More than Chair Circles? - Serious Games related to water governance and their potential effects on policy design

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Abstract

Climate change demands innovative ways of managing limited resources, such as water, by confronting policymakers with so far unknown situations. However, trying to deal with such unknown situations is a problem in itself, and it can be seen as a wicked problem, involving not only uncertainty but often considerable complexity (for decision-making), and at times also conflict. One approach to address wicked policy process problems like water stress and to develop successful and comprehensive coping or mitigation strategies is to build upon participatory research. Cooperative measures draw on various kinds of knowledge while simultaneously reducing the potential non-knowledge, among other advantages. A participatory approach might supply the opportunity to frame issues more comprehensively and potentially improve the effectiveness of measures. In addition, participatory approaches such as “serious games” offer the opportunity to “play” with real or designed cases, while involving different stakeholders and participants in cooperative, argumentative, or problem-solving settings. In most cases, serious games are used to help participants understand the potential impact of their actions, often with the aim of improving the acceptance of certain measures.
We ask: How do serious games deal with the uncertainty, complexity and at times conflicting character of water governance? How do they affect policy processes, design and outcome, and what potential effects are not fully explored or empirically validated yet?
In this paper, we explore the influence of water governance-related serious games (SG) on knowledge production and policy-making processes. We conduct a systematic literature review on serious games in the water sector with a focus on effects on policy design, including the analysis of actor involvement. We assess how serious games currently deal with future uncertainty, complex interrelations and goal conflicts. We outline the potential implications of these serious games for policy-making processes and discuss what role serious games do and could play in research, policy advice and policy design. The focus is on (a) types of influences on policy processes, (b) effects that have already been measured empirically, or (c) that have been expected or postulated but not validated yet. Finally, we address research gaps as to the use of serious games for water governance.

1. Introduction

Exploring different possibilities has always been of critical importance, whether through scientific research in general or through more specific methods such as simulations or scenario research that explore the effects of different options or possible short- or long-term futures. In addition, climate change and other factors challenge the current management of limited resources such as water by confronting, for instance, policy-makers with previously unknown situations. Dealing with possible future developments, which are often complex and uncertain in themselves confronts those responsible for taking decisions with wicked problems, especially as their decisions can have serious consequences for future developments. One approach to address

wicked policy problems such as water management and to develop successful and comprehensive coping or mitigation strategies could be to build on participatory research. For this assumption, it should be mentioned that there is already a discourse on the extent to which participatory methods are actually effective for wicked problems and policy design (Kirschke & Kosow, 2022). As one specific participatory method, serious games (SGs) can be used to "play" through (potential) scenarios and explore different options for action. As serious games allow for the involvement of multiple players with different backgrounds, this approach can be seen as an important tool for combining participatory research with the exploration of possibilities (options for action and future scenarios).

There are already some examples of literature reviews of SGs in the context of water governance (Medema et al., 2014; Furber et al., 2018; Medema et al., 2020) or water management to support decision-making (Savic et al., 2016; Xu et al., 2020; Mittal et al., 2022). Adding to this research, we are particularly interested in the effects of serious games and what potential benefits serious game participants see, especially in terms of influences on decision-making. The main focus of this literature review is the way in which serious games approach the idea of wicked problems. In particular, we consider the participants of these games and their involvement. We ask: How do SGs deal with the uncertainty, complexity and at times conflicting character of water governance? How do they affect policy processes, design and outcome, and what potential effects of SGs are not fully explored or empirically validated yet? Based on our specific research questions, we decided to conduct a qualitative systematic literature review. For this review, we focused specifically on water (policy) serious games and their perceived, measured and potential impacts on policy-making. In recent years, water scarcity and water shortages have received increasing coverage in the German media. This becomes evident when looking at the number of search results for „Wasserknappheit“ (water scarcity) and „Wassermangel“ (water shortage) on the professional research platform GENIOS (GBI-Genios, 2023a & b). Media reports for both terms in Germany roughly tripled from 2017 to 2018. Both terms peaked in 2022 with 1,741 results for water scarcity (more than five times the amount of 2017 (316)) and 2,279 results for water shortage (more than four times as many as in 2017 (550)). This suggests the rising importance of water for Germany. Consequently, even in rather water-rich Germany policymakers will have to learn how to handle water stress in the future (Bake et al., 2021).

In the following chapters, we will outline the potential implications of water serious games for policy-making processes and discuss the role that serious games play and could play in research, policy advice and policy design. Section 2 explains why and how the systematic literature review was undertaken. Section 3 presents a condensed selection of serious game studies with a focus on water; we will show the diversity of SG research in theory and practice, but also analyse its limitations. The fourth section summarises the effects of serious games that we found in the review, namely (a) different types of influences on policy processes, (b) effects that have already been measured empirically, or (c) effects that have been expected or postulated but not yet validated. Finally, we address gaps in research on the use of serious games for water governance.

2. Framework of the study

2.1. Serious games in water governance - a first assessment of theory

Serious games are particularly well suited for use in water governance when multiple perspectives on an issue need to be considered and there is a certain urgency to act. This can be the case if decision-making is subject to (1) time constraints, (2) complexity and uncertainty, and (3) subjectivity (i.e. socially constructed reality that requires a negotiation process) (Furber et al., 2018; Medema et al., 2016). Following this, wicked problems are an important topic in public policy (Head, 2022), especially when external influences such as climate change or other impacts create significant uncertainties. These uncertainties, once recognised, can be discussed in various ways to reduce them. In the case of water governance, for instance, which is affected not only by climate change but also by human interactions, serious games could provide a solution or at least an open space for discussion. Serious games in the context of water, we would suggest, are quite crucial but may be underestimated so far, especially in settings where water is an everyday commodity. However, due to ongoing climate change and fear of change, serious games can be used to pre-experience such future events in order to adapt decisions and concerns. This also applies to different actors or countries that may be affected by the same or similar problems and need a platform to discuss them before they actually happen, to avoid possible worst case scenarios.

Serious games can therefore be especially helpful in a transboundary water context (Douven et al., 2014) because those cases are usually characterised by a high degree of complexity and subjective, often differing views on the issue. Regulation by a single authority is hardly possible (Mayer et al., 2021). Water can, moreover, be interpreted as a shared common pool resource with the associated well-known coordination problems (Albrecht et al., 2018; Hardin, 1968). Ostrom (1990) stresses that in such circumstances collaboration is a more promising approach than top-down imposition. She also emphasises the importance of increasing and sharing knowledge. Proven against three theoretic approaches, namely Cultural Theory (Douglas, 1970), advocacy-coalition framework (Sabatier & Jenkins-Smith, 1993), and Transition Theory (Rotmans, 2005, Van der Brugge, 2009), Valkering et al. (2013) state that serious games in water-related settings create valuable insights for actors into future conditions and respective strategies, with the latter likely to change according to societal trends. As such, the gaming environment allows to experience a volatile context with large uncertainty, in which decisions must be made, while each decision also limits the horizon of further steps. The authors analyse especially the interaction between a hydrological system, the societal response, and the broader context (STEEP: social, technological, economic, environmental, and political implications) when players try to manage a river sustainably. As such, the study is a valuable contribution to serious games not only in a complex and uncertain but also in a possibly constantly changing environment, in which technical solutions can only be part of a sound strategy.

With this background in mind, the paper proceeds 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.

2.2. Methodology of the literature review

This paper presents a qualitative systematic literature review (Rother, 2007) on serious games in the field of water governance and knowledge production. Given our specific research questions, such a systematic literature review is useful because it focuses on articles that are relevant to our study. The process, therefore, starts with questions that narrow the scope of the review by relevance, as opposed to a broader literature review on a particular topic that attempts to comprehensively cover existing research. We then describe the databases and search methods used in order to make our process reproducible and comparable with other similar studies. Criteria for inclusion or exclusion of the literature found are derived from the research question. While systematic reviews can have a strong quantitative focus, we focus our analysis on the qualitative evidence, i.e. the effects or outcomes of SGs as presented by the studies.

However, if a perceived effect is mentioned repeatedly, this is interpreted as an indication of its validity. For this reason, the frequency of reported effects (quantitative analysis) is also roughly taken into account. To reiterate our review approach, this qualitative review addresses the broader topic of serious games in water, focusing on policy implications as defined by the research question. While there is some existing work on SGs in water governance - e.g., Forrest et al. (2002) published a comprehensive list of serious games used for flood management - there is still a lack of bringing together both empirically measured and postulated but not yet validated effects of serious games used for water governance. This may partly be a consequence of the complexity of water management: there are multiple and very different challenges in dealing with droughts or floods, heavy rainfall or swelling water bodies. Also, the network of actors is case-dependent and often limitless when considered in its entirety. Therefore, this review aims to represent the wide range of serious gaming literature on water governance, not only by analysing the way some individual games are conducted but also by synthesising the effects and implications (for policy making) that all these games have in common.

To reduce both author and selection bias, a manual selection of search terms was grouped by Boolean operators in order to build a comprehensive literature pool of the field of SG in water governance. The grouped search terms (Boolean strings) included terms from all three elements of the research question and were formulated as follows:

(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"*)))

Searching on Scopus, we found **250** publications fitting those terms on either title, abstract or keywords. The same search on “Web of Science” resulted in **137** publications. Simultaneously, all authors of this paper conducted a free snowballing literature search in order to complement the computational results and prevent relevant publications to get lost through search terms or

journal bias, which seemed sensible in an only emerging research field. This approach resembles the hybrid search strategy presented by Wohlin et al. (2022), see figure 1. Clearing up duplicates, the literature body consists of **311** publications. In the next step, all publications' abstracts were manually checked to fit into answering the research question. Exclusion criteria were as follows: Does the paper refer to serious games? Does the serious game relate to water governance? Is it a literature review? Publications were excluded in successive stages by first title, and second abstract. In the second step, we looked at the full texts of the remaining publications. Each study was reviewed by at least two authors to reduce bias in the selection or non-selection of literature. In addition to the first exclusion criterion, which was used again if some papers had been selected because of a vague abstract, we added the criterion that the study should report results from the implementation of its serious game, as well as whether the publication could generally answer our questions about effects for this study. This approach allowed us to systematically reduce the literature body to the central publications, while also getting aware of the range of authors working on this topic.

The selection process led to a combined literature body of **27** publications, which were then read in depth. Of these **27** publications, **8** studies, representative of a wider field, are introduced in the next section of this paper, to give some examples of what has already been done. In order to address our overarching research question and to present the work of others in a clear and precise manner, we extracted data from the studies according to this structure:

1. Topic, case and research question/goal,
2. Region and/or actual conflict, if applicable,
3. Development, kind and implementation context of serious gaming approach, including role and type of participants,
4. Postulated effects and reflection by authors,
5. Additionally identified research gaps, if applicable.

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

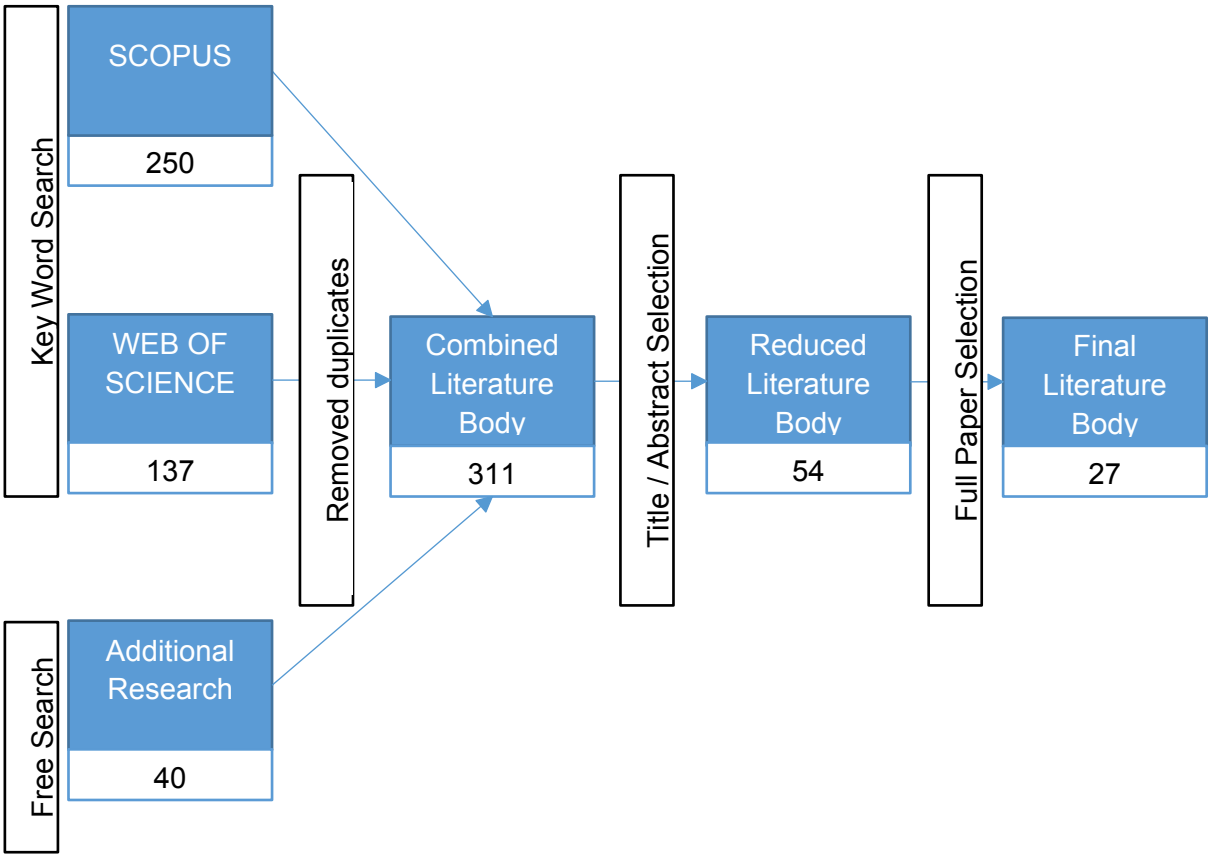

Figure 1: Literature Selection Process

3. Exemplary cases for serious games in water governance

In this section, we evaluate some serious games as examples of possible different effects of serious games. To do this, we describe the relevant aspects of serious games as mentioned above. Although we know and have noticed that there is a lot of overlap in the effects of serious games and that it is not so easy to make a clear distinction, we have tried to give some general examples for the following headlines. For this reason, some of the examples could also be mentioned in a different sub-section, but we have focused our analyses on the example according to the headline in which it appears. First, we focus on a general knowledge production effect that could be associated with serious games, such as understanding complex issues (3.1). Subsequently we will highlight the potential influence on cooperation and possible relationship building (3.2) and finally, we give some examples where serious games have been used more in the context of policy design (3.3).

3.1. Serious Games in relation to learning processes

One central effect of serious games seems to be the chance for knowledge production, for individuals but also in interaction with others to create shared knowledge (improvement of learning processes). The exchange between different actors might create mutual understanding on topics and could help to have different kinds of knowledge or viewpoints. Medema et al. (2017) explored the possibilities of networks regarding knowledge co-production, in the case of

watershed governance networks. As they identified a challenge for water organisations in facilitating knowledge, not only could communication technology improve information sharing, but perhaps also communication coupled with serious games. In order to elaborate more on serious games and knowledge, we move on to some examples that we are going to look at in more detail:

Hummel et al. (2011) focus on the individual learning improvements through serious game usage. In a pilot study in the Netherlands, 12 students with a background in water management were tasked to participate in a scripted collaboration game built by EMERGO (http://www.emergo.cc), a toolkit usable for serious game development (Hummel et al., 2011). The topic was aquaculture, which is a relatively new field in the Netherlands. This sector was still open to interpretation because of loose or contradictory laws and little understanding of both governmental actors and upcoming entrepreneurs. However, a broad knowledge of the subject and related aspects is also necessary for future potential specialists in the field, such as students undertaking water management studies. Comprehensive knowledge, ideally including an understanding of more than one dimension, e.g. natural, technological, political (or policy) and social aspects. A preliminary result of their study was that using such a serious game setting can help with learning and understanding complex fields. Students even perceived the scripted collaborative approach as a good tool for experiencing different perspectives that would be useful for future water management tasks related to their university degree. The researchers conclude by suggesting the need for further research into this particular type of serious game and also highlight some of the shortcomings of this study. For instance, a lack of real collaboration was raised by students as this particularly serious game was played individually and only on the computer. More collaboration would have been more engaging and could have further enhanced the learning, which might also help with the problem of adapting to new topics, such as the governmental and political aspects, and learning with serious games in general. Another limitation seems to be the mandatory perspective imposed on the students playing the serious game instead of giving them more freedom of choice.

Bathke et al. (2019) present the complete opposite in terms of game design, namely a serious game played with multiple participants and directly against each other. Bathke et al. (2019) investigated whether serious games can be a helpful tool, for instance, for testing public policies (public participation theory, Creighton (2005)), here also in the case of knowledge production and exchange. They used 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 for reducing the impacts of flooding, drought and water quality under climate scenarios affecting the watershed. The serious game was played in teams where collaboration was encouraged to score better points than the other teams. Sixty participants took part in the study, with backgrounds ranging from government actors (from federal to local) to non-governmental organisations, academics and farmers and were divided into seven mixed teams. The study also included a survey approach before and after the tournament to explore the results. These questions included whether collaboration had been fostered or whether participants had met new people for coordinated action. But also, if and how they used their newly developed knowledge for decision-making, especially for the Cedar region. Many of the respondents said that they had sought new collaborations and projects. And even 64% agreed that the threat scenarios proved useful for future decision-making. Finally, participants mentioned the acquisition of new knowledge about water, floods and droughts. In the tournament itself, the

researchers found that the players collectivised their knowledge to adjust their decisions. Moreover, a kind of bigger picture of such conflict fields was achieved, even helping to understand financial investments and their potential impacts. In this study, it was interpreted that a kind of social learning was taking place, which helped to engage with different people from different backgrounds to collaborate on scenarios. As such, the serious game succeeded in presenting a complex case that could be used for broad knowledge production by the participants.

Another serious game, “Ready for Drought?”, focuses on water scarcity and, beyond serving as an educational tool, also stresses the importance of communication and cooperation (Poděbradská et al., 2020). It can be played in person with 12 to 42 people and has been designed for the Missouri River Basin region where the six hypothetical communities of the game are located. The game proceeds in four phases: “Prepare”, “Response”, “Recover” and “Adapt”. In the “Prepare” phase, players are assigned to groups and gather according to sectors (e.g., private citizens, industry, first responders). They then jointly have to decide which resource cards to keep for the next phase. In the “Response” phase, players are regrouped according to their assigned communities and are confronted with a specific drought-related challenge. For every challenge, there are two possible solutions that require certain resources each. Participants now decide on the allocation of their resource cards, which they are also allowed to trade, and are optionally confronted with a surprise wildfire challenge. Afterwards, the facilitator joins the community teams and determines the game scores in the “Recover” phase. A discussion and evaluation of the game led by the facilitator follow in the “Adapt” phase. In order to ensure that “Ready for Drought?” is applicable both for educational and team-building purposes, the game has been tested with groups of university students and groups of professionals from different backgrounds, such as state and federal agencies, local governments and non-profit organisations. All participants were asked to complete a survey after playing. More than 90 % agreed that the game was an effective team-building or icebreaker exercise, and more than 80 % stated that it made them more familiar with the process of drought planning. However, Poděbradská et al. (2020) identified a couple of gaps, the first of which concerns the adaptation of the game to other regions, as the documentation of the necessary steps of such a game is still not detailed. A second gap is the assessment of long-term impacts since a follow-up survey after a certain period of time is lacking.

3.2. Serious games in relation to (transboundary) collaboration

After the focus on knowledge and learning, the following examples on collaboration will show that serious games could be a way to support or initiate such interpersonal processes. Jean et al. (2018) used the serious game “Aqua Republica” to investigate the changes in the interaction of the participants involved. The question of the study was whether there were signs of changes in the interactions over the course of the game sessions, for instance in the quality or quantity of the interactions. "Aqua Republica", which is normally a single-player game used to experience the difficulties of water management, was in this study used as a game for forced competition. Jean et al. ran four competitions with a total of 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 organisations playing the role of different stakeholders. Following these competitions, some general

observations were made, particularly in relation to interactions and collaboration. For one, they noticed 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 foster the creation of mutual understanding and sometimes initiate new collaborations. In their case, however, it was not clear how serious games could affect the co-creation of knowledge. The authors, therefore, 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 animate cooperation or interaction in a transboundary context. A serious game was conducted regarding an aquifer that is located on both the US and the Mexican sides of the border. This case seemed important as it is already an example of an aquifer where more water is extracted than recharged in a year. For this cross-border case, there were also participants from both countries while also trying to include actors from the municipal or industrial sector. In sum, 20 participants engaged in the serious game, but since there were six online sessions over a four-month time period that took between 60 to 80 minutes each, participation varied over the course of sessions. The SG was a discussion game with different actors on potential strategies to solve the problem of excessive water use. The potential scenarios and water values to be discussed were developed by the researchers and based on the real case. The researchers noted an effect of the SG on social learning, as by the end of the sessions none of the participants accepted the status quo scenario (business as usual) anymore. Although there was no clear outcome regarding the future of this aquifer, the serious game was noted as being helpful for animating the interaction between the different actors. “Over the course of the workshops, participants were capable of understanding the relevance, or importance, of joining a collaborative effort” (Mayer et al., 2021, p. 12). The serious game also appeared to achieve a sharing of perspectives between all stakeholders and a recognition that a depleted aquifer would be detrimental to all. The SGs inspired participants to work together and cooperate. 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. This lack of interaction was also noted by participants as having hindered the potential of this study and its discussions.

Another serious game in a transboundary setting that focuses on inducing cooperation is the “Shariva” game by Douven et al. (2014). They conducted a SG in the Mekong River basin with the aim to improve transboundary cooperation. Their participants were mid-level professionals from agencies – mainly ministries, but also some training and educational institutes – in the four member countries of the Mekong River Commission, Cambodia, Lao PDR, Thailand and Vietnam. In their abstracted serious game, Douven et al. (2014) address the plans of the upstream region to build hydropower dams and to increase irrigation of agricultural areas. These plans would have implications for the downstream region with respect to fisheries, sediment dynamics, agriculture, and freshwater availability in general. In conjunction with the serious game, they offered three workshops to share background information and ensure a level playing field in terms of participants' knowledge. However, although they had these accompanying workshops, they did not explicitly consider the option of further co-designing the game with the participants. Douven et al. (2014) conclude that the SG increased participants’ awareness and knowledge. Particularly the decisions to use a simplified imaginary situation for the game instead of the real-life case and to have the participants switch their roles proved beneficial to enable open dialogue.

That way, cooperation in the game was made possible since participants were able to agree on the abstracted case. However, it could not be assessed if cooperation persists and can be transferred to the real situation.

3.3 Serious games in relation to policy design

With the goal of assessing collaboration and trust processes, Onencan, Enserink and Van de Walle (2018) developed a SG for policymakers in the Nzoia River basin in Western Kenya and conducted assessments before, during and after the game. Because of trust issues, the cooperation between the county governments of the Nzoia River basin regarding the management of water resources is strongly limited. Resolving these issues has the potential to increase the production of food and energy in the basin. The water policy game requires communication and collaboration for sustainable management of the river basin, which is the common goal. However, the game design makes it difficult to fulfill all goals because some of them can collide in situations such as drought. Seven game sessions were held, each played by varying groups of five policymakers. No co-design happened in this case. For the assessment, Onencan, Enserink and Van de Walle (2018) adopted a modified version of Evans and Revelles' (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 assessment results were analysed with three methods of descriptive statistics. The study shows that competition as well as cooperation are rising constantly and therefore coexist. The study also concludes that decreased uncertainty and complexity weakened distrust, while increased uncertainty and complexity strengthened trust. Onencan et al. (2018) argue that, supported by findings by Gambetta (1988) and Luhmann (2000 & 2017), trust is not necessary for decision-making when uncertainty and complexity are low because then trust does not alter the decision. In case of high complexity and low uncertainty, not trust but hard work is needed to cope with a complex situation. The weakening of distrust over the course of the game is explained by the authors due to a higher familiarity of the players amongst each other and with the potential risks, i.e. lower complexity and uncertainty. The weakening effect, however, was not significant.

Onencan et al. (2016) conducted a different study to look at the effects of the computer-assisted and collaborative board game "WeShareIt" on the strategic foresight of Nile Basin policymakers in the face of global warming-driven disasters. One game session with four rounds was held with eleven players from Moi University Centre for Public Sector Reforms and the Kenyan Ministry of Water and Irrigation. The game was evaluated with the help of questionnaires before, during and after the game. Additionally, the interactions and decision-making of the participants during the game were observed. The results suggest that strategic foresight is an important part of reducing disaster risk and that serious games have a great potential to improve the strategic foresight capacities of policymakers.

In another setting, Fonseca-Cepeda et al. (2022) conducted a role-playing game workshop in Columbia with people from the local palm oil and the banana sector as well as the processing

and environmental protection, playing the role of producers and one water distributor. The authors analysed both hydrological and power relations within the Aracataca River basin, where uniform irrigation practices have not yet been applied. Since the region experiences the risk of water shortage, the participants were asked to negotiate water harvesting permits, develop a watershed management plan, and deal with intense drought. In a total of four rounds, the participants established institutional arrangements to organise 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 uncovers the “pushed forward” reason for resource scarcity, facilitates to analyse of structural power asymmetries and initiates a process of establishing policy and sanctioning institutions.

In this brief overview of the example of serious games, we have seen that the games can go in different directions and also have different approaches, for instance, chair circles, but also board or computer games. At the same time, there were some limitations to the scientific assumptions and research, especially the policy aspects that were part of our analysis. For instance, these serious games were mostly conducted from a 'game' rather than a 'serious' perspective. Also, these games were sometimes only played or tested once, rather than over a longer period of time. In the next chapter, we will describe the most important effects we have found, based on these examples and other literature.

4. Results

Given that there are different approaches and possible effects of SG, as seen in our examples, we would like to give a general overview of the types of effects we have found in the literature (4.1), the types of effects that were effectively empirically measured in the context of playing the serious game (4.2); and finally, the potential effects that have not yet been properly analysed, but which are expected or claimed by the studies (4.3), see also Figure 2.

4.1. Types of influence from serious gaming

In terms of the nature of the influences, in the described examples in particular, we observed a strong correlation between playing SGs and possible resulting learning effects for participants (Hummel et al., 2011). Notably, longer or follow-up sessions were found to improve learning over time, or in other words, learning by experience with respect to the scenarios played (Hoekstra et al., 2012). This experiential learning effect also included gaining an understanding that aiming for the 'best' solution is not always helpful, especially when there are many uncertainties and influences in the scenarios (Hoekstra et al., 2012). Related to this learning effect is also the influence on participants to potentially better understand complex topics (Hummel et al., 2011) and to gain a broad understanding of the given topic. 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 (van Pelt et al., 2015). Another influence is that participants gain an understanding of other actors, for example, the interdependence of certain actors 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 actors (Fonseca-Cepeda et al., 2022).

A follow-up influence is the potential for decision-making, which would be one of the most important aspects for future policy-making. Here it is assumed that serious games can improve decision-making (Bathke et al., 2019). Serious games could be used to evaluate strategies for policy makers (Valkering et al., 2013) and to 'play' with different scenarios or even to evaluate 'unexpected' strategies (Hertzog et al., 2014). Unexpected strategies in this context refer to strategies that evolved over the course of the game. Onencan et al. (2016) also showed that SGs can improve strategic foresight in (water related) disaster risk reduction. In addition to content learning, there is also the influence on social learning, as it was mentioned with the changes in relationships or cooperation. While playing these games, it could be noticed that relationships were formed or even that cooperation was enhanced (Bathke et al., 2019; Jean et al., 2018). Serious games could help build optimism that cooperation 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 'icebreakers' to create relationships in respect to important topics, especially when they have not yet been built for the future already (Poděbradská et al., 2020): When trying to get future stakeholders around the table, discussing real topics that are currently affecting them may be a barrier to having a fruitful discussion at all, as they may not be keen to meet. Therefore, a more playful game could be used to slowly move them in this direction, from discussing in a non-binding game to discussing real cases.

4.2. Empirically measured effects (cooperation?)

Looking through these examples of serious games, we noticed that in general many effects were mentioned, but real evidence that these effects were reproducible or even related to the games was vague. Some of the effects we want to mention here were noted in the studies, but could also be related to the social interaction of the actors. For example, the longer the participants interacted in the serious games, the more their interaction and also cooperation improved (Jean et al., 2018; Onencan et al., 2018). This strengthening of relationships was often reported. Follow-up studies also found that participants' sense of urgency improved in relation to the cases they played (Mayer et al., 2021).

4.3. Postulated, not yet measured effects

Finally, some of the effects that were mentioned (expected or claimed) but not assessed or even measured are as follows: Although the most frequently found type of influence was the improvement of relationships and their connection to better cooperation, there were no studies on this effect over a longer period of time or on the effect in general (Poděbradská et al., 2020). It was even mentioned as a research gap that it would be necessary to investigate this observed effect of improved relationships after a certain period of time (Jean et al., 2018). Furthermore, it was 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 et al., 2012). Even the development of the serious games themselves may require several iterations and adaptations with participants in order to be linked to the effects mentioned, such as social learning.

Types of Influences	Measured Effects	Postulated / to be measured Effects
Improvement of learning (in terms of subject matter, but also in terms of social learning, such as actor roles and relationships)	Increase of interactions (over the course of the game)	Long-term impact on relationships
Awareness of complexity and urgency	Potential strengthening of relationships	Effectiveness on decision making
Improvement of decision-making (assessment of different scenarios and actions)	Improvement of urgency awareness Improvement of strategic foresight	Transferability of match results to other cases / Adaptation to new cases
Growth in relationships and cooperation (perceived need for cooperation)		Validity for a wide range of actors (as most games were conducted with students)

Figure 2: Types of influence of Serious Games and measured vs postulated Effects

5. Discussion & Conclusion

This review of serious games in the context of water governance has shown that this is still a relatively new field with a small number of publications. Most of the literature is case studies with one specific tool and sometimes even the first use of that tool. In addition, there are only a few reviews or overview articles in this field of water governance and policy serious games. We noticed that the papers on forecasting dealt with future uncertainty through unforeseen future developments, which they tried to assess and understand with serious games using scenarios, and thus gain potential insight into uncertain decisions that have to be made for the future. However, in this context, there were few examples of serious games with a strong policy focus to address or manage these developments. Furthermore, most publications are more focused on describing their specific serious game, such as the game process, the application area, the topic of water management and the challenges involved. As a result, there is a lack of comprehensive knowledge about the effects or impact of these games. We have identified two main challenges shared by (almost) all studies: The representation of the complexity and the link to real actors (and therefore "real" strategies or goals, etc...). However, it is never possible to create a useful game with full complexity, as some simplifications are always necessary, otherwise, for example, the players would be too overwhelmed by the game itself, in addition to the case they have to play. Therefore, we suggest considering the second challenge and reducing some of the limitations. Instead of only involving students or other participants as representatives, it might be beneficial to include "real actors" who have already experienced these problems or are decision-makers who will have to face such problems in the future.

In the literature, we found that most games were played with students. This could be seen as limiting the potential results. For example, students give a more “young” perspective on issues, as they may not have the experience of people who have been working in a particular field for years. Furthermore, depending on their age, they may not have the experience of strict responsibility or of living with their own financial capital. Therefore, their views should always be compared with those of stakeholders who are more involved in these areas. Apart from the selection of participants, we also noticed a lack of involvement of the actors in these serious games. Of course, when playing these games, the participants were mostly at the centre of the

study, but what about the design of the serious game in the first place? In order to better reflect reality and the needs and understanding of problems of local actors, a co-creative approach between researchers and stakeholders might be beneficial. Otherwise, complexity may be lost, which may of course be a decision of the researcher designing the game to simply have a broader case. But if there is no involvement of “real actors” in a serious game (either in the design or in the play sessions) trying to represent possible futures, the potential insights are lost. This may be one reason why it is still unclear whether serious games can provide robust experiences and information to improve, for example, future decision-making.

In our review, we found that some of the claimed effects, such as improved understanding of complexity or general learning, still lack empirical evidence, especially as studies were mostly short-term and researchers even mentioned the lack of long-term research. Moreover, these effects were often reported by the participants, in this case, students, rather than “real stakeholders”. In addition, the link between the effects and the game itself was often fuzzy, so it was not always clear whether the effects were due to the game and its particular design, or to the interaction between the actors, especially for social learning and interaction. Furthermore, studies only reported the effects of individual games but did not provide a basis for generalisation. Here we see an opportunity to involve “real stakeholders” to fill this gap. By letting certain stakeholders who are knowledgeable in their field follow the whole design process of a serious game, we at least get a deeper insight into our evaluated case. However, it is evident that in most cases it is not easy to involve key stakeholders in a project at the same time, and compromises have to be done to get the research completed. Depending on the situation, stakeholders may be in open conflict and therefore do not want to interact with each other and especially do not want to discuss the issue at hand. Even a latent conflict could emerge when certain actors come together. Here we have seen in the literature that in this case of conflict, serious games can help to facilitate the exchange, as they can be used as a kind of ice-breaker for the subsequent discussion. Using a serious game to mitigate a potential conflict or to “play” with a particular conflict is on a different level than trying to discuss the real issue. We could say that it is a difference in the frame or set environment that might have an effect, but as with the other effects we have found in the literature, it is still open to debate how this relates to SG. In spite of the potential problem of gathering “real actors”, we suggest that they should be kept in mind to some extent, as this can help to sharpen the case. This is why an effort could be made to ensure that serious games are potentially based on, or more closely linked to, the needs of potential stakeholders who might use these games to improve their decision-making. Nevertheless, if there is an opportunity to work with “real stakeholders”, the insights gained, not only for the research but more importantly for the stakeholders, could potentially be linked in some way to the process of designing these serious games. Especially if the co-creation with stakeholders is done in different formats, for example in one-on-one workshops, so there is no problem of “normal social interaction” being an obstructive variable. Finally, serious games, especially when co-created by stakeholders, could help to make complex, uncertain futures more tangible, as the cases are then more likely to have been considered in detail.

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