	2016	Development, local livelihoods, and vulnerabilities to global environmental change in the South American Dry Andes	Regional Environmental Change
P067	Moore M.L.	2013	Perspectives of Complexity in Water Governance: Local Experiences of Global Trends	Water Alternatives
P068	Mosello B.	2015	How to deal with climate change?: Institutional adaptive capacity as a means to promote sustainable water governance	Springer
P069	Mukherji, A. Shah, T.	2005	Groundwater socio-ecology and governance: a review of institutions and policies in selected countries	Hydrogeology Journal
P070	Neville K.J.	2011	Adversaries versus partners: Urban water supply in the Philippines	Pacific Affairs
P071	Newig J., Fritsch O.	2009	Environmental Governance: Participatory, Multi-Level – and Effective?	Environmental Policy and Governance
P072	Nielsen H.T., Frederiksen P., Saarikoski H., Rytönen A.-M., Pedersen A.B.	2013	How different institutional arrangements promote integrated river basin management. Evidence from the Baltic Sea Region	Land Use Policy
P073	Pahl-Wostl C., Becker G., Knieper C., Sendzimir J.	2013	How multilevel societal learning processes facilitate transformative change: A comparative case study analysis on flood management	Ecology and Society

ID	Authors	Year	Publication title	Source title
P074	Pahl-Wostl C., Knieper C.	2014	The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes	Global Environmental Change
P075	Pahl-Wostl C., Lebel L., Knieper C., Nikitina E.	2012	From applying panaceas to mastering complexity: Toward adaptive water governance in river basins	Environmental Science and Policy
P076	Poddar R., Qureshi M.E., Shi T.	2014	A Comparison of Water Policies for Sustainable Irrigation Management: The Case of India and Australia	Water Resources Management
P077	Rabelo D.C., Espluga J., Teixeira E.C., Brugué Q.	2014	Citizenship participation in water management plans in the Doce River Basin, Brazil and Catalonia, Spain	Water Policy
P078	Ravesteijn W., Song X., Wennersten R.	2009	The 2000 EU water framework directive and Chinese water management: Experiences and perspectives	WIT Transactions on Ecology and the Environment
P079	Ross A.	2016	Groundwater governance in Australia, the European union and the western usa	Integrated Groundwater Management: Concepts, Approaches and Challenges
P080	Schlager E., Heikkila T.	2009	Resolving water conflicts: A comparative analysis of interstate river compacts	Policy Studies Journal
P081	Scott T.	2015	Does Collaboration Make Any Difference? Linking Collaborative Governance to Environmental Outcomes	Journal of Policy Analysis and Management
P082	Sehring J.	2009	The politics of water institutional reform in neopatrimonial states: A comparative analysis of Kyrgyzstan and Tajikistan	The Politics of Water Institutional Reform in Neopatrimonial States: A Comparative Analysis of Kyrgyzstan and Tajikistan
P083	Serrao-Neumann S., Renouf M., Kenway S.J., Low Choy D.	2017	Connecting land-use and water planning: Prospects for an urban water metabolism approach	Cities
P084	Silveira A., Junier S., Hüesker F., Qunfang F., Rondorf A.	2016	Organizing cross-sectoral collaboration in river basin management: case studies from the Rhine and the Zhujiang (Pearl River) basins	International Journal of River Basin Management

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P085	Speelman S., Frija A., Buyse J., Van Huylbroeck G.	2011	The importance of irrigation water rights: Lessons from South Africa and Tunisia	Water Policy
P086	Srinivasan V. , Lambin E.F., Gorelick S.M., Thompson B.H., Rozelle S.	2012	The nature and causes of the global water crisis: Syndromes from a meta-analysis of coupled human-water studies	Water Resources Research
P087	Swamikannu X., Radulescu D., Young R., Allison R.	2003	A comparative analysis: Storm water pollution policy in California, USA and Victoria, Australia	Water Science and Technology
P088	Teamsuwan V., Satoh M.	2009	Comparative analysis of management of three water users' organizations: Successful cases in the Chao Phraya Delta, Thailand	Paddy and Water Environment
P089	Van Buuren A., Vink M., Warner J.	2016	Constructing authoritative answers to a latent crisis? Strategies of puzzling, powering and framing in Dutch climate adaptation practices compared	Journal of Comparative Policy Analysis: Research and Practice
P090	Varady R.G., Zuniga-Teran A.A., Gerlak A.K., Megdal S.B.	2016	Modes and approaches of groundwater governance: A survey of lessons learned from selected cases across the globe.	Water
P091	Venot J.-P., de Fraiture C., Acheampong E.N.	2012	Revisiting dominant notions: A review of costs, performance and institutions of small reservoirs in sub-Saharan Africa	IWMI Research Report
P092	Vink M.J., Benson D., Boezeman D., Cook H., Dewulf A., Termeer C.	2015	Do state traditions matter? comparing deliberative governance initiatives for climate change adaptation in dutch corporatism and British pluralism	Journal of Water and Climate Change
P093	Vinnaria E.M., Hukkab J.J.	2010	An international comparison of the institutional governance of water utility asset management and its implications for Finland	Water Policy
P094	Wang Y., Mukherjee M., Wu D., Wu X.	2016	Combating river pollution in China and India: Policy measures and governance challenges	Water Policy
P095	Wehn U., Rusca M., Evers J., Lanfranchi V.	2015	Participation in flood risk management and the potential of citizen observatories: A governance analysis	Environmental Science and Policy

ID	Authors	Year	Publication title	Source title
P096	Wiering M., Kaufmann M., Mees H., Schellenberger T., Ganzevoort W., Hegger D.L.T., Larrue C., Matczak P.	2017	Varieties of flood risk governance in Europe: How do countries respond to driving forces and what explains institutional change?	Global Environmental Change
P097	Wiering M., Verwijmeren J.	2012	Limits and Borders: Stages of Transboundary Water Management	Journal of Borderlands Studies
P098	Wu H., Leong C.	2016	A composite framework of river sustainability: Integration across time, space and interests in the Yellow River and Ganges River	Water Policy
P099	Wu X., Ching L.	2013	The French model and water challenges in developing countries: Evidence from Jakarta and Manila	Policy and Society
P100	Yang Y.	2009	From decentralized autonomy to central governance: Case of Murray-Darling River Basin and its implication for the governance of Tai Lake Basin	2009 International Conference on Management Science and Engineering - 16th Annual Conference Proceedings
P101	Yu H.	2016	Can water users' associations improve water governance in China? A tale of two villages in the Shiyang River basin	Water International
P102	Yu H.H., Edmunds M., Lora-Wainwright A., Thomas D.	2016	Governance of the irrigation commons under integrated water resources management - a comparative study in contemporary rural China	Environmental Science and Policy
P103	Zhao C., Wang P., Zhang G.	2015	A comparison of integrated river basin management strategies: a global perspective	Physics and Chemistry of the Earth
P104	Zingraff-Hamed A., Greulich S., Wantzen K.M., Pauleit S.	2017	Societal drivers of European water governance: a comparison of urban river restoration practices in France and Germany	Water

Appendix B. Review matrix

This appendix provides the matrix that guided the full-text review and the analysis of the findings. The matrix is presented here in the same order as the results are presented in the main manuscript.

Criteria	Type of information	Explanation of the category or possible options	Reference (where applicable)
A. Generic information			
Main issue	Numbered (select one option)	<ol style="list-style-type: none"> 1. River basin management 2. Agriculture 3. Urban water services 4. Flood risk governance 5. Groundwater governance 6. Transboundary water management 7. Environmental protection 8. Watershed management 	Adapted from Cook and Bakker (2012)
Specification of main issue	Free field	Further specification of the main scope of the publication	
Objective/Question	Free field	Research objective(s) or question(s) as stated in the publication	
B. Definitions, elements and frameworks			
Type of water governance definition	Numbered (select one option)	<ol style="list-style-type: none"> 1. Existing definition 2. Own definition 3. No/unclear definition 	
Definition used	Free field	If applicable, the definition (and the reference) is copied from the publication.	
Type of framework for comparison	Numbered (select one option)	<ol style="list-style-type: none"> 1. Existing framework, 2. Own framework A (developed and then used to compare cases), 3. Own framework B (developed out of the comparison e.g. inductively or through grounded theory), 4. No/unclear framework 	

Criteria	Type of information	Explanation of the category or possible options	Reference (where applicable)
Governance elements included	Free field	Description of the theoretical concepts or governance elements that are assessed and compared. For example, institutions/actors; policies; legislation; instruments; structures; coordination.	
Type of governance elements	Numbered (multiple options possible)	<ol style="list-style-type: none"> 1. Legislation, instruments, policies 2. Participation and stakeholder involvement 3. Cooperation and coordination 4. Resources 5. Knowledge and expertise 6. Governance levels 7. Governance qualities 8. Water/environmental management and outcomes 9. Other 	Expanded from Rogers and Hall (2003)
C. Case selection, location and boundaries			
Case selection rationale	Free field	If applicable, the specific method or rationale that was used to select cases, e.g. most similar, most different research design. Left as empty when no reason for selecting the cases is provided.	
Unit of analysis	Free field	The unit of analyses (cases) that are being used to compare, e.g. a watershed committee, a river basin, a participation arena. The term that is used by the authors is copied.	
Number of cases compared	Insert number	The number of cases compared	
Name(s) of country/countries	Free field	The name of up to 10 of the countries that are compared. When more than 10 countries are compared just write the number of countries and the relevant region.	
Name(s) of jurisdictional unit (not a country)	Free field	The name of the city, subnational or multi-national region that is being compared, e.g. Europe, city of Manila, region in central Spain	
Name(s) of hydrological basin(s)	Free field	The name of the basin and its location. For example, Elqui Basin (Chile); Mendoza Basin (Argentina); Pucara Basin (Bolivia)	

Criteria	Type of information	Explanation of the category or possible options	Reference (where applicable)
Case boundaries	Numbered (select one option)	<ol style="list-style-type: none"> 1. Hydrological borders 2. Jurisdictional 3. Both (This option applies when jurisdictional borders are used to define a part of a hydrological unit (e.g. Dutch part of the Rhine basin)) 4. Not clearly specified 	
Hydrological borders	Numbered (select one option if hydrological borders apply)	<p>Options for applicable hydrological unit when the cases are defined by a hydrological border (e.g. River (sub-)basins / aquifers / streams / wetlands or parts thereof):</p> <ol style="list-style-type: none"> 1. Whole transboundary river basins. For example, the Rhine basin, Danube River (if tributaries and the catchment area are not considered) 2. Whole domestic river basins. For example, the Thames basin, Loire River (if tributaries and the catchment area are not considered) 3. Sub-basins of domestic or transboundary river basins. For example, the Tisza basin (part of the Danube basin), Doñana wetland, Mississippi delta 4. Aquifers 	Tanago et al. (2016); Varady et al (2016)
Jurisdictional borders	Numbered (select one option if jurisdictional borders apply)	<p>Options for applicable jurisdictional boundaries:</p> <ol style="list-style-type: none"> 1. Local: Comparison of towns, communities or cities. For example, London; 2. Sub-national regions: Comparison of provinces, counties or federal states. For example, Western USA, Bavarian part of the Danube basin; 3. Countries: Comparison of countries, e.g. Spain 4. Multi-national regions: Comparison of region that encompasses multiple countries 5. Global: The comparison covers the entire world 	
D. Data and methods			
Type of data	Numbered (select one option)	<ol style="list-style-type: none"> 1. Primary data (interviews, observations or documents collected for research purposes) 2. Secondary data (collected by others for other purposes, e.g. indices, censuses, monitoring data) 3. Both 4. Other 	Van de Ven, 2007
	Free field	If "Other", the data used is specified.	

Criteria	Type of information	Explanation of the category or possible options	Reference (where applicable)
Methods	Numbered (select one option)	1. Only qualitative methods (in-depth case study) 2. Only quantitative methods (e.g. statistics) 3. Only set-theoretic methods (e.g. Qualitative Comparative Analysis) 4. Other (e.g. a combination of methods)	
	Free field	If “Other”, the method or the combination of methods used is specified.	
E. Reflections			
Implications of comparative choices and methods	Free field	If applicable, the following questions are answered: 1. What reflections do the authors offer on their method of comparison? 2. What recommendations do the authors provide for comparative analysis?	
Current and/or emerging issues and research gaps	Free field	If applicable, the following question is answered: 1. What governance-related gaps for future research do the authors identify?	

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