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More than chair circles? A qualitative systematic review of serious games related to water governance and their potential effects on policy design

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ABSTRACT

Water management presents unprecedented challenges to policymakers and requires innovative approaches. This paper conducts a qualitative systematic literature review on the impact of serious games in the water sector, assessing the perspectives of these games in terms of their potential influence on policy design. The review points to the positive effects of serious games in enhancing knowledge acquisition, fostering collaboration, and supporting policy-making, facilitated by the direct and collaborative exchange between participants in the interactive game sessions. However, in the absence of long-term studies to support these findings, further research is recommended.

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Introduction

Climate change confronts policymakers with unprecedented situations and requires innovative ways of managing limited natural resources, such as water. Over the last decade, global awareness of water scarcity has increased significantly, with Europe – historically a water-rich region – being one of the main drivers of this awareness (Ahmad & Kam, 2024). In addition, the impact of droughts on agriculture is becoming more severe, posing significant challenges to society (Chen et al., 2024; Madadgar et al., 2017; Toreti et al., 2024; VicenteSerrano et al., 2022).

Despite the progress in research, the uncertainty about water-related extreme events remains a difficult challenge, especially in the face of climate change (Sharafati & Pezeshki, 2020). This poses a significant challenge to the public, and especially to policymakers, in understanding the situation and in making informed decisions. Given the increasing severity of events such as droughts, it is imperative that decisive action is taken, even in the absence of comprehensive knowledge.

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In the wake of climate change, even in originally water-rich countries such as Germany, policymakers will have to learn how to deal with water stress and different water availability or quality in the future (Bake et al., 2021; Bathke et al., 2019). This is also reflected in the German media, which has increasingly reported on climate risks such as water scarcity and shortages in recent years. The number of search results for *Wasserknappheit* (water scarcity) and *Wassermangel* (water shortage) on the professional research platform GENIOS (GBI-Genios, 2023a, 2023b) shows that media coverage of both terms in Germany roughly tripled between 2017 and 2018. Both terms peaked in 2022, with 1741 results for water scarcity, more than five times as many as in 2017 (316). Similarly, there were 2279 results for water shortages, compared to just 550 in 2017. This increase in media coverage indicates the growing importance of water for Germany.

However, attempting to deal with such previously unknown situations is a problem that can itself be recognized as a wicked problem (Head, 2022), involving not only uncertainty but also often considerable complexity or conflict. One approach to addressing wicked policy process problems such as water management and developing successful and comprehensive risk or mitigation strategies is to build on participatory methods. In addition to traditional methods like chair circles, where stakeholders discuss an issue face to face, we are interested in the effects of additionally using serious gaming formats to stimulate the discussion and exchange perspectives. Participatory methods can be particularly useful for dealing with new problems, where past experience is insufficient, and where conventional approaches – such as deriving certain criteria for successful policies from past best practices (Ostrom, 1993) – reach their limits. Collaborative policies seek to combine different types of knowledge to reduce potential ignorance. Moreover, participatory approaches may offer the opportunity to frame issues more comprehensively and potentially improve the effectiveness of the policies developed. However, the extent to which participatory methods are effective for wicked problems and policy design is a current discourse (Kirschke & Kosow, 2022). Serious games are a specific participatory method useful for simulating potential scenarios and exploring different options for action with participants, including stakeholders. In this environment, participants can engage with the research through the game, as well as with each other. Thus, serious games can be used to promote interaction not only between participants and researchers but also between different stakeholders.

Serious games are defined as games that ‘are developed for a purpose beyond entertainment and aim to address real-world challenges’ (Jean et al., 2018). They originate from game theory (Abt, 1987), i.e., the theory of strategic reasoning (Von Neumann & Morgenstern, 1940), where players’ actions are interdependent (Schelling, 1980). A distinctive feature of serious games is that stakeholders actively participate as players in the game (Abt, 1987), going beyond mere thought experiments.

As serious games allow for the participation of multiple actors, including participants and stakeholders from diverse backgrounds, this approach is seen as an essential tool for integrating participatory research with the exploration of options, such as future management options. In most cases, serious games are used to help participants understand the potential impact of their actions, often to increase the acceptance of certain measures (Keseru et al., 2021; Tori et al., 2023). Several literature reviews on serious games in the context of water governance (Furber et al., 2018; Medema et al., 2020, 2014) or water management to support decision-making (Mittal et al., 2022; Savic et al., 2016; Xu et al.,

2020) have already been documented. Building on previous research, our specific focus is to explore the effects of serious games in the highly intertwined field of water governance, and to investigate the potential benefits perceived by participants, particularly in terms of their impact on policy processes.

This review therefore explores the following key questions:

- (1) How do serious games address the challenges posed by the uncertainty, complexity, and sometimes conflicting nature of water governance?
- (2) What types of effects are expected to influence policy processes, and which of these effects are empirically observed and which (still) lack validation?

To examine the impact of serious games in water governance on knowledge generation and policy-making processes, we conduct a qualitative and systematic literature review on serious games in the water sector, focusing on their effects on policy design, including an analysis of stakeholder engagement.

The next section outlines the methodology adopted for this systematic literature review, explaining the rationale behind our chosen approach and its implementation. In the third section, we present a curated selection of studies on serious games in the water domain, highlighting the rich diversity of serious games research in both theory and practice. We also critically evaluate the limitations inherent in this body of work. Throughout this review, we contextualize serious games within the framework of wicked problems characterized by uncertainty, complex interrelationships, and conflicting objectives (Head, 2022). We then outline the potential implications of serious games for policy-making processes and discuss their current and potential roles in research, policy advice, and policy design. The fourth section provides a summary of the effects of serious games as identified in our review, focusing on (1) the different effects on policy processes, (2) effects that have already been observed empirically, and (3) those that have been hypothesized but await validation. In the final sections, the discussion and conclusion, we address key suggestions and research gaps regarding the use of serious games in water governance, recognizing their potential applicability to other thematic areas.

Framework of the study

Serious games in water governance

Serious games are particularly well suited to use cases in water governance where multiple perspectives on an issue need to be considered and there is a particular urgency to act. This can be the case when decision-making is subject to (1) time constraints, (2) complexity and uncertainty, and (3) subjectivity (i.e., a socially constructed reality that requires a negotiation process; Furber et al., 2018; Medema et al., 2016).

In addition, subjectivity can play a dual role in this context, as human interactions also influence the situation beyond its relevance to the issue under discussion. Therefore, wicked problems (Head, 2022) can arise in water governance. Serious games could provide potential solutions, ideas, or at least an open space for discussion. However, their potential contribution is, in our opinion, underestimated in research. Research could use serious games to develop new scenarios or to explore future contexts (Kosow et al., 2024), allowing the pre-experience of possible future events to analyse and address concerns, while potentially supporting decision-making. Serious games are considered

particularly helpful in a transboundary water context (Douven et al., 2014), as these cases tend to be characterized by high levels of complexity and subjective, often divergent, views on the issue. Conversely, regulation by a single authority is almost impossible (Mayer et al., 2021), suggesting that systematic and comprehensive approaches are crucial. Moreover, water is mostly available as a shared common pool resource, with the associated well-known coordination problems (Albrecht et al., 2018; Hardin, 1968), such as in the case of rivers flowing through several countries. These problems of cooperation between countries are particularly challenging in times of drought (Bocchiola et al., 2017). Ostrom (1990) emphasizes that in such circumstances, cooperation is a more promising approach than top-down imposition. She also highlights the importance of increasing and sharing knowledge, which participatory serious games could potentially promote.

Furthermore, Valkering et al. (2013) state that serious games in water-related contexts can generate valuable insights for the participants in terms of reflecting future conditions and corresponding strategies, with the latter likely to change according to the current societal trends. As such, the game environment allows for the experience of a volatile context with significant uncertainty, where decisions have consequences and can limit the horizon of further steps.

Methodology of the literature review

This paper presents a qualitative and systematic literature review (Rother, 2007) of serious games in the research field of water governance and knowledge production. The conduct of this review was influenced by the PRISMA standard, a general guideline for the structure and scope of a literature review, which outlines the steps to be taken from the start of an initial search to the final selection of papers for analysis (Sarkis-Onofre et al., 2021). Given our specific research questions, a systematic literature review is useful because this approach allows us to focus only on articles that are particularly relevant to our study. The systematic literature review process begins with questions that narrow the scope of the review by relevance (in terms of the research objective). In line with this systematic approach, we provide details of the databases and search methods used to make our process reproducible and comparable with similar or subsequent studies. Furthermore, while systematic reviews can have a strong quantitative focus, our analysis focuses on qualitative evidence, i.e., the effects or outcomes of serious games as reported in the literature.

We assumed that repeated mention of effects in the literature might be an indication (certainly not a proof) of their validity. Therefore, we still assessed the frequency of reported effects to provide a more comprehensive picture (see [Appendix A](#) and [Appendix B](#)). While some existing work has explored serious games in water governance, such as Forrest et al. (2022), who compiled a comprehensive list of serious games used for flood management, there remains a gap in the literature: of bringing together both empirically validated and claimed but not (yet) validated effects of serious games used for water governance. The complexity of water management, encompassing various challenges related to droughts, floods, heavy rainfall, and swelling water bodies, contributes to this gap. In addition, the network of actors is case-dependent and often infinite when considered as a whole. Therefore, this review aims to represent a broader range of serious

gaming literature on water governance. It goes beyond the analysis of individual games by synthesizing their common effects and implications for policy-making. To reduce both author and selection bias, we used the websites’ search term algorithm to build a comprehensive literature pool of water-related serious games by adapting terms from the aspects of our research question. Some of these terms used in combination with the Boolean search were: water, governance, serious game, conflict, water management, and policy design (see also [Appendix C](#); further details of the literature review available on request).

Scopus and Web of Science were searched for the last 30 years. In parallel, all the authors of this paper carried out an additional literature search (including a snowball search with the articles already found), which seemed advisable in an emerging area of research and to reduce the risk of selection bias. Our approach is thus similar to the hybrid search strategy presented by Wohlin et al. (2022). We then had two authors examine each reference independently to reduce selection bias. The complete selection process is depicted in [Figure 1](#).

The selection process resulted in a combined body of literature of 27 publications (see [Appendix A](#)), which were then subjected to in-depth analysis by two of the authors. They collaborated in the formulation of the results, which were subsequently verified by another author. The main exclusion criterion at this stage was that the authors of a publication either did not conduct the serious game themselves or did not provide sufficient detail about it. Of the final 27 publications, 8 studies are presented in the next section as examples that are representative of a wider field. In order to address our overarching research question and to present the work of others in a clear and consistent way, we extracted data from the studies according to this structure:

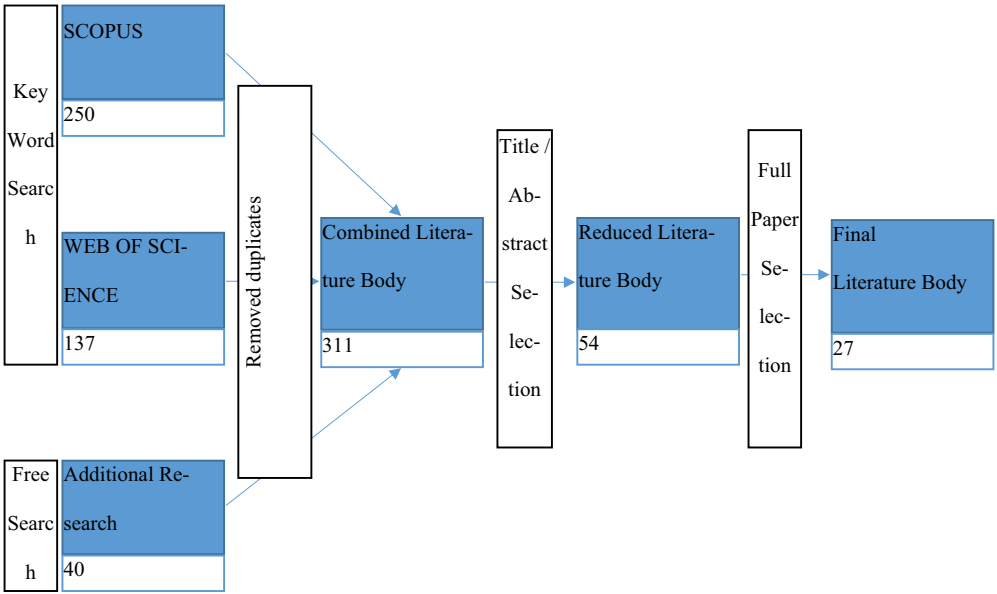


Figure 1. Literature selection process.

- (1) Topic, case, and research question/objective
- (2) Region and/or actual conflict, if applicable
- (3) Development, type, and implementation context of the serious games approach, including role and type of participants
- (4) Claimed effects and reflections of the authors of the serious games studies
- (5) Additional identified research gaps, if applicable.

The following sections provide a general summary of the effects described in all 27 studies reviewed, as well as some illustrative study cases with the points mentioned above. The description of the illustrative cases is provided to give examples of the general design of serious games and to identify gaps that could be addressed.

Against this background, the paper continues with the role of knowledge creation and social learning induced by serious games before turning to their potential for cooperation and collaboration, including (but not limited to) transboundary water governance.

An initial classification of serious games in water governance

In this section, we evaluate some water-related serious games as examples of possible effects of serious games, derived from the observations mentioned in the literature. It is important to note that this is intended to be an exploratory rather than a comprehensive review. Thus, the aim is to identify any gaps between intended or expected and actually observed effects of serious games in order to inform the development of future serious games. We do so by reviewing the literature as described in the previous section (steps 1–5). Although there is much overlap in the effects of serious games and it is not always easy to make clear distinctions, we provide some general examples for the following topics. Some serious games are potentially applicable to different subsections. We have chosen them for their content to introduce the effects mentioned, as we want to illustrate these effects through some exemplary cases, keeping in mind the idea of showing specific patterns (a first ‘classification’) in these water-related serious games. First, we focus on a general knowledge production effect that could be associated with serious games, such as understanding complex issues. We then highlight the potential effects on collaboration and possible relationship building, and finally, we describe some cases that are more relevant in the context of policy design.

Serious games in relation to learning processes

A key effect of serious games seems to be the opportunity for knowledge production, both for individuals and in interaction with others, to create shared knowledge (improving learning processes). Exchanges between different actors could create mutual understanding of topics and could contribute to the acquisition of different types of knowledge or new points of view. Medema et al. (2017) explore the possibilities of networks in terms of knowledge co-production in the case of watershed governance networks. They identify challenges for water organizations in facilitating knowledge: limited communication between the players is identified as one of these challenges, where communication technologies, such as online maps, could improve information sharing. Furthermore,

insufficient interaction was an additional concern. In this context, we briefly evaluate two outstanding serious games that could help to overcome the problem of lack of interaction and communication, while at the same time improving knowledge sharing.

Hummel et al. (2011) focus on individual learning improvements through a single-player serious game. In a pilot study in the Netherlands, 12 students with a background in water management were asked to participate in a scripted collaborative game built by EMERGO, a toolkit for serious game development. They evaluated the topic of aquaculture, a relatively new field in the Netherlands, especially for policymakers. The focus was on improving understanding, including multiple dimensions such as natural, technological, political, or social aspects. The study concludes that the use of such a serious game setting could help with learning and understanding complex issues. Students even perceived the scripted collaborative approach as a good tool for experiencing different perspectives, which would be useful for future water management tasks related to their university studies.

Bathke et al. (2019) present a different type of game design, namely a serious game played with multiple participants in direct competition with each other. The authors investigate whether serious games can be a useful tool for testing public policies (e.g., Creighton's (2005) theory of public participation), here also in the case of knowledge production and exchange. They use a so-called 'Multi-Hazard Tournament' for the case of the Cedar River Watershed in the state of Washington and let the participants develop the best solutions to reduce the impacts of flooding, drought, and water quality degradation under different climate scenarios affecting the watershed. The serious game was played in teams where collaboration was encouraged in order to score more points than the other teams. Sixty participants with backgrounds ranging from government actors (federal and local) to non-governmental organizations, academics, and farmers took part in the study, divided into seven mixed teams. The study also included a pre-and post-tournament survey to explore the outcomes, asking questions such as whether collaboration had been fostered, whether participants had met new people for coordinated action, and whether and how they had used their new knowledge in decision-making, particularly for the Cedar region. Many of the respondents said that they had sought new collaborations and projects, and as many as 64% agreed that the threat scenarios had proved helpful in future decision-making. Finally, participants said they had gained new knowledge about water, floods, and droughts. In the tournament itself, the researchers found that the players collectively used their knowledge to adapt their decisions. In addition, a kind of bigger picture of such conflict fields was achieved, even helping to understand financial investments and their potential impact. In this study, the authors concluded that a kind of social learning took place that helped to engage different people from different backgrounds to work together on scenarios.

In many serious games we see similar patterns of learning processes for the participants, ranging from general learning about a particular topic or from future decision-making to social learning. However, in most of these examples, the latter effects are mentioned more implicitly, with the exception of Bathke et al. (2019).

Serious games about (transboundary) collaboration

The following examples of collaboration show that serious games can be a way to support or initiate interpersonal processes. Jean et al. (2018) used the serious game 'Aqua Republica' to investigate the changes in the interactions of the participants involved throughout the game sessions, addressing both the quality and quantity of interactions. 'Aqua Republica', usually a single-player game used to explore the difficulties of water management, was run as a forced competition game in this study. Jean and colleagues ran four competitions with 42 participants from different backgrounds. One competition was between master's students in water management, another with the board of directors of the 'Rideau Valley Conservation Authority', and two with watershed organizations playing the role of different stakeholders. Some general observations emerged from these competitions, particularly about interactions and collaboration. For one thing, they found that interactions increased over the course of the games. They even credited serious games with the ability to strengthen existing relationships but also found that the games could facilitate the creation of mutual understanding and sometimes initiate new collaborations. In their case, however, it is unclear how serious games could affect the co-creation of knowledge. In addition, the authors mentioned the need for longer observation of participants to assess if and how interaction develops over several months.

Mayer et al. (2021) show how serious games can stimulate cooperation or interaction in a transboundary context. An aquifer on the US–Mexican border served as the setting for this serious game. As an example of an aquifer that already extracts more water than is replenished each year, this case seemed significant. For this cross-border case, there were participants from both countries, while also trying to include stakeholders from the municipal or industrial sector. In total, 20 participants took part in the serious game. However, as there were six online sessions over a four-month period, each lasting between 60 and 80 minutes, the number of participants varied from session to session. The serious game was a discussion game with different agents about possible strategies to solve the problem of excessive water use. The researchers developed the potential scenarios and water values to be discussed based on the real case. They found that serious games had a social learning effect, as by the end of the sessions, none of the participants accepted the status quo scenario (business as usual). Although there was no clear outcome regarding the future of this aquifer, the authors noted that the serious game helped to animate the interaction between the different participants. 'Over the course of the workshops, participants were capable of understanding the relevance, or importance, of joining a collaborative effort' (Mayer et al., 2021). Nevertheless, this study identifies several shortcomings. First, the number of participants in general, as well as the changes in participants over the course of the meetings, was less than ideal. An additional problem, or perhaps the cause of the first, was the Covid-19 outbreak, which prevented real face-to-face interaction. Participants also felt that the lack of interaction limited the potential of this study and its discussions.

In these examples, there is a strong social influence induced by serious games. All cases show similar patterns: players are randomly assigned to groups at the beginning of the

game, and cooperation develops as the game progresses. In this way, it seems that interaction between players from different backgrounds (or different countries) can be actively encouraged by the game. Being together in the same boat ('game') enables a specific interaction that may be important for future real cases.

Serious games in relation to policy design

To assess political collaboration and trust processes, Onencan et al. (2018) developed a serious game for policymakers in the Nzoia River basin in Western Kenya and conducted assessments before, during, and after the game. Due to trust issues, the collaboration between the county governments in the Nzoia River basin on the water resource management is severely limited. Against this background, the game was designed to require communication and cooperation for sustainable river basin management. However, the game design makes it difficult to achieve all the objectives, as some of them may conflict in situations such as drought. Seven game sessions were held, each played by different groups of five policymakers. There was no co-design. For the evaluation, the authors used a modified version of Evans and Revelle's (2008) Propensity to Trust (PTS) scale with a total of 18 questions. The derived variables allowed them to measure three groups of constructs: trust (six variables), trustworthiness (eight variables), and the respondent's cooperative nature (four variables). The results of the assessment were analysed using three methods of descriptive statistics. This case study of the Nzoia River demonstrated the potential co-existence of competition and cooperation, as both factors continued to increase. For the observed game session, the study concluded that reduced uncertainty and complexity led to a decrease in mistrust, while increased uncertainty and complexity increased trust. Onencan et al. (2018), supported by the findings of Gambetta (1988) and Luhmann (2000, 2017), argue that trust is not necessary for decision-making when uncertainty and complexity are low, as trust does not change the decision in this case.

In another setting, Fonseca-Cepeda et al. (2022) conducted a role-playing game workshop in Colombia with people from the local palm oil and banana sectors, as well as the processing industry and environmental protection agencies. They played the role of producers and a water distributor. The authors analysed both hydrological and power relations in the Aracataca River basin, where uniform irrigation practices have not yet been applied. As the region is at risk of water shortage, the participants were asked to negotiate water-harvesting permits, develop a watershed management plan and deal with severe drought. Over four rounds, the participants developed institutional arrangements to organize water distribution; however, illegal water harvesting continued and was not sanctioned, nor were those arrangements improved. The results suggest that despite water shortage, the real problem is informal power imbalances that hinder collective action. As such, the game reveals the root cause of resource scarcity, facilitates the analysis of structural power asymmetries, and initiates a process of establishing policy and sanctioning institutions.

Even if they are fuzzy, these examples have shown that the previous effects (learning and interaction) are important in terms of policy design. Playing games with a focus on policy design could help to identify specific friction points and useful aspects for subsequent policies. It can also help re-evaluate already developed policies through such games.

This brief overview of water-related serious games already shows that these games can have different orientations and employ different approaches, such as chair circles, but also board or computer games. However, according to the articles reviewed, these games have often only been played or piloted once, rather than over an extended period of time. In the following section, we will highlight the main findings we found, based on these examples and other research.

Results

As the previous section has illustrated there is a wide variety of different approaches and possible effects of water-related serious games. We now summarize our findings by giving a general overview of the types of effects we found in our literature review. We distinguish between the types of effects that were observed and described (by the study's authors) in the context of playing the serious game, and the potential effects that are merely expected or claimed by the studies but have not yet been adequately analysed. We analyse these effects alongside four types of effects, namely education, wickedness, policy, and cooperation (see Figure 2). These types form categories that relate to the intended goals of serious games as stated by the authors of the publications and help to structure the analysis of outcomes.

Observed effects of serious games

Regarding the nature of the effects, in the described examples in particular, we noticed the presentation of a correlation between playing these serious games and possible resulting learning effects for the participants (e.g., Hummel et al., 2011).

Types of Effects		Observed Effects	Claimed Effects
Education	Improvement of learning (in terms of subject matter, but also in terms of social learning, such as actor roles and relationships)	Improvement of learning and / or common understanding (in terms of the topics and social aspects) [17]	Transferability of match results to other cases / Adaptation to new cases [1]
Wickedness	Awareness of complexity, uncertainty, urgency, and conflict	Improvement of complexity and urgency awareness and reflexivity [6]	Validity for a wide range of actors [0]
Policy	Improvement of decision-making (assessment of different scenarios and actions)	Improvement of strategic foresight[4]	Effectiveness on decision-making [5]
Cooperation	Growth in relationships and collaboration (perceived need for cooperation)	Increase of interactions (over the course of the game) [3] Potential enhancement of relationships and/or interactions [6]	Long-term impact on relationships [3]

Figure 2. Types of effects of serious games and observed versus claimed effects, number in brackets indicates the frequency in the 27 publications selected for qualitative analysis. Shades according to frequency (green: more than half; orange: less than half; red: one or none of the publications reviewed), suggesting a need for further research in most areas. Readers of the print article can view the table in colour online at <https://doi.org/10.1080/02508060.2025.2501511>.

Specifically, longer or subsequent sessions led to improved learning over time, so that normal experimental learning of the scenarios played is possible (Hoekstra, 2012). This experiential learning effect also included an improved understanding that aiming for the ‘very first’ solution is not always helpful, especially when there are many uncertainties and impacts in the scenarios (Hoekstra, 2012). Other impacts related to this learning effect are the participants’ ability to better understand complex issues in water governance (Hummel et al., 2011) and to gain a broad understanding of the given case, especially regarding the potential impact of dynamics that are usually difficult to grasp (Haasnoot et al., 2012). In this context, complexity is meant in terms of possible future interactions (Hertzog et al., 2014) or a better understanding of the need to deal with uncertainty (Buchholz et al., 2016; Van Pelt et al., 2015). Another effect is that participants gain an understanding of other factors, such as the interdependence of certain stakeholders and their different choices (Goodspeed et al., 2020; Moore et al., 2011). Finally, playing such games could also improve the understanding of certain power relations between stakeholders (Fonseca-Cepeda et al., 2022).

A follow-up effect is the potential for decision-making, which would be one of the most critical aspects of future policy-making. It has been shown that serious games can improve decision-making (Bathke et al., 2019; Orduña Alegría et al., 2020). They can be used to evaluate policies for decision-makers (Valkering et al., 2013) and to ‘play’ with different scenarios or even to evaluate ‘unexpected’ strategies (Hertzog et al., 2014) that evolved over the course of the game. Onencan et al. (2016a, 2016b) have also shown that serious games can improve strategic foresight in water-related disaster risk reduction. In addition to content learning, there is also an effect on social learning, as was mentioned in relation to changes in relationships or collaboration. While playing these games, it could be found that relationships were formed or even that collaboration was improved (Bathke et al., 2019; Jean et al., 2018). Serious games could help build optimism that collaboration can work (Goodspeed et al., 2020), but this would also depend on the outcome and post-evaluation of these games. Importantly, however, serious games can be used as an ‘icebreaker’ to build relationships around key issues, particularly where there has been no previous collaboration (Poděbradská et al., 2020) or where different knowledge bases have impeded it (Shrestha et al., 2021). Trying to get future stakeholders around the table to discuss real issues that currently affect them can be a barrier to having a fruitful discussion at all, as they may not be keen to meet. Therefore, a more playful approach can slowly move them in this direction, from discussing in a non-binding game setting to discussing real cases (e.g., Douven et al., 2014). However, when we looked at the examples of serious games from our literature base, we found that, in general, many effects were mentioned, but the actual evidence that these effects were reproducible or even related to the games was vague. Some effects were reported in the studies but could also be related to the social interaction of the participants. For example, the longer the participants interacted in the serious games, the more their interaction and collaboration improved (Jean et al., 2018; Onencan et al., 2018). This strengthening of relationships is a recurring theme in the literature. In this context, repeated workshops with the same participants were also seen as a helpful approach, e.g., to improve mutual understanding or the relevance of the case presented (Mayer et al., 2021). It is worth noting, however, that most games have only been played in single playing sessions. Therefore, there is

a lack of research on specific dynamics related to processes over time with multiple sessions.

Claimed effects of serious games

Some of the effects that were mentioned (expected or claimed) but not yet evaluated or observed are as follows: although the most frequently found type of effect was the improvement of relationships and their link to better cooperation, there were no studies on this effect over a longer period or on the effect in general (Poděbradská et al., 2020). It was even mentioned as a research gap that it would be necessary to re-examine this observed effect of improved relationships after a certain period of time (Jean et al., 2018). Furthermore, the authors noted that attempting to measure the potential effects of a game or role play with the tools of the game itself would not be sufficient to truly measure them (Hoekstra, 2012). Even the development of the serious games themselves may require several iterations and adaptations with participants in order to be associated with the effects mentioned, such as social learning (Magnuszewski et al., 2018). However, we could only find a few games in our literature base that were co-designed with the participants, e.g., Powell et al. (2021). Other authors saw time constraints due to project frames as a major problem (Rodela et al., 2019).

Discussion

This review of serious games in the context of water governance covers a relatively unexplored field with a small number of publications. Our findings are an initial indication of this, rather than a comprehensive or generalizable assessment of their effects. Nevertheless, these findings may prove valuable for further studies in this field. Most publications focus on the use of games developed by the authors themselves. There are only a few reviews or survey articles in this research area of serious games in water governance and policy (e.g., Forrest et al., 2022; Medema et al., 2016; Mittal et al., 2022). We noticed that the papers on forecasting used scenario-based serious games to deal with future uncertainty due to unforeseen future water developments (e.g., Hertzog et al., 2014; Valkering et al., 2013). In this way, the researchers were able to gain potential insights into the decisions under uncertainty that will have to be made in the future. However, in this context, there have been few examples of serious games with a strong policy focus to address or manage issues, such as the policy implications of water governance (e.g., Ghodsvali et al., 2022). In addition, many publications tend to focus solely on describing their particular game, resulting in a lack of comprehensive knowledge about the effects or implications of these games. We identified two main challenges common to most studies: the representation of complexity and the inclusion of associated agents or stakeholders. Regarding complexity, it is advisable to optimize functional complexity while minimizing complexity that is irrelevant to understanding the problem (Westera et al., 2008). Overly complex learning environments in serious games can hinder the learning process by overwhelming the player, especially novices (Van der Spek et al., 2008). This is particularly relevant for water-related issues, which tend to be highly complex and therefore involve considerable scientific uncertainty (Ostrom et al., 2003). However,

using a serious game for educational purposes may not accurately convey the expected objectives, as each player may have a different understanding (Marc et al., 2010). Therefore, the term ‘educational intentions’ is usually preferred to ‘educational objectives’ (Alvarez, 2007). In order to communicate these intentions to the relevant target group, we propose to address the second challenge related to stakeholder involvement. Instead of involving only students or third-party participants as representatives, it might be beneficial to involve stakeholders who have already experienced these problems, or who are decision-makers and will have to face and manage them in the future. Indeed, it has already been shown that involving real stakeholders instead of (or in addition to) academic experts can lead to more consistent and robust scenario outcomes (Reed et al., 2013), improve the acceptance of certain policies (Keseru et al., 2021; Tori et al., 2023), promote understanding, and improve the management of complex problems (Bammer, 2019).

Many of the serious games in our literature review were conducted with students and, depending on the desired research, this could be seen as limiting the potential outcomes. For example, students may have a more open perspective on issues, as they lack the experience of people who have been working in a particular field for years. Therefore, their views should always be compared with those of stakeholders who are more involved in these areas and know the potential risks. In this context, it might be worth exploring new ways of transferring knowledge to improve future management. Researchers conducting serious games should focus on the goal of the serious game, for example, to inform people about a particular complex problem or to try to solve a particular problem. Both approaches could lead to different policy recommendations and may also require different approaches (Voinov et al., 2018) and target groups (Zhao et al., 2013). Depending on the research question, students or even younger people can serve as important reference groups or can complement the study.

Apart from the selection of participants, we also noticed a lack of stakeholder involvement in the design of these serious games. A co-design approach between researchers and stakeholders could be beneficial to incorporate local perspectives and knowledge and thus create a more realistic game setting. Involving stakeholders throughout the design process is also a recommendable approach to improve the outcome of a serious game (Bunt et al., 2024). Otherwise, complexity may be lost, which may of course be a conscious decision by the researcher designing the game to simply have a broader case. However, if a serious game does not involve the relevant stakeholders (either in the design or in the play sessions) in an attempt to represent possible futures, the potentially interesting insights will not be unearthed. This may be one reason why it is still unclear whether water-related serious games can provide robust results and information to improve, for example, future risk management.

Based on this analysis, we suggest that stakeholders should be kept in mind to sharpen the case. Efforts should be made to ensure that serious games are closely linked to the needs of potential stakeholders who will use them to improve their decision-making. One option would be to conduct interviews with potential stakeholders and incorporate these issues and risks highlighted by the participants into the game design. We expect that this approach would result in a wider range of potential problems and solutions to be discussed. Furthermore, a water problem is likely to be best solved together with the people related to that ‘body of water’, especially as such conflicts are often intertwined

(Brauner, 2024). For example, such as, in one of the cases mentioned, a conflict on the border between Mexico and the United States of America involved participants from both sides (Mayer et al., 2021).

In our review, we found that some claimed effects, such as improved understanding of complexity or general learning, still lack empirical evidence. In particular, studies have tended to be short term, and researchers have even mentioned the lack of long-term research, which could be addressed by a collaborative approach (Jean et al., 2018). It was not always clear whether the effects were due to the specific design of the game or to the interaction between the players, particularly in terms of social learning and interaction. A deeper understanding of the evaluated case could be achieved by letting certain stakeholders, who are experts in their field, follow the whole design process of a serious game. However, it is obvious that in most cases it is not easy to involve key stakeholders in a given project, as they may be preoccupied with their busy schedules and therefore compromises have to be made to complete the research. Therefore, we think it is important to keep the idea of co-creation in mind at all stages and always try to involve the stakeholders at least at the most important stages and otherwise do the best to match the case with already published or similar information. The challenge is not only to motivate participants but also to make them aware that the content of such serious games can help to shape the future. In the best case scenario, gaming sessions with stakeholders could lead to improved decision-making or cooperation in the future. This potential to shape the future should be a pre-announced possibility of serious games by the researchers, perhaps as an incentive for stakeholders to participate. However, depending on the situation, stakeholders may have conflicting perspectives or interests, which could undermine collaboration (Dentoni et al., 2018; Reed et al., 2018). It is important to remember that future developments around water scarcity could lead to severe conflict, as illustrated by the tense situations in some regions of Africa or arid Arab states, with the Grand Ethiopian Renaissance Dam potentially affecting the Nile (Egypt) downstream being a recent prime example (Matthews & Vivoda, 2023). Here we have seen in our body of literature that in this case of conflict, serious games can help to facilitate the exchange, as they can be used as a kind of icebreaker for the subsequent discussion.

Conclusion

Overall, this study suggests that the analysis of the effects of water governance serious games on participants is still an open field for further research. In particular, if serious games are to become more common, their use and potential effects should be explored, including how different serious games might produce certain outcomes. To date, the number of serious games, particularly in the field of water governance, is still manageable. This initial review has outlined some current use cases in the field of water governance (Appendix A) and some effects that have been observed by the authors of the studies (Appendix B), such as improving critical assessment of complex cases or fostering relationships between even disagreeing individuals.

With regard to the wickedness dimension of research question 1, we found that some studies explicitly emphasize a positive effect of serious games in reflecting complexity, uncertainty, and conflict. This is particularly the case for understanding hidden policy interactions and the diversity of possible future developments (i.e., Haasnoot et al., 2012;

Hertzog et al., 2014). In terms of the types of effects identified in this review (question 2), very different areas are captured by other research. However, there is little embedding of individually observed effects of one gaming approach into others, and little externally verifiable validation.

Many of the effects lack long-term analysis, so the observed effects may be temporary. Furthermore, most of the authors cited do not evaluate the effects in terms of their actual impact, nor do they relate their approaches to other games. One reason for this may be the lack of similar measurement tools for these potential effects. We also noticed that serious game researchers should pay more attention to the selection of participants. For example, involving stakeholders related to the specific case may benefit certain serious games, while others designed for a wider audience may not require such involvement. As a result, the link between games and actual policy processes remains unclear. Finally, our review has identified that a reflective approach would be beneficial in critically evaluating the use of serious games, especially those that aim to improve knowledge, change player behaviour or inform policies design. Therefore, it is suggested that researchers planning serious games should ask themselves: first, for which topic (case, problem) do I want to develop a serious game? Second, who might benefit from this serious game? Involving potential beneficiaries already in the design of the serious game could be a valuable approach. Third, what is a long-term goal for the development of this serious game, e.g., the relevance of its results or its potential impact on the participants?

This is also reflected in some of the recommendations we identified during the review, which may be important when setting up a serious game: (A) considering the potential of the game in relation to the objectives of the chosen water case; (B) playing with stakeholders, rather than surrogates; (C) choosing a format appropriate to A and B; and (D) running the game over multiple sessions to strengthen the long-term impact.

Although this literature review could provide some insights into the potential impact of serious games on policy-or decision-making, it is important to note that it is only exploratory and examines a limited part of this important topic. As we have focused on water governance, it seems interesting to open up such a review to other topics or to generalize it even more. Furthermore, only scientific publications were included that also covered or described these serious games in significant detail. Other serious games in a scientific or non-scientific contexts that have already led to noteworthy results would be an enlightening extension for this review. In addition to including more case studies of serious games, there is also the possibility of considering or comparing serious games on other topics. Do they have similar approaches or are they different, especially if, for example, these issues do not have a clear policy focus? The effects we found on our dimensions of education, policy, wickedness, and cooperation are also possible areas for more in-depth analysis, not only in terms of literature reviews by examining further cases, but also in the possibility of conducting our own serious games or interviewing serious game researchers about these concepts. By addressing their understanding of these issues, even more insight could be gained that could improve serious game approaches. Additional findings could be obtained by consulting the participants and stakeholders involved in such serious games and assessing their experiences as well.

Finally, we conclude that serious games, especially when co-created by stakeholders, could help to make complex, uncertain futures more tangible, as the cases are more likely to have been considered in detail. However, more research is needed to fully understand

the potential effects of these games. Therefore, it seems crucial to conduct long-term research involving the selected stakeholders or participants.

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Data availability statement

The authors confirm that all data analysed in this study are included in the published article. The mentioned literature corpus from which the analysed studies were selected is available on request from the corresponding author: s.brauner@fz-juelich.de.

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Appendixes

Appendix A. List of selected publications for literature review

	Reference; open or closed access (OA/CA)	Serious Game Type	Players	Target Group	Effects	
1	Bathke et al. (2019)* OA	'Invitational Drought Tournament'	Representatives from governments to non-governmental organizations, farmers, and academia plus facilitators			A, H
2	Buchholz et al. (2016) OA	Business simulation game, manage a virtual cash- crop farm	Farmers	Farmers, political decision- makers	<i>Ex-ante</i> policy impact analysis of irrigation policies Reflect complexities	B, C, F
3	Douven et al. (2014) CA	'Shariva game'	Interdisciplinary mid-level professionals from lower Mekong countries in roles of real institutions	Water and related professionals	Create awareness and design policies Improve knowledge of complex systems Support cooperation	A, H
4	Fonseca- Cepeda et al. (2022)* OA	Interviews, board game/role- playing workshops 'Upstream'	Farmers/producers and processors, non- governmental organization representatives in the role of producers, and water distribution representative	Local stakeholders	Facilitate long-term development of institutional arrangements through balancing/reducing the role of power asymmetries	I
5	Forrest et al. (2022) OA	Review of 37 games	Players of flood risk management	Research and game design	Enhance governance- based and holistic perspective, test environment for decision-makers, increase engagement	A, H

(Continued)

	Reference; open or closed access (OA/CA)	Serious Game Type	Players	Target Group	Effects	
6	Furber et al. (2018) OA	Interviews as identification for serious games as a viable measure	Water resource managers	–	Improve decision-making through robust solutions Reach consensus in complex and urgent context situations	A, F
7	Ghodsvali et al. (2022) OA	'S.N.O.G.'	Food–water–energy nexus community in the role of decision- makers in integrated food–water–energy management	Broad target group: public and private sector, academia, and local stakeholders (California) groundwater stakeholder	Test impact of decision- making Identify and indicate key drivers of integrated resource management	A, F, H
8	Goodspeed et al. (2020) OA	'Groundwater Management Game' is an in- person role- playing game	Students, citizens, and professionals in random stakeholder roles		Awareness of interdependences of common pool resources Learning and cooperation	A, C
9	Hertzog et al. (2014) CA	Role-playing board game 'FOWIS (Future of Water in Irrigated Systems)'	Decision-makers and local stakeholders in the roles of family farmers, large-scale investors, or the manager of the irrigation scheme		Understand future consequences of management and strategies	A, E
10	Hoekstra (2012) OA	Computer- supported 'River Basin Game' and 'Globalization of Water Role Play'	Students in the role of farmers respectively in the role of government officials from different nations	–	Enhance systems thinking Develop cooperative action	A, I
11	Hummel et al. (2011)* CA	'Aquaculture' online game with scripted collaboration	Water management students in the role of project leader	Students, related workplaces	Improve learning	A
12	Jean et al. (2018)* CA	Informal, in- person game simulation events with 'Aqua Republica'	Students, professionals and stakeholders of watershed management		Increase of cross- boundary interactions in quality and quantity Improve stakeholders' relationships	G, H
13	Magnuszewski et al. (2018) OA	'Lords of the Valley' (LOV) board game	Citizens in roles of inhabitants of a river valley, government, bank and non- governmental organizations	–	Present complexity of environmental and social interactions	A, G
14	Mayer et al. (2021)* OA	Bi-national multisector serious games workshop (online)	Participants from two river riparian states, municipal as well as industrial players		Agree on a shared problem Understand the value of and start bi-national group decision-making Evolve conversation skills and social learning	A, E, H
15	Medema et al. (2016) OA	Interviews as assessment for serious game indication	Students, youth, water resource manager	Water resource managers	Social learning	A

(Continued)

	Reference; open or closed access (OA/CA)	Serious Game Type	Players	Target Group	Effects	
16	Mittal et al. (2022) OA	Review of 15 serious games in the urban water cycle	–	(Decision- makers)	–	–
17	Moore et al. (2011) OA	‘UVa Bay Game’ as a base for further game design	–	Farmers or regulators/ government players of a watershed	Social learning, understanding the link between humans and the ecosystem	A, C
18	Onencan et al. (2016a) OA	‘We Share It’, a computer- assisted board game	Participants from the Kenyan Ministry of Water and Irrigation and Moi University Centre for Public Sector Reforms	Policymakers affected by climate change	Improve strategic foresight under uncertainty	C, E
19	Onencan et al. (2016b) OA	Mobile-phone location-based game design only	–	(Kenyan) citizens	Improve social learning for joint action	–
20	Onencan et al. (2018)* OA	‘We Share It’	Policymakers from Kenyan counties		Increase trust for long- term cooperation	I
21	Orduña Alegría et al. (2020) OA	‘MAHIZ’, board game	Researchers, farmers, citizens	Corn farmers with groundwater withdrawal	Identify decision-making processes associations between social parameters Enhance trust and communication	A, G
22	Poděbradská et al. (2020) OA	In-person role- playing game ‘Ready for Drought?’	Students and professionals from diverse water-related backgrounds	–	Encourages discussions and collaborations	A, F
23	Powell et al. (2021) OA	Game co-design	Professionals from diverse water-related backgrounds	–	Comprehension of wicked situations Foster self-organized collaboration	C
24	Rodela et al. (2019) OA	Review, iterative rounds of the ‘ALEGAM’ project game	Farmers	–	Enhance (social) learning	A
25	Shrestha et al. (2021) CA	Web-based platform ‘Supporting Water Resources Management (SWARM)’	–	Multi- stakeholder partnerships	Promote water cooperation Understand future implications of actions	–
26	Valkering et al. (2013) CA	Online game ‘Waas Pilot’	Water managers and academics in the role of water managers	–	Explore future river management dynamics Enhance policy development	E, F
27	Van Pelt et al. (2015) CA	Workshops with the ‘Sustainable Delta’ simulation game	Water managers, students, scientists (indirectly)		Foster understanding and communication of complexity/uncertainty	A, C

*Outlined in the manuscript.

Appendix B. Frequency of effects

Observed effects		Frequency in selected papers (compare Appendix A)
A	Improvement of (social) learning and/or common understanding	17
B	Transferability of match results/adoption to new cases and reflexivity	1
C	Improvement of complexity and urgency awareness	6
D	Validity for a wider range of people	0
E	Improvement of strategic foresight	4
F	Effectiveness on decision-making	5
G	Increase of interactions (over the course of the game)	3
H	Strengthening of relationships/interactions	6
I	Long-term impact on relationships	3

Appendix C. Search terms

(TITLE-ABS-KEY ('Water' AND 'Governance' AND 'serious game') OR TITLE-ABS-KEY ('Water' AND 'conflicts' AND 'serious game' AND ('impact' OR 'cooperation' OR 'learning' OR 'knowledge')) OR TITLE-ABS-KEY ('Water governance' AND 'serious games' AND ('policy design' OR 'policy making' OR 'policy process' OR 'policy outcome')) OR TITLE-ABS-KEY ('water' AND 'uncertainty' AND ('management' OR 'policy' OR 'knowledge') AND 'game') OR TITLE-ABS-KEY ('water governance' AND ('actor' OR 'player') AND ('complex' OR 'wicked problem' OR 'goal conflict')))