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TOPICAL REVIEW

Tools for adaptive governance for complex social-ecological systems: a review of role-playing-games as serious games at the community-policy interface

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Abstract

The management of natural resources—from forests to fisheries to freshwater—is becoming increasingly complex and requires new tools and processes for engaging with individuals, communities, and decision-makers. Policy makers and practitioners have begun using serious games (SGs) (those used for purposes other than entertainment) to overcome some of the complex challenges of governing resources in social-ecological systems. This paper uses a systematic literature review methodology to assess role-playing SGs for natural resource management. Fifty-two articles from the role-playing game (RPG) subset of SGs are identified, synthesised and analysed using a multi-criteria evaluation framework. First, we explore three theoretical and conceptual elements of games: principles of RPGs, functions of games, and (practical) game characteristics. We evaluate game elements, including game design, adherence to reality and the degree to which games integrate elements of participatory—and action research. These dimensions of RPGs are then analysed and discussed. Particular attention is paid to the value and application of RPGs to address complex problems with interacting environmental, social, cultural and economic challenges, and the extent to which they can inform adaptive governance solutions. Results show that RPGs can be a valuable tool at different levels; however, we also identify important gaps in the current state of knowledge, in particular, related to bridging community—and higher-level decision-making scales through RPGs.

1. Introduction and background

Serious games (SGs) are games primarily intended for education, rather than amusement (Abt 1987: 9), contributing to pre-defined objectives while engaging the user (Susi *et al* 2007). In recent years, SGs have been used in diverse contexts including agriculture (Hill *et al* 2014), risk management, food security, water resource management, climate change (Lawrence and Haasnoot 2017), environmental management (García-Barrios *et al* 2017), health and education (Ricciardi and De Paolis 2014) to engage individuals, communities, and decision-makers with complex resource problems, including wicked problems (Lawrence 2010, Flood *et al* 2018). Many of these games, in an environmental context, draw attention to, or focus on, adaptive governance mechanisms for resolving tensions between competing demands.

Adaptive governance in this context refers to an emerging mode of governance that rejects linear or goal-based frameworks in favour of flexibility, shared resources and mutual understanding (Brunner *et al* 2005, Chaffin *et al* 2014, Schultz *et al* 2015). While there remains some debate in the literature about its precise definition (Koontz *et al* 2015, Hasselman 2017), several common characteristics have been

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identified (Karpouzoglou *et al* 2016), including adaptability (e.g. Folke *et al* 2005, Olsson *et al* 2006), collaboration to achieve desired outcomes (Wyborn 2015, Chaffin and Gunderson 2016), learning and experimentation (Crona and Parker 2012, Sharma-Wallace *et al* 2019), and flexible governance arrangements (Janssen and van der Voort 2016, Nanda *et al* 2018). Adaptive governance principles ensure that the social, political, cultural and ecological contexts of environmental problems are directly incorporated into existing governance structures in order to transform governance structures themselves and the whole system in order to address the problem(s) in a more holistic way (Folke *et al* 2005).

The challenges of implementing adaptive governance for common-pool and other resources are well documented. Critically, we see an opportunity for SGs to provide a pathway for experiential learning and adaptation by different actors, providing a safe innovation space for experimentation, at various political and administrative levels across geographic scales (Johnson *et al* 2011, García-Barrios *et al* 2017, den Haan and van der Voort 2018, Flood *et al* 2018). Given the growing interest in adaptive governance and SGs, the following review seeks to systematically identify, review and assess the literature, to support the empirical application of adaptive governance and accelerate conceptual and theoretical development. More specifically, the review focuses on a subset of SGs: role-playing SGs (RPGs)—in which individual players assume a different identity for the purposes of the game.

There are other reviews of SGs, although they are limited in number Roberts (1976) provides one of the most relevant and comprehensive reviews; however, given the adaptive governance turn in environmental and natural resource sectors, an update is warranted. Katsaliaki and Mustafee (2012) assessed sustainable development SGs focused on learning and teaching and find that these SGs are generally online, single player and aimed at young people. There was no examination of how games can support collaboration, a key element in adaptive governance. Reckien and Eisenack (2013) review 52 SGs for climate change, noting that less than half deal with adaptation to climate change, a gap that is dealt with in the review by Flood *et al* (2018). Mayer (2009) published a review of gaming in policy—the promotion and use of gaming in policy-making, and how policy-making can be supported through gaming. Most recently, den Haan and van der Voort (2018) review 42 publications, specifically to assess social learning outcomes addressing sustainability issues.

Social learning refers to the 'collective process of acquiring, processing and disseminating knowledge' (Heikkila and Gerlak 2013: 486). It is understood as a change in understanding achieved through interaction in collaborative and participatory settings (den Haan and van der Voort 2018). Deliberative interactions form the backbone of social learning approaches, whereby a broad range of stakeholders work together building relationships that result in some form of collective action (Cundill and Rodela 2012, Baird *et al* 2014, den Haan and van der Voort 2018). Baird *et al* (2014) define social learning as changes in cognitive (knowledge and thinking), normative (norms and approaches) and relational (interpersonal connections, networks and trust building) learning. SGs offer the collaborative and participatory stakeholder interactions necessary to generate positive social learning outcomes (Medema *et al* 2016, Salvini *et al* 2016, Becu *et al* 2017, Ampatzidou *et al* 2018).

We anticipate the outcomes of this review will inform both the growing body of literature in games and gaming, and the development, use and application of serious RPGs in adaptive governance approaches to community land-use management and development. The review can inform game design, particularly the scaling of games to fit particular decision-making contexts. The review will also demonstrate the ability of RPGs to inform adaptive decision-making and contribute to social learning. While previous reviews have included RPGs, none of these studies have systematically considered the use and application of RPGs with reference to adaptive governance.

The review is structured as follows: We begin by describing the conceptual elements and principles of SGs and role-playing games (RPG) and their relationship to adaptive governance, and advance a framework for empirically evaluating their significance. We then present the results of the systematic review, focusing on the significance of RPGs for adaptive governance and their impacts, followed by discussion, conclusions and recommendations.

2. Adaptive governance and role-playing SGs

There is a growing body of literature investigating the relationships between institutional arrangements and the management of natural resources, for example, water management, conflict and cooperation around land and water and community management of forests (see Cleaver 2017). Developed over the last three decades, much of this work conceives the relationship between the biophysical environment and the human management systems, governance and institutional arrangements and practices used to sustain them, in terms of linked social-ecological or human-environmental systems. In theory, such systems are capable of responding to change, while preserving functionality (Berkes *et al* 2002, Folke *et al* 2005).

In practice, however, decision-making processes for natural resource management often entail complex social dynamics including trust building, power imbalances and vested interests. Stakeholders may become polarised, adopting antagonistic positions, or processes may be costly, leading to disillusionment. To

overcome some of these challenges, adaptive governance has been proposed as a way to better account for the social dimension of adaptive co-management of ecosystems and landscapes (Brunner *et al* 2005, Pahl-Wostl 2009). Unlike conventional modes of governance which rely on linear- or goal-based frameworks, adaptive governance focuses on tools and approaches that seem to be of significance in responding to crisis, shaping change and building resilience for reorganisation and renewal of social-ecological systems, both internally and in relation to shocks and stressors (Dietz *et al* 2003, Walker *et al* 2004, Folke *et al* 2005). Marking a shift from management to governance, adaptive governance acknowledges the dynamic, multi-faceted character of environmental issues, which necessarily involve diverse scales, actors, and contexts, and notes the subsequent need for flexibility, social learning, and capacity for change in any proposed solution (Brunner *et al* 2005, Olsson *et al* 2007, Armitage *et al* 2008, Akamani *et al* 2016).

Recent reviews of the field note the continuing importance of adaptive governance in theory and practice but flag critical areas for further study (Chaffin *et al* 2014, Wyborn 2015, Karpouzoglou *et al* 2016, Sharma-Wallace *et al* 2018). The role of power and equity relations is an understudied but central component of adaptive governance process and outcomes, often contributing to either the success or failure of adaptive governance approaches on the ground (McDougall *et al* 2013, Wyborn 2015, Sharma-Wallace *et al* 2019). Wyborn (2015) suggests that adaptive governance scholarship devote more attention to situated, contextual, or relational perspectives over the traditional focus on abstract design principles and conditions underlying adaptive governance systems.

Other challenges relate to the empirical operationalization of adaptive governance. A more comprehensive understanding of both the methods, tools, and frameworks necessary for adaptive governance approaches and the existing institutional and regulatory barriers to its application is still required for the successful implementation of adaptive governance across cases (Olsson *et al* 2006, Chaffin *et al* 2014). In order to help address this gap, Sharma-Wallace *et al* (2018) reviewed 92 empirical cases of adaptive governance to distil eight methods or elements of adaptive governance in practice. They found that adaptive governance includes collaboration, coordination, social capital, community empowerment, capacity development, linking knowledge and decision-making, leadership and governance opportunities.

Collaboration involves meaningful cross-scale multi-actor interaction, emphasising the incorporation of a large range and diversity of stakeholder perspectives and capacities, including formal and informal opportunities (see Brunner *et al* 2005, Olsson *et al* 2008). Coordination involves bringing together geographical, actor and issue scales, often through a formal coordinating body (Olsson *et al* 2007, 2008). Central to adaptive governance is social capital, or base levels of trust, familiarity and goodwill between actors; often this is built up over long time periods (see Van Niekerk 2014). Community empowerment is also critical, as communities are where governance change is implemented and felt (see Olsson *et al* 2008). Capacity development is necessary for adaptive governance and includes knowledge, resources and the scope for action to sustain governance activities (see Abrams *et al* 2015). Adaptive governance also needs to link science and decision-making. Stakeholders require the best available information concerning the problem and potential solutions (see Serrao-Neumann *et al* 2016). While the foregoing elements are necessary, sometimes a skilled, charismatic and passionate leader is required to locate emerging or old problems, bring actors together and coordinate support (Olsson *et al* 2004). Finally, Sharma-Wallace *et al* (2018) highlight the necessity of being ready for windows of opportunity for adaptive governance—taking advantage of events (such as natural disasters or a change in government) to initiate adaptive governance (Olsson *et al* 2006, Brundiers and Eakin 2018, Cradock-Henry *et al* 2019).

The notion of adaptation implies capacity to respond to change and even transform social-ecological systems into improved states (Folke *et al* 2005, Olsson *et al* 2006). Adaptive governance thus focuses on experimentation and learning, and it brings together research on institutions and organisations for collaboration, collective action and conflict resolution in relation to natural resource and ecosystem management (Brunner *et al* 2005, Chaffin and Gunderson 2016). The essential role of individuals needs to be recognised in this context (e.g. leadership, trust building, vision and meaning); their social relations (e.g. actor groups, knowledge systems and social memory); and social networks serve as the web that ties together the adaptive governance system (Gunderson and Light 2006, Chaffin and Gunderson 2016). It involves cross-level and cross-scale activities (Janssen and van der Voort 2016) and includes governmental policies that encourage creativity and experimentation with different tools, methods, and approaches.

Rumore and Susskind (2013) introduce the concept of role-playing simulations for adaptive planning. However, while not specifically designed for adaptive governance, several of the functions of games as described by Mayer *et al* (2004) can be related to adaptive governance. Democratisation or equal access for all participants links closely with Sharma-Wallace *et al*'s (2018) cross-scale multi-actor collaboration element, which emphasises incorporating a large range and diversity of stakeholders (participants). Mediation and the development of methods for conflict resolution can also be related to adaptive governance through the element of social capital, where stakeholders negotiate initial disagreements or conflict, and over the longer term, go on to develop working

Table 1. Linkages between game characteristics and adaptive governance, compiled from ProActive (2009) and Sharma-Wallace *et al* (2018).

Good game characteristic	Adaptive governance element	Linkages
Conflicts and objectives; participants work towards a resolution	Cross-scale multi-actor collaboration	Both elements touch on the diversity of stakeholders and the diversity of views that each will have, creating the opportunity to negotiate through conflicting positions
	Community empowerment and engagement	
	Social capital	
Short feedback cycles; feel the impact of their decisions quickly	Cross-scale multi-actor collaboration	While not necessarily quick in the case of adaptive governance, both elements describe how the results from participation in adaptive governance exercises need to be fed back to decision-makers for inclusion, and the implementation of policies or plans
	Community empowerment and engagement	
Immersion and engagement; entertaining players	Cross-scale multi-actor collaboration	While not necessarily about entertaining participants, there is a need in adaptive governance to ensure that stakeholders are engaged in processes from planning to implementation
Challenges; learning skills	Bridge and match scales	Games can serve as learning tools that can help participants to develop their capacity to integrate different types of data into decision-making
	Capacity development	
	Link science and decision-making through data collection and monitoring	
Collaboration amongst peers	Cross-scale multi-actor collaboration	Over time, participants will develop working relationships amongst themselves, collaborating on developing solutions
	Social capital	

relationships. Finally, we note Mayer *et al*'s (2004) design and recommendation, which is described as 'out of the box' thinking and delivering solutions, links well to cross-scalar and multi-actor collaboration, where the results of the collaboration process are fed back into official policy and practice.

The characteristics of robust SGs; relationship with the real world, having purpose and value, and being engaging and enjoyable for players (Harteveld 2011) and those described by ProActive (2009) in table 1 also link to Sharma-Wallace *et al* (2018)'s elements of adaptive governance.

Finally, Simons and Ruijters (2008) and ProActive (2009) suggest there are five metaphors for learning, where four can contribute to adaptive governance. Learning by doing relates to capacity development, participation and social concepts of learning relates to cross-scale multi-actor collaboration, discovery or transformative actions through engagement relates to community empowerment and engagement, and transfer of information can be linked to linking science and decision-making through data collection and monitoring. All of the metaphors for learning can be related to capacity development.

By focusing on role-playing SGs (RPGs)—in which individual players assume a different identity for the purposes of the game—the following review seeks to gain insight into the degree to which RPGs can…. Furthermore, the review focuses on RPGs as a subset of SGs, for their potential replicability in remote areas. While advances in computer simulations for SGs are welcomed, their suitability is limited in areas with poor telecommunications infrastructure, including some rural regions in developed countries and many developing country contexts, especially those that are data or bandwidth poor. As such, the review is broadly applicable to other remote or less developed regions, and relevant for nearly all complex environmental issues in crossing decision-making domains between community and other higher levels.

3. Methods

To assess the literature on function, use and potential of RPGs for resource management, a systematic review methodology was used. Systematic review provides a structured process for the collection and analysis of knowledge. Transparency and documentation allows for data validation and replication, while the typically large scope of the review helps generate new insight across existing work (Petticrew and Roberts 2006, Higgins and Green 2008, Booth *et al* 2016).

We followed a multi-step systematic review process, including development and documentation of the research question and research protocol, progressive literature search and refinement phases and data extraction, synthesis and analysis (Khan *et al* 2003,

Table 2. Inclusion and exclusion criteria used in the literature search and document selection phase.

Inclusion criteria	Exclusion criteria
Must be a game or a role-play	Does not include game or role-play
Type of study: article, book, book chapter or conference paper	Type of study: NOT article, book, book chapter or conference paper
Must be land-based; may include urban, peri-urban and estuarine areas	Non-land-based or marine areas
English language publication	Non-English language publication
Novel/new information not repeated elsewhere	Repetition of published material
Date range[a]: post-1990 to present	Date range: pre-1990

[a] A survey of serious games on sustainable development found that the first game paper dated back to 1990 (Katsaliaki and Mustafee 2012).

Higgins and Green 2008). Table 2 outlines the inclusion and exclusion criteria applied during the literature search and refinement stages of the review.

A preliminary search of the literature on game-based scenarios returned many education-focused results on 'game-based learning'. Based on terminology found in previous studies on scenarios and natural resource management (see Castella *et al* 2005), we expanded our search terms for the review to include: simulation gaming and multi-agent modelling; RPGs; multi-agent simulations; multi-agent system simulations; gaming simulation; game-based learning; and structured game-based training. The filter term 'and natural resources' was added to all keyword searches. Following the initial searches, we added the term 'SGs' and 'natural resources' due to its repeated appearance in the literature. We searched the Scopus, Web of Science, Science Direct, Google Scholar and Google Web databases and screened results for relevance on the keyword, title, abstract and full text level according to the inclusion and exclusion criteria (table 2). If the search terms were present in any of the search fields, we included the result in the initial phase of literature collection (table 3, Phase 1). Our literature database included the full bibliographic citation information for each search result and was screened to remove exact duplicates (table 3, Phase 2). After inclusion/exclusion screening was completed, our final body of literature included 147 studies on game-based scenarios and natural resource management (table 3, Phase 3).

Following a scan of the 147 systematic search results, we discovered that many of the articles located in our search reported the same or slightly different aspects of the same overall projects in which a RPG was embedded. From the scan of each article, the RPG was determined to be a 'constant', and thus, no new data about the game itself was presented in the multiple articles. As a result, only one or two papers from the same project were selected to provide the greatest 'coverage' of RPGs in natural resource management contexts where the RPG aspects remained constant while other data or methods were explored. In addition, the criteria for the type of papers to be reviewed were tightened, eliminating theses, working papers and most reports. Only peer-reviewed journal and conference papers were included in the final review. Some exceptions to these more stringent requirements included those papers that already had data extracted, and the few papers that provided an actual RPG, along with some information on its creation and/or deployment (see Emerson *et al* 1999, Barrett *et al* 2003, Walsh *et al* 2014). Fifty-two cases were included in the final review (table 3, Phase 4).

Table 4 summarises the categories used in the data extraction, organisation and analysis stage of the literature review. Data extraction methods followed the general systematic review template. We extracted, organised and analysed data from the final body of literature based on a series of data variables chosen for their correspondence to the research questions and foci. Manual coding, synthesis and analysis drew from these categories to emphasise mechanics of game purpose, design, execution, and evaluation and internal and external factors for success or failure. Knowledge gaps and lessons for practice within the context of the research programme were also identified.

Each of the papers were searched for key terms distilled from Sharma-Wallace *et al* (2018), and the text scanned for further details to determine whether the games and their outcomes corresponded to the intent of one or more of the elements of adaptive governance. Table 5 shows the elements and the key words.

4. Results and review

The following discussion, review and analysis is based on an examination of 52 papers on RPGs that have been applied to one or more aspects of natural resources management. An additional five papers on role-play simulations were also included. Of these, 39 were situated in developing countries and seven in developed countries. Three papers provided general overviews of RPGs, while the rest were focused at the international scale.

The demographic context for game design and play varied across the reviewed cases with a few major points of commonality. While the games targeted diverse sectors, agriculture and water management were predominant and frequently linked (Farolfi *et al* 2004,

Table 3. Summary of the literature search and refinement phase.

Phase	Description	Number of studies
Phase 1: initial literature scope	Total studies	955
	–Web of Science	– 127
	–Scopus	– 341
	–ScienceDirect	– 301
	–Google Scholar	– 71
	– Google Web	– 115
Phase 2: elimination of duplicate papers from different databases	Total studies	955
	–Total unique papers	– 437
	–Total exact duplicate papers excluded	– 518
Phase 3: first stage literature refinement	Total included[a]	147
	Total excluded	290
	–No role-playing game	– 197
	–Not land-based	– 40
	–Type of study: not article, book, book chapter, working paper, report, conference paper or thesis	– 32
	–Virtual (not face-to-face)	– 2
	–Pre-1990	– 7
	–Multiple criteria not met	– 12
Phase 4: case extraction and refinement	Total included[b]	52
	Total excluded	95
	–Working paper, report or thesis	– 18
	–Repetitive RPG description	– 25

[a] Includes relevant chapters extracted from edited books, accounting for the discrepancy between Phase 2 and Phase 3 inclusion and exclusion totals.

[b] Several studies included multiple and/or duplicate cases. We extracted individual cases from each study and screened the cases for relevancy according to the inclusion and exclusion criteria described above.

Table 4. Categories used in the data extraction, organisation and analysis phase.

Category	Details
Bibliographic details	Author(s), title, publication data
Study context	Research question(s)
	Type(s) of games used
	Definition for games used
	Study findings
	Study limitations
Game(s)	How each game was designed
	How each game was executed
Case context	Location
	Scope
	Timeframe
	Sector
	Community demographics
	Issue problem
	Actors involved
Outcomes of game(s)	Desired outcome
	Actual outcome
	Measurement and evaluation methods for success or failure
Reasons for outcome	Positive contributions
	Negative contributions
Adaptive governance	Elements of adaptive governance
Other	Gaps identified
	Researcher comments

Rajabu 2007, Souchère *et al* 2010). Most of the games were designed and implemented in local or regional contexts in the global south, usually at the community or catchment level. Twenty of the papers related to games played to assist natural resource management at the local level, 23 at the regional level, and four at the international level. Of these international games, two were truly international, while the other two were played at the local/regional level and incorporated international components (e.g. international relations and trade). Generally these papers reported on games that had been played in a rural or peri-urban setting. The focus on the local scale potentially reflects the short-term fixed nature and livelihood dimensions of natural resource management, where regardless of the scale of governance, practice and outcome is enacted and experienced on-the-ground first. The majority of games nevertheless accounted for the multiple parties implicated in natural resource issues, with most designed around a particular collective environmental conflict or coordination problem. The range of game participants subsequently included a variety of community-level actors with some stake, agency, and pre-existing role in natural resource practice and outcomes such as farmers, landowners, municipal government officials and planners.

Table 5. Elements of adaptive governance and key words (from Sharma-Wallace *et al* 2018).

Elements of adaptive governance	Key words
Cross-scale multi-actor collaboration	Stakeholders; diversity; scale
Bridge and match scale	Geographic scale; actor scale; issue scale
Social capital	Trust; familiarity; goodwill
Community empowerment and engagement	Community involvement; Communities; outcomes
Capacity development	Knowledge; resources; scope for action (gained)
Link science and decision-making	Data collection; best information available; experiential learning
Strong leadership	Skilled; charismatic leaders
Exploiting social-ecological context	Change; implementation

With respect to games' purpose, the papers reviewed included one RPG for each of climate change and natural hazards/disasters, two for forestry, and three generally relating to natural resource management. Two games were purely for educational purposes within a resource management context. Five papers had a conservation focus. The highest number of games was focused on water management (15 papers) and agriculture (16 papers). Several papers provided general details of role-playing and triadic design games (games which balance reality, meaning and play—see Harteveld 2011), without the natural resources context. This mix of foci provide a variety of perspectives, designs and methods for creating RPGs that can be adapted or customised to deprived areas in developed countries and other adaptive governance contexts.

In practical terms, we found that the RPGs in the review were generally designed to advance sustainable solutions to complex natural resource management and common-pool resource problems. This is in line with the stated goals of adaptive governance, to provide collaborative, flexible and learning-based approaches to wicked or complex problems (Olsson *et al* 2006). These might include protracted or emerging stakeholder conflict over resource use, such as tensions between methods of use and distribution of benefits (Etienne 2003, Dung *et al* 2009, Hertzog *et al* 2014). Problems may also involve overuse or mismanagement of resources, leading to environmental degradation. Examples include encroachment of farmland into areas of ecological significance or intensive agricultural practices contributing to soil erosion and runoff risk (Souchère *et al* 2010, Vieira Pak and Castillo Brieva 2010, Gourmelon *et al* 2013, Villamor and Badmos 2016). In all instances, the games we reviewed sought an acceptable balance or compromise in the form of conflict resolution between competing stakeholders or consensus between environmental protection and community livelihoods.

The following discusses results in more detail, focusing on the links between RPGs and adaptive governance, and evaluation of learning outcomes. A brief overview is next, we then identify and discuss examples of RPGs and their contribution to the following elements of adaptive governance: cross-scale interactions, social capital, community empowerment and engagement, capacity development, monitoring and evaluation, and social-ecological context. The approach is designed to examine RPGs from purpose to design, actual games and each evaluation phase as they relate to adaptive governance.

4.1. Games and adaptive governance

From the 57 examples of RPGs reviewed we found 35 with several close connections to characteristics or features of adaptive govenance. No one game contributed to all elements of adaptive governance. For example, several of the RPGs highlight socio-ecological dynamics and/or governance arrangements. For example, Walsh *et al* (2014) use the RPG to teach the complexities of socio-ecological systems and problems, while Villamor and van Noordwijk (2011) provide understanding of local dynamics and conditions for free and prior informed consent around payments for ecosystem services. There were 6 cases where the game was focused more on the farmer/forester, player and researcher interface; i.e. the game had elements of adaptive governance, but was more aimed towards what the researchers could gain from the game-play (Etienne 2003, Castella *et al* 2005, Boisseau and Castella 2006, Castella 2009, Villamor and van Noordwijk 2011, Gourmelon *et al* 2013).

4.1.1. Cross-scale interactions

Adaptive governance seeks to account for the interaction and successful realisation of cross-scale opportunities. The games we reviewed were generally intended to facilitate a low-stakes, risk-free environment in which participants were free to clarify and negotiate values and perspectives, grow awareness, and create and test future innovative management strategies across scales. RPGs in particular, are a useful facilitation tool as they provide virtual opportunities for collaboration rather than competition (Adamatti 2009). For example, work by Souchère *et al* (2010) found that game participants developed better 'self-knowledge' and ways to work with others, allowing the discussion of classical and innovative strategies for watershed management, while Gourmelon *et al* (2013) found that having no written or recorded record of the game promoted knowledge acceptance and viewpoint

sharing because there were no consequences. Gourmelon *et al* (2013) also found that spatial elements (in particular 3D simulations) stimulated the sharing of opinions and discussion of different interests and perspectives among participants. Rumore and Susskind (2013) highlight the collaborative approach, and found that there was a significant increase in the perceived importance of engaging stakeholders and collaboration.

D'Aquino *et al* (2003) game worked to define and identify appropriate stakeholders for participation in land-use decision-making, while Barreteau *et al* (2007) used games to introduce current stakeholders to new stakeholders. Other games attempted to encourage greater participation, interaction and coordination between stakeholders (Etienne 2003, Rajabu 2007, Dung *et al* 2009, Ducrot *et al* 2014, Hertzog *et al* 2014), including 'experimenting' with collective action amongst landowners and community members (Barreteau *et al* 2007, Ducrot 2008, Castella 2009, Gourmelon *et al* 2013). Speelman *et al* (2014), Barreteau *et al* (2001), Souchère *et al* (2010 and Vieira Pak and Castillo Brieva (2010) encourage open discussion and negotiation between stakeholders. Villamor and Badmos (2016) focus on communicative learning amongst stakeholders, while Barnaud *et al* (2007) seek to coordinate farming action between villagers. Dionnet *et al* (2008) and Walsh *et al* (2014) look to get stakeholders out of a 'conflict zone' and in the case of Walsh *et al* (2014) develop a management plan that suits all competing interests. Finally, some games focused on bringing different stakeholders together in new constellations and provide a forum for novel interactions (Barreteau *et al* 2001, Barreteau *et al* 2007, Blanchard and Buchs 2015). However, Morardet *et al* (2012) highlighted that even within the inclusive embrace of RPGs, power differentials and organisational problems exist, and can and do lead to the exclusion of stakeholders.

In the United States, Susskind (2010), Dolin and Susskind (1992) and Rumore and Susskind (2013) bring together a wide variety of stakeholders both at single (city or local and national) spatial scales, and across multiple scales—local, county, state and national (also Susskind and Corburn 1999). Whether at a single or multiple scales, a diverse variety of actors are included in the simulation games—town officials, business leaders and residents at the local level (Rumore and Susskind 2013) to local, county and state officials, NGOs, community members and leaders (Susskind 2010) to House of Representatives, Senate members, company CEOs and heads of public institutions (Dolin and Susskind 1992).

In a number of games, there were a limited variety of player roles and/or cases where participants played their real-life roles (Dung *et al* 2009, Souchère *et al* 2010, Vieira Pak and Castillo Brieva 2010, Speelman *et al* 2014). This method might help stakeholders to clarify their own perspectives, visions, and management strategies. Nevertheless, the lack of player variety also limits learning across different perspectives. Particularly in environmental and natural resource situations where the actions of one party almost invariably affect other actors at another scale, a more nuanced understanding of other stakeholders' experiences may be crucial for game success and learning.

The majority of the games were focused at a single actor or geographic scale, usually local communities (see Adamatti 2009, Castella *et al* 2005, Ducrot *et al* 2007, Rajabu 2007, Dung *et al* 2009, Villamor and van Noordwijk 2011, Hertzog *et al* 2014, Walsh *et al* 2014) or across two levels of scale, usually household and local community or local community and regional/provincial scales (see Bernardo and Sanders 1993, Barreteau *et al* 2001, Boissau and Castella 2006, Ducrot 2008, Castella 2009, Susskind 2010, Morardet *et al* 2012). Blanchard and Buchs' (2015) RPG was played solely at the international scale, but across a number of different sectors, which could be considered 'issue' scales. Susskind (2010) has also designed games that cross sectors or issue scales, including public education,wildlife, wetland, farm and forest land preservation and the built environment. Ducrot (2008) highlighted one of the 'concerns' that adaptive governance aspires to address, namely the mismatch between organisational scales and the scale at which the problem manifests.

4.1.2. Social capital

Social capital is developed through stakeholders getting to know each other, step-by-step negotiating through conflict (Etienne 2003), collective action (see Morardet *et al* 2012), and improved exchanges between stakeholders (Ducrot *et al* 2007). Barnaud *et al* (2010) look to equalise power relationships, derive more equitable impacts and address social inequalities, all which can contribute to building social capital. RPGs provide many of these opportunities for participants to develop social capital, whether directly or indirectly. D'Aquino *et al* (2003), in pursuit of social capital, strive to not provide solutions through RPGs, but steer stakeholders in a shared direction. Barreteau *et al* (2007) found that their experience with RPGs enhanced exchanges between players beyond the game, seeming to develop social capital in reality through gaming. In contrast, Blanchard and Buchs (2015), found that their game was not overly successful in developing group cohesion and bringing people together.

An additional social-capital building function of games are the relationships and trust built between 'farmers', players and researchers. Some of these games were partially aimed at building social capital to provide researchers with a more complete understanding of the social-ecological system under investigation (see Etienne 2003, Castella *et al* 2005, Boissau and Castella 2006, Castella 2009, Gourmelon *et al* 2013). This goal

was not always the primary reason for RPGs, but a 'side-effect'.

4.1.3. Community empowerment and engagement

To enhance their relevance for applied problem-solving and support decision-making, a number of RPGS seek to reflect participants' reality as closely as possible (Dionnet *et al* 2008, Dung *et al* 2009). Many of the games relied on community-based participatory action research, working with participants to diagnose problems and assess and analyse relationships between actors and environments (Ducrot 2008, Souchère *et al* 2010, Morardet *et al* 2012, Hertzog *et al* 2014, Speelman *et al* 2014). While potentially labour-intensive and time-consuming, a community-based approach has the dual benefit of targeted bottom-up knowledge production and enhancing a game's legitimacy by engaging community members in the research process sooner rather than later.

Bourgoin and Castella (2011) note that game play in their work empowered participants to have input into land-use planning, while Rajabu (2007) simply noted that the RPG facilitated local involvement in local land management. We note, however, that the games that appeared to be farmer, participant, researcher interactions (Etienne 2003, Castella *et al* 2005, Boissau and Castella 2006, Castella 2009, Gourmelon *et al* 2013) may also promote community empowerment, as Villamor and van Noordwijk (2011) note that their game was intended as a communication tool between researchers and community members.

On the other hand, pre-existing power differentials between game participants and researchers limited the extent to which local communities could benefit from or participate in the game play and outcomes (Rajabu 2007, Dung *et al* 2009, Villamor and van Noordwijk 2011, Gourmelon *et al* 2013, Ducrot *et al* 2014, Hertzog *et al* 2014). Stakeholder inequality can impede open dialogue and collaboration and influence choices within game play, factors that should be accounted for in the game design and execution stages. One group of researchers managed power imbalances in the case community by holding separate game sessions with different stakeholder groups (Hertzog *et al* 2014) to minimise potential conflicts, but with the result of limiting cross-stakeholder interaction. A lack of official or government participation and openness in Gourmelon *et al*'s (2013) case likewise dictated the use of an RPG as an education rather than mediation tool. A skilled facilitator regarded by the majority of the participants as being neutral therefore is crucial to ensuring maximum inclusion and accessibility of the game even in the context of unequal power structures (Barrett *et al* 2003, Rajabu 2007, Dung *et al* 2009; see Barnaud *et al* 2010).

4.1.4. Capacity development

As RPGs are often intended as a learning tool, we contend that all of the games reviewed have some level of learning or capacity development (see Dionnet *et al* 2008, Bourgoin and Castella 2011, Blanchard and Buchs 2015). In keeping with the complex nature of most natural resource problems, and the need for flexibility and adaptability (Dietz *et al* 2003, Walker *et al* 2004, Folke *et al* 2005), the 'solutions' promoted in the RPGs prioritse: stakeholder collaboration, communication and problem-solving over specific technical guidelines or mandated ecological outcomes. This is reflected in the evidence of positive social learning outcomes as RPG users acquire topical knowledge and understanding (cognitive learning), adjust their views and opinions (normative learning), and develop new interpersonal connections and networks in a trusting environment (relational learning) (Aubert *et al* 2018, den Haan and van der Voort 2018, Flood *et al* 2018). In several cases, games were a preliminary step in a larger process, 'priming' participants for cooperation and ultimately behaviour change (Ducrot *et al* 2014).

A number of the games specifically promoted learning about negotiation and communication, for example to facilitate bridging cultural divides (see Bernardo and Sanders 1993, Farolfi *et al* 2004, Barreteau *et al* 2007, Barnaud *et al* 2010, Speelman *et al* 2014, Rumore *et al* 2016, Villamor and Badmos 2016). Morardet *et al* (2012), Rumore *et al* (2016) and Bernardo and Sanders (1993) describe RPGs as helping make sense of different stakeholder positions and, for example, global factors, economics and policy, which are often poorly understood. However, Ducrot *et al* (2014) found that social learning and skill acquisition attained from their RPG was not able to be sustained over a longer period of time.

Susskind (2010) and Rumore *et al* (2016) note that RPGs or role-playing simulations (RPSs) are excellent vehicles to be able to transfer large amounts of technical, context and process based knowledge to participants (e.g. in the context of climate change) and help people understand the implications of it. Another way in which capacity development occurred is through learning that the process of negotiating e.g. a new energy policy, took so much time and effort that it would not be feasible if and when a crisis occurred (Dolin and Susskind 1992).

4.1.5. Linking science and decision-making through data and monitoring

The RPGs in our review were implemented in order to affect social-ecological outcomes; to enhance collaboration through social learning or improvements in communication, or through changes in management practices, or some combination thereof. Uncommonly, in a few cases, researchers attempted to evaluate the tangible impacts of the games on participant behaviour and ecological indicators. To do so, games incorporated pre- and post-game surveys or questionnaires to aid the comparison of player knowledge, capacity and skills before and after the game

session (Rumore and Susskind 2013, Ducrot *et al* 2014, Speelman *et al* 2014, Walsh *et al* 2014, Rumore *et al* 2016). Rajabu (2007) describes the application of a post-game tracer study in their Tanzania case community to assess the game's impact on long-term water management practices. The study incorporated key informant interviews and a structured questionnaire to compare the management performance of four villages involved in the RPG with a group of four control villages and found improved water management behaviours in the game villages. On the other hand, Ducrot *et al* (2014) conducted individual interviews with game participants immediately following and eight months after implementation and found that although some social learning and skills acquisition had occurred, players were not able to maintain these skills in a real-world context over an extended period of time. Like the companion modelling process described earlier, results from comprehensive evaluation methods, including group debriefing, written feedback and post-game individual interviews was intended to be fed back into future games or management interventions to enact enhanced social-ecological and governance outcomes.

Several of the RPGs incorporated participatory research into the conceptualisation and design of a computerised multi-agent systems model which was later integrated into the execution of the RPG (Dung *et al* 2009, Souchère *et al* 2010, Gourmelon *et al* 2013, Ducrot *et al* 2014). This approach, called companion modelling (Gurung *et al* 2006), combines participatory, field, and desktop research methods with computer-based modelling tools to simulate the social-ecological effects of different land-use decisions; the model can subsequently be refined to reflect new variables and participants' responses which are then fed back into the game. Use of companion modelling in the reviewed games allowed quick, accurate feedback on the short- and long-term consequences of player actions and associated participant learning, contingent on the model's validity and robustness. For example, Villamor and Badmos (2016) attempt to understand farmer behaviour in response to climate variability and facilitate social learning. In their game, there are different outcomes depending on player behaviour, leading to experiential learning.

As one element of monitoring, we found that some form of evaluation of game play experience and effects is necessary in order to refine techniques and assess the game's impact. Evaluation methods for RPGs varied across the cases in our review from no evaluation at all (Villamor and van Noordwijk 2011) to a detailed multi-step game assessment process combining participant debriefing sessions with post-game implementation reviews to determine real-world impacts (Rajabu 2007, Ducrot *et al* 2014). At the earliest level of implementation, game test sessions were sometimes incorporated into project design to gauge game validity and accessibility and modify substance and format as needed prior to official play (Morardet *et al* 2012, Villamor and Badmos 2016). These tests took place over multiple sessions with a range of stakeholders and integrated post-game participant debriefing and player evaluations of the game design and structure.

In a few cases, the game sessions were video- or audio-recorded to facilitate more detailed analysis of player strategies and interactions during play (Etienne 2003, Ducrot *et al* 2014, Hertzog *et al* 2014, Speelman *et al* 2014). By far the most common form of game evaluation was a short (ca. 30–90 min) post-play debriefing where players engaged in facilitated collective and individual discussions about game decisions, strategies, outcomes, and implications alongside a more general appraisal of the game experience and characteristics (e.g. Emmerson *et al* 1999, Dung *et al* 2009, Souchère *et al* 2010, Speelman *et al* 2014). Debriefs were frequently supplemented with written surveys or questionnaires and individual interviews meant to elicit open player reaction (see Barnaud *et al* 2007, Dionnet *et al* 2008, Adamatti 2009).

4.2. Impacts of game play and adaptive governance

From a game play perspective, ProActive (2009) proposes key elements for success in designing games. Elements include having clear goals and rules, holding all players' attention through an appropriate level of challenge, entertaining and fun elements, promoting good competition, replayability and ensuring appropriate support and feedback is available. From the learning perspective, ProActive (2009) notes success elements in an education context; however, these can be adapted to other contexts, e.g. natural resource management. These elements for learning success include ensuring the game rests within the broad educational objectives of the 'project', and is embedded in a comprehensive learning scenario. Games may also be deemed success from a learning perspective where they are comprehensible to players, provide relevant learning resources and provide for a progressive acquisition of knowledge through a personalised learning process.

We assess 37 if52 games/papers (70%) to gain insight into learning outcomes and impacts of play. In these papers, outcomes from the RPGs have been described, together with the measurements used, including one paper (Rajabu 2007) that conducted a tracer study to examine the impacts of the game on real-world behaviour. It is important to note that the majority of games were part of larger modelling/simulation exercises, and not played in isolation, so few had short-term goals or objectives linked to game play specifically. Games contributed, for example, to long-term goals relating to landscape, or to direct participants to an interim stage from which they could collaborate more effectively over constitutional- or resource time scales. The behavioural impacts from these games therefore have not been examined, as they

Table 6. Author assessment of papers reviewed against Baird *et al*'s (2014) three typologies of learning.

Learning typology	Anticipated outcome	Actual outcome
Cognitive	12	20
Normative	3	7
Relational	17	20

have occurred far beyond the actual playing of the RPGs, and the final impacts will be the product of other significant factors. Nevertheless, several of these studies do note increased player awareness and understanding of environmental issues immediately following the game sessions.

We further examined the games with outcomes described under a typology of learning effects proposed by Baird *et al* (2014). They identify three types of learning effects in relation to environmental governance—cognitive, normative and relational learning. Cognitive learning is the acquisition or restructuring of knowledge, normative learning refers to changes in norms, values or paradigms, and relational learning relates to building understanding, relationships, trust and cooperation (Baird *et al* 2014: 53). Two of Baird *et al*'s (2014) categories—cognitive and relational—are closely related to Pahl-Wostl's (2009) distinction between instrumental learning, which allows the acquisition of new skills and knowledge (cognitive) and communicative learning, which allows understanding and interpretation of knowledge through communication with others (relational).

In light of these categories and general criteria, we analysed the 37 papers that described anticipated and/or actual outcomes of the RPGs in their studies. Four papers provided anticipated or actual outcomes; however, these were technical in nature, i.e. describing the mechanics of the RPG and the anticipated or actual outcome of making the game, and the learning typology did not apply to them and they were excluded. The other papers did not provide any anticipated or actual outcomes with respect to the RPGs.

Table 6 provides the breakdown of papers with different learning typologies identified for both the anticipated and actual outcomes. Note that the totals do not add up to the same number of papers with outcomes as some anticipated and/or actual outcomes incorporated more than one of the learning typologies.

Eighteen of the papers had 'matching' typologies for the anticipated and actual outcomes including: relational (see Bernardo and Sanders 1993, Barnaud *et al* 2007, Rajabu 2007, Dionnet *et al* 2008, Ducrot 2008, Dung *et al* 2009, Souchère *et al* 2010, Viera Pak and Castillo Brieva 2010, Ducrot *et al* 2014, Hertzog *et al* 2014, Speelman *et al* 2014); cognitive (see Farolfi *et al* 2004, Boissau and Castella 2006, Barreteau *et al* 2007, Ducrot *et al* 2007, Ducrot 2008, Barnaud *et al* 2010, Morardet *et al* 2012, Gourmelon *et al* 2013, Ducrot *et al* 2014, Hertzog *et al* 2014, Walsh *et al* 2014); and normative (see Bourgoin and Castella 2011, Speelman *et al* 2014). The majority of the 'mismatched' typologies refer to cases where the anticipated outcome was relational or cognitive and the actual outcome was cognitive or relational, respectively.

With the exception of Villamor and Badmos (2016), authors claimed to have realised anticipated and desired outcomes. In this study, the authors were hoping for normative learning, however, they found that the game only elicited player perceptions, expectations and goals (Villamor and Badmos 2016). While the games reviewed in this work have generally been successful in achieving learning, it may not have necessarily been achieved as intended.

5. Games, gaps and governance

5.1. Games as a tool for adaptive governance

The findings from our review suggest RPGs are a useful tool for creating and nurturing a basis for adaptive governance. Games function as a social learning platform, enabling participants to familiarise themselves with long-term problem solving, and attune themselves with the complexity inherent in managing shared resources over time. For the majority of games in our review, their overall aim was to enhance collective awareness of environmental problems and foster collaborative capacity in immersive, low-risk settings. In cases where players switch roles, participants are directed toward a more holistic understanding of the problem and steps toward a potential solution through their experience of other stakeholders' perspectives, values and challenges. Players' increased understanding may eventually encourage a shared or common language which is an important first step to continued collaboration on environmental problem-solving in the future.

In particular, RPGs may provide one way to address, or explore, power imbalances in the context of environmental problem solving. In its simplest expression, power is the influence or control of others' behaviour in relation to resource governance (Berbés-Blázquez *et al* 2016). The influence and effect of power is a critical, but understudied component of adaptive governance (McDougall *et al* 2013, Cooper and Wheeler 2015, Brisbois and de Loë 2016). We found evidence to suggest, however, that RPGs may help address power imbalances in the context of environmental problem solving, especially when participants switch roles during the game (Dionnet *et al* 2008, Ducrot 2008). When participants take on roles that are different to their own, their current roles are either 'de-powered' (more powerful players are directed to speak from and/or emphasise with less powerful roles), or empowered (less powerful players are enabled to participate in the decision-making process

under the guise of a more powerful role and regardless of their prior standing). Players were assigned roles that were different to their own in some but not all the RPGs in our review. However, for the purposes of de-powering and empowering, we suggest that players switch roles during the game, and moreover, that the game includes a variety and number of different roles or characters.

As a tool or mechanism for adaptive governance, RPGs, when played with community members and decision-makers, allow community members to drive adaptation and restoration based on their own social and cultural capital. The use of RPGs is democratising: they allow anyone to play, regardless of their expertise, skills, technology, standing or resources. Games also provide a safe space for learning and experimentation. Such spaces are essential to support the emergence of solutions to complex problems (Pereira *et al* 2015). For players within the game environment there is no right or wrong, no 'real-life' consequences, so they can be immersed in comprehensive and interactive simulations to gain new insight and perspectives. Additional factors for designing a credible RPG or simulation are to situate it in the future, to help alleviate any concerns about current reality, and also potentially level out power relations between players in real life. Using actor-based perspectives in designing characters and game play allows differentiated or individual consideration of the various actors who are modelling individual and organisational decision behaviour.

5.2. Research gaps and areas for further study

In closing, while the reviewed games presented a diversity of roles, none of them have been played at the interface between community and policy. We found instead, the majority of RPGs were played at two distinct levels. Games are typically played at the local level, with individual landowners gaming scenarios or games were played with decision-makers at higher scales and focused on policy and planning (see Barrett *et al* 2003). Very few games were played for community decision-making (see Adamatti 2009). Therefore, we identify a research gap in RPGs that include both local landowners and land-users and a higher-level policy-making domain, from local to regional to central government agencies. While this combination of lower- and higher-level governance scales may add complexity to the design and implementation of a RPG, such a game would be applicable on a wide scale because complex environmental issues cross community, policy and higher-level decision-making domains.

We also found the predominance of computer-aided simulations and/or companion modelling in many of the reviewed games (Dung *et al* 2009, Souchère *et al* 2010, Gourmelon *et al* 2013, Ducrot *et al* 2014) potentially limits ease of replication of the RPGs in remote, under-resourced, unconnected or under-connected areas.

On the question of power, RPGs can enhance collaboration through de-powering and empowering stakeholders' current positions or fictionalising a tense real-life problem context, but we found that games can only address power imbalances to the extent that the most powerful stakeholders actually participate in the game session. Gourmelon *et al* (2013) and Hertzog *et al* (2014) identified power as an obstacle that threatened RPG success in each of their cases, but were unable to satisfactorily address inter-group power imbalances through their games. In the context of existing power imbalances, game designers should be careful to ensure that all or most stakeholders are represented in the game or that the game results are otherwise fed back into decision-making processes. This potentially requires work outside of as well as within the game, echoing our findings in the literature that RPGs are an important, but not sufficient, tool for adaptive governance and improved environmental decision-making.

Finally, we found that RPGs can be an effective mechanism to achieve cognitive and relational learning among and between participants. In the reviewed papers that specified the desired and actual outcomes of the games, cognitive and relational learning were among the key stated goals. Conversely, there were only three cases in which a more normative application was desired, and only seven cases in which a normative outcome was achieved. Because normative outcomes were not a priority in the reviewed RPGs, nor a predominant outcome, further research is needed to (1) assess the potential of tools such as RPGs to achieve normative learning; and (2) to develop optimal RPG design, structure, and execution to elicit such outcomes.

6. Conclusions

Our review of RPGs in the natural resource sector suggests that games can be a productive way to engage stakeholders and improve environmental outcomes across cases, contexts and sectors. In particular, RPGs have broad potential to complement and strengthen adaptive governance approaches to environmental problem solving. As a social learning platform, RPGs may help establish and nurture the human relationships, trust, capacity and connections required to address the long timescales and uncertainty associated with complex environmental issues (Dietz *et al* 2003, Walker *et al* 2004, Folke *et al* 2005). Social learning is thus highly complementary to the principles of adaptive governance, through building capacity and connections between stakeholders, amongst other elements, to address complex, environmental issues. While RPGs are seldom seen as a tool for adaptive governance (Sharma-Wallace *et al* 2018), they

represent an innovative way of advancing more holistic and context-sensitive decision-making practices.

Our review also highlights the adaptability and scalability of RPGs, and their potential application in a wide variety of contexts, situations and scales. RPGs can be designed for, and implemented across, disciplines, skills, backgrounds, positions and many other 'demographic' factors. The ability of researchers to incorporate interdisciplinary thinking into game development enriches the gaming experience for both participants and the researchers. Incorporating players from a wide range of personal and professional backgrounds—those that are most obviously relevant for the situation, but also those that may not be immediately seen as relevant—enhances the players' experience as well as the data and information that emerges from playing the game. This is particularly valuable where there are complex, multi-dimensional problems. This potentially allows us to create an RPG that can be played with community members and others to assist in community-level decision-making.

Nevertheless, the review does highlight some important gaps in the RPG literature, for example, we find limited evidence of games that bridge community—and higher-level decision-making scales. Purposeful RPG design may be useful in this regard and will require outcomes and purposes to be clearly defined from the initial design stages. We also note limited application of RPGs played for community decision-making outcomes (see Adamatti 2009), even though there is a significant need for decision-making tools to address complex problems involving multiple stakeholders and scales. While the review advances a foundation upon which future researchers or communities will be able to use RPGs at the community decision-making level (between individual landowners and the policy level), further research is needed to fully realise RPGs' potential in this area. As a first step, considering other literature (i.e. around simulation, conflict resolution and organisational change) into the theory behind game development and execution may provide rich exploratory pathways for better integration of community and policy scales into RPGs.

In this light, RPGs are best seen as a useful tool in the adaptive governance toolbox, which can contribute to robust environmental outcomes when used progressively and/or in combination with other management applications. SGs and RPG are an effective way to trial innovative decision-making, assess the consequences of management actions and adapt thinking without real-world consequences in the context of environmental decision-making. By providing participants and players with the opportunity to assume other roles, game play enhances and enables social learning. Such safe innovation spaces can help advance effective environmental decision-making to resolve intractable problems, removing the risks otherwise associated with decisions, to allow for greater experimentation and flexibility (Geels 2011), and accelerate progress towards adaptive governance solutions.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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