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Gaming Good Governance: Co-Design of a Serious Game about Overcoming the Barriers of Natural Flood Management

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ABSTRACT

Natural Flood Management (NFM) implementation faces many barriers, notably governance and collaboration challenges, at catchment scales. During an embedded research project on NFM implementation in the Allan Water and River Esk catchments in Scotland, United Kingdom, we suggested that serious game co-creation would be an effective tool to improve cooperation. We conducted five 2.5-hour game co-creation workshops aimed at understanding the reality of NFM implementation, the potential purpose of a game, and the elements that could be included in gameplay. We found that the game co-design process led to an improved understanding of NFM implementation. The workshops led to a defined game purpose: players experience the barriers to NFM implementation and try to find ways to overcome these barriers by collaborating at catchment scales. The workshops also led to ideas for elements to be included in the game, such as uncertainty and trade-offs. The game could be a useful resource for catchment stakeholders to increase cooperation.

KEYWORDS: Natural Flood Management; Serious Games; Game Design; Stakeholder Engagement; Decision-Making

1 INTRODUCTION AND LITERATURE REVIEW

Natural Flood Management (NFM) implementation is a complex challenge because it involves coordinating decisions between diverse stakeholders at large spatial scales in the face of uncertainty. Uncertainty exists in two forms, both physical uncertainty about flood risk, and social uncertainty about the decisions that people make (Thorne et al., 2018). For these reasons, NFM has been described as a "wicked problem" (Blackett et al., 2022; Rittel & Webber, 1973; Wingfield et al., 2021).

NFM has been used in pilot projects around the world but has not yet been implemented at a large scale due to various "barriers" (Holstead et al., 2014; Tabas et al., 2025; Wingfield et al., 2021). Catchment organisations often face "complexity" (Waylen et al., 2023). Furthermore, governance challenges, especially constraints at the local government level, make it difficult to upscale NFM (Tabas et al., 2026). Innovative approaches are needed to encourage collaboration to increase NFM implementation.

This paper argues that Serious Game (SG) co-creation is a useful stakeholder engagement tool to enable a deeper understanding of NFM implementation. It presents evidence from a SG co-developed in Scotland with stakeholders from two river catchments, the Allan Water and the River Esk. As explained by Lankford & Craven (2020), "the game design process is valuable in itself." This paper describes the co-

development process for a new game which is focused specifically on understanding and overcoming the barriers to NFM upscaling.

1.1 Serious Games and Flood Risk Management

A game is "a system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome" (Salen & Zimmerman, 2003). SGs are a subset of games with a purpose beyond the game such as education, negotiation, and decision-making (Abt, 1987; Djaouti et al., 2011; Uskov & Sekar, 2014). SGs have the potential to build enthusiasm and investment among players (Harteveld & Suarez, 2015; Mendler de Suarez et al., 2012) and can have real-world impact, such as encouraging new types of thinking and "paradigm shifts" (Garcia et al., 2022; Kuhn, 1962).

SGs are uniquely suited to solve wicked problems like the challenge of NFM upscaling because they allow a simulation of different perspectives and decision-making in the face of uncertainty (Mendler de Suarez et al., 2012; Powell et al., 2021). A review of flood-related SGs found diverse types of games: board games and computer games, real and imaginary settings, and emphases on different phases of the disaster cycle (Forrest et al., 2022). Examples of existing SGs related to flooding include a computer game on flood risk management in Millbrook, UK (Khoury et al., 2018), the "Upstream, Downstream" board game simulating farming decisions in Nicaragua and Guatemala (Mendler de Suarez et al., 2012), and a land use-focused game in Scotland (Novotny et al., 2025).

1.2 Designing and Evaluating Serious Games

Triadic Game Design (TGD) conceptualizes SGs as having three key components: a realistic game represents a problem well; a meaningful game achieves a clear purpose; and a fun game keeps players involved (Harteveld, 2011). "Iteration" is an important part of game design (Baaden et al., 2018; Craven et al., 2017; Kellerhals et al., 2021; Salen & Zimmerman, 2003). Co-design can improve how well the game represents the real world (Ball et al., 2021) and give agency to the communities involved in the research (Blackett et al., 2022). Three methods for measuring how well SGs achieve their purpose are before/after questionnaires, in-game observations, and debrief discussions (Forrest et al., 2022).

2 METHODS

The SG co-creation described in this paper emerged from an extensive, four-year embedded research project on NFM implementation in the Allan Water and River Esk catchments in Scotland, UK. This paper aims to answer the following research questions:

1. In what ways can the process of co-creating a SG improve understanding of NFM implementation?
2. What are the central ideas that should be included in a game about NFM implementation?

The Allan Water and River Esk have catchment areas of approximately 200 km^2 and 300 km^2, respectively (Figure 1). The catchments include upstream farms and small towns, and downstream urban areas with significant flood risk. The authors learned that governance-related challenges make NFM upscaling challenging to achieve in practice: it is difficult for catchment stakeholders at various levels (local, national, etc.) to collaborate with each other to implement NFM (Tabas et al., 2026). Based on research by Garcia et al. (2022), Harteveld (2011), and Mendler de Suarez et al. (2012), the researchers recommended that a SG would be an effective method to increase cooperation between upstream and downstream communities. When asked about this idea, catchment stakeholders expressed keen interest in participating in the game design process.

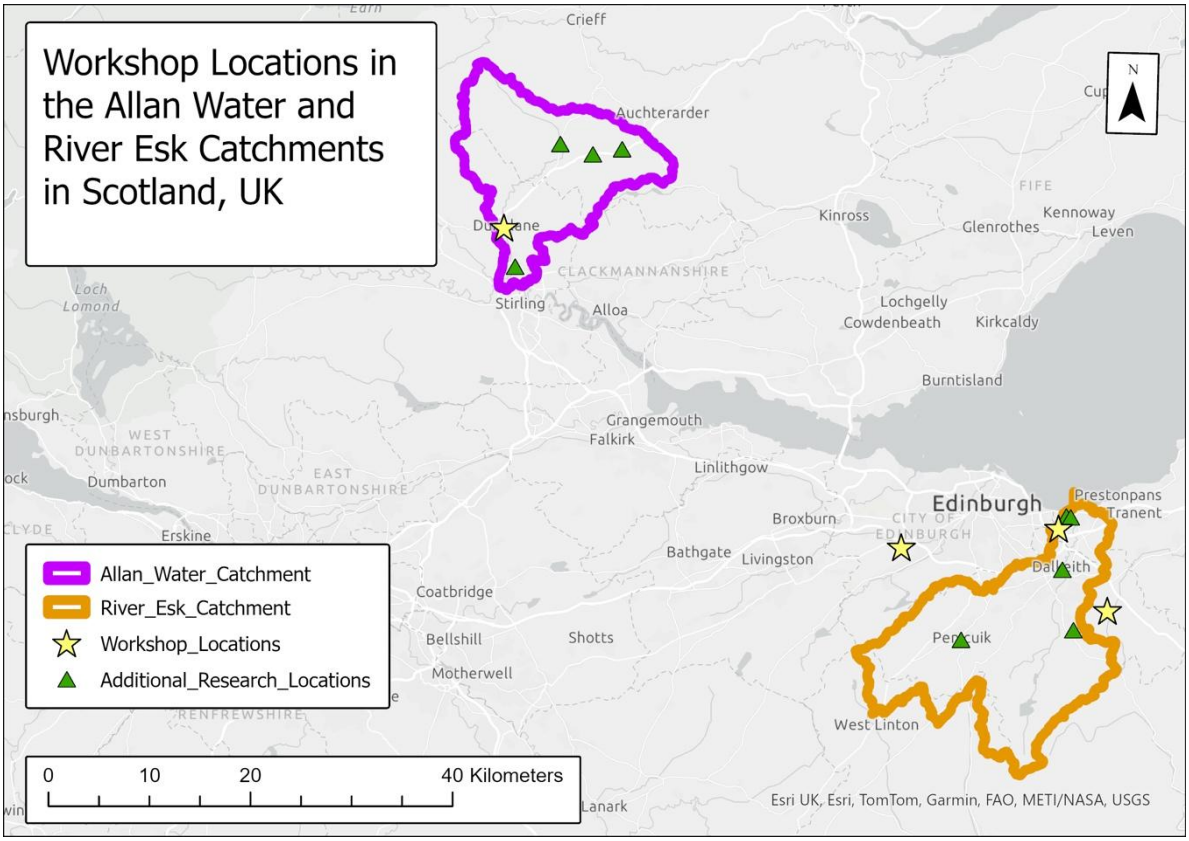

Figure 1: Map showing the workshop locations within the Allan Water and River Esk catchments in Scotland, United Kingdom.

The research team chose the triadic game design (TGD) approach because it provides a clear structure for conceptualizing SGs (Harteveld, 2011). We note that others have used TGD for SG design such as Kellerhals et al. (2021) and Holstead et al. (2026). The fact that TGD's three areas of Reality, Meaning, and Play correspond roughly with Salen & Zimmerman (2003)'s three areas of Rules, Play, and Culture was an added reason for selecting this method. Furthermore, because the research team has experience using TGD to teach undergraduate classes about catchment flood risk management, the team has a familiarity with TGD that made it easier to implement and to explain to the stakeholder co-creation team. The research team also considered advice from Douven et al. (2014) regarding game design to include "imaginary, but realistic" catchments in water management games.

This paper reports on five game co-design workshops with catchment stakeholders and additional data gathering conducted from January – July 2025 in the Allan Water and River Esk catchments. The workshops each had a theme from TGD, as shown in Table 1. Each workshop was 2.5 hours in length, and researchers took handwritten notes and audio recorded discussions. The workshop content is treated like a focus group (Bryman, 2004) for data analysis purposes. Quotes include a participant code which indicates where the workshop was conducted (A1-A12 represents Allan Water participants; E1-E14 represents River Esk participants). Data also includes land managers' responses to questionnaires conducted in-person at a community event in July 2025 to provide additional context.

Table 1: Description of Game Co-Design Workshops and Research, January – July 2025

Workshop Number	Stakeholder Group	Number of Participants (not including facilitators)	TGD Focus Area
1a	Allan Water	10	Reality
1b	River Esk	11	
2a	Allan Water	5	Meaning
2b	River Esk	7	
Additional data	Land managers	15	Reality
3	Combined	3	Play

This research was conducted as part of the project "Making Natural Flood Management at the Catchment Scale a Reality." Phase 1 ethics approval (2023-4979-7567) and Phase 2 ethics approval (2024-9018-12600) were provided by Heriot-Watt University (Edinburgh, Scotland).

3 RESULTS

The game co-design process led to an improved understanding of NFM implementation (section 3.1); a consensus around the reason for developing the game (section 3.2); and initial ideas of elements to include in the game (section 3.3).

3.1 How does Natural Flood Management implementation work?

In workshops 1a and 1b, participants described NFM implementation and its role in flood risk management. First, they listed the key decision-makers: national government and public-sector organisations, local government, landowners, NGOs, communities, and consultants. These organisations have a variety of interests, resources, and priorities, and one of the key governance-related challenges is finding ways for them to cooperate effectively (Tabas et al., 2026). Second, they discussed potential flood resilience measures, including engineered defenses and NFM techniques such as ponds, wetlands, and leaky dams. Third, participants described the various types of land use that exist in Scottish catchments. Initial land uses highlighted in workshops 1a and 1b were urban, agriculture, forestry, peatland, and wetland.

3.2 Why play a game?

Participants were enthusiastic about the potential of a game to inspire change. As stated by one participant, "*I think one benefit of using the gaming approach would be being able to demonstrate the benefits of working together*" (A7). Collaboration therefore emerged as a key theme of the game. Similarly, another participant emphasized the potential of the game to be a tool to increase empathy: "*I think it's a really powerful opportunity for people to potentially role-play and try to understand other peoples' perspectives*" (E14). Based on these and other insights, the following purpose for the game was established: Players experience the barriers to NFM implementation and try to find ways to overcome these barriers by collaborating at catchment scales. This purpose emphasises that the goal of the game is to inspire paradigm shifts (Kuhn, 1962) among the people who play it.

Participants also explained the importance of including NFM's co-benefits beyond flooding-related impacts in the game. As one participant stated, "*Could you also have it show all the different outcomes? You could get rewards for the co-benefits*" (E11). A consideration of NFM's flooding-related benefits would only tell part of the story, missing the implications of these practices for biodiversity, recreation, carbon sequestration, and other ecosystem services.

3.3 What experience will the players have?

The researchers suggested that a multi-player board game would be an effective platform to highlight the social dynamics at play in flood risk management and achieve the purpose stated above. Participants highlighted the importance of including trade-offs in the game: "*Tradeoffs would be, I would think, an interesting part. Priorities, impact, and cost*" (E7). Participants also suggested that the game include uncertainty: "*Include a random element though in it. Because life's random*" (E5). Based on these discussions, balancing trade-offs and managing uncertainty became central features to include in the game. Workshop 2a and 2b participants were invited to sketch what the game could look like. Initial ideas from the workshops (Figure 2) included a variety of designs, with common themes including rivers, catchments, and water drops.

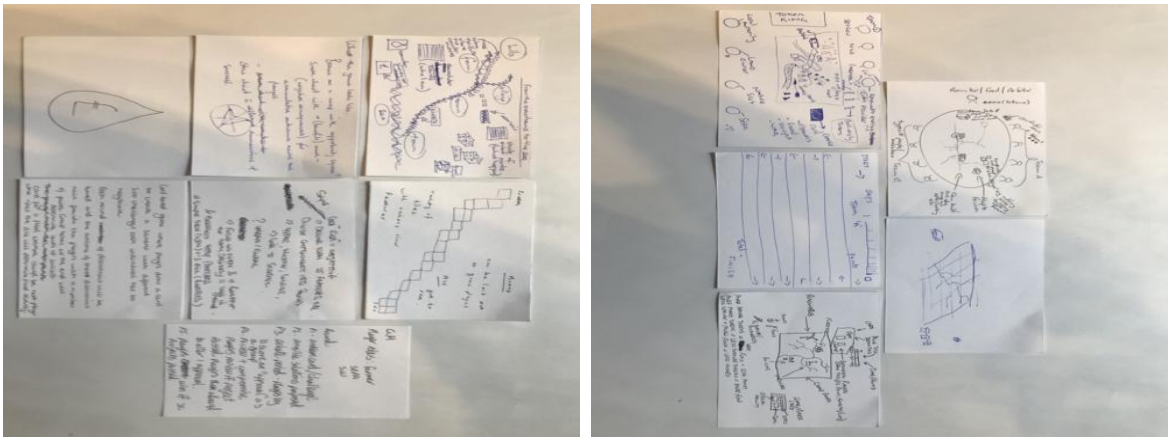

Figure 2: Catchment stakeholders' illustrations of the potential look of the game.

4 CONCLUDING DISCUSSION

Researchers co-designed a SG about NFM implementation with catchment stakeholders in the Allan Water and River Esk catchments in Scotland, United Kingdom. During five workshops and one stakeholder outreach session, the researchers gathered data about views on NFM to inform game design.

This project has resulted in an improved understanding of NFM implementation, a clear purpose for the game, and a list of elements for inclusion in the final game such as uncertainty and trade-offs. These insights will be central to continued game development.

A limitation of this research is that both case studies are located in the same country. Researching this topic in an international context could lead to new insights. However, researchers feel that the lessons learned during game design are of global relevance, as stakeholder cooperation in the face of wicked problems is a universal challenge.

Future research will involve the continuation of game development workshops: the researchers intend to iterate the game and to hold one additional "Balancing" (Harteveld, 2011) workshop in each catchment to ensure that the final game design is effective. Once the game is completed, it will be played with NFM stakeholders in Scotland. Researchers will use questionnaires, observations, and discussions to evaluate whether it is effective (Forrest et al., 2022). The intention is that the game will be an effective tool for changing minds about NFM implementation.

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