No	Comments and Answers
1	Thank you for sharing this interesting work with me. First of all, please let me apologize if I have not properly understood those elements of the paper on which I give comments, or if my perception was wrong. The paper documents the process of designing and applying a serious game based on a system simulation model. The application of serious games as a contribution to sustainable development receives increasing attention also raising high expectations. The presented work documents a game design process and intends to provide evidence on outcomes from playing the game. It can help to better understand the potentials and limitations of the approach and can meaningfully inform future serious game design processes. I strongly support the publication of the paper. Having said this, I want to share some thoughts which I hope can help to improve the paper.
2	*The study has two objectives:* 1. *Develop an adaptable serious game* 2. *Assess if game facilitates knowledge transfer and sharing, and supports negotiation and coordination.* *I am not sure whether the paper really addresses these two objectives. Either rethink your objectives or structure the paper more strongly around the ones you formulated. You documented the game development process which I consider an important contribution. It is difficult for me to judge how easy it is to adapt the developed game to a different context. The paper does not really make this clear.* Answer: Thank you. We rephrased the two objectives to be closer to what we actually discuss 1. Develop a serious game that is adaptable to different socio-hydrological contexts and issues 2. Clarify how such game can facilitate knowledge transfer and sharing, and can support negotiation and coordination by context-specific use *I am even more concerned about the second research question. The methods section does not explain the approach in sufficient detail. An input-output process is mentioned as methodology without explaining it. You state that information was collected throughout the game development and implementation process. How was this information collected and analyzed? You mention a post-game survey. Please provide more information on: 1) who was interviewed and how have respondents been selected, 2) how many respondents were interviewed, 3) how was the survey implemented (also addressing the strong risk of social desirability bias), 4) when was it conducted?* Answer:

	You have similar question with reviewer 2 (RC 2). We add more information about how we collect the data for the evaluation survey in the section 2.5 about the game evaluation. "From the long list of criteria (Belcher et al., 2016), we chose four credibility criteria, five salience criteria and two legitimacy criteria which we considered to be the most relevant for evaluating the H2Ours game to meet the objective of the game. Each of these criteria were included during the game design process and the evaluation after game implementation. We included those criteria during the game design using ARDI and DPSIR frameworks to structure socio-hydrological data and information based on the research findings from ICRAF and Tropenbos Indonesia (both already and to be published) to meet the criteria during the game development process. For evaluation after game implementation, we converted those criteria into several question ans statements for the q-method and Likert survey and asked all game participants to fill in the survey. In the Likert scale survey, we used five-point scales (strongly disagree, disagree, neutral, agree, and strongly agree) on six statements to ask about their feeling during the game, their understanding of the rules of the game, the length of the game simulation, new knowledge that they got from the game, and how close the game to their reality. We used q-method to capture participants' subjectivity regarding the relationship between vegetation, water and humans, the causes of socio-hydrological problems in their region and the factors that determine the success of hydrological condition restoration activities. To capture changes in their perceptions regarding these three questions, participants conducted the q-method before and after the game using the same questions and q sort statements. The results of the q-method will be presented in another paper along with their decision making, preferences, vision, collaborative and collective action." *For answering the second research question, can you share information on the decisions of players in the game? Do you see patterns and changes over the rounds? Can you share information on what has been discussed during the game sessions?* Answer: As the objective of this manuscript is to document the development and adaptation process of the H2Ours game, so in this paper we focus on the development process. We plan to make a series of publications about H2Ours game in Rejoso watershed and Pawan-kepulu peatland: 1. H2Ours game development and adaptation process (this manuscript) 2. Result of the H2Ours game. We decided to present the results of the H2Ours game in different manuscript to have more space to present the conditions of the research location which are closely related to how players make decisions regarding land and water management, including changes in perception and knowledge. We mentioned in section 2.5 (game evaluation), we mentioned: "The results of the q-method will be presented in another paper along with their decision making, preferences, vision, collaborative and collective action"
3	*In this context, I recommend giving more weight to Section 3.3. Interesting statements are made regarding the game dynamics. It could be combined with some statements included in the*

	discussion (e.g. that setting up the game has built emotions). The value of the information depends, however, on the transparency of how information was generated. Answer: In accordance with the objective of this manuscript which focuses on the H2Ours development process, the results shown in this manuscript are more about the form of the H2Ours game itself. Implementation results are presented in section 3.3 is only indicative result. We believe that the dynamics of the game results correspond to the character of the socio-hydrological system and changes in participants' perceptions can be an interesting article which provide more space for explanations. So we will deliver more detailed result in another paper.
4	*On a conceptual level, I am not convinced that collecting data on credibility, salience/relevance, and legitimacy can answer the second research question. This would at least require stronger justification. Going a step further, I do not think that the survey questions are adequate indicators for Belcher's et al. criteria. For instance, asking a player whether she sees the possibility to apply the knowledge acquired in the game does not provide information on how inclusive the process has been. I would propose a more differentiated approach regarding how you provide evidence on different criteria. Players will not be able to give meaningful answers to some of them. For instance, by playing the game, a player does not need to be aware of the underlying theory of change. I would move Table 1 to an appendix to make space for a better explanation of the methodology and the key results.* Answer: In the theory of change related to this game, the desired changes refer to the 4 stages of the knowledge to action chain (understanding, commitment, operationalization and innovation). Based on the definitions of credibility, salinity and legitimacy in section 2.5: "From the game development perspective, credibility refers to whether a game is built based on scientifically reliable knowledge, including the data and methods used to build the game. Salience refers to how far the game can show the relevance of goals, rules and finding to the actual situation. Finally, legitimacy refers to how the participant can accept the game by relating the game simulation to their actual situations (Cash et al., 2002)." In order to achieve the second objective of this paper, to clarify how games can facilitate the sharing and transfer of knowledge, we want to ensure relevance of game situations to the reality (salience), the acceptance that game conditions resemble their conditions (legitimacy), and supported by appropriated data and methods (credibility). Thank you for your suggestion. We moved table of criteria of credibility, salience and legitimacy to Appendix C, and replaced that table with short summary in the sub-section 2.5, please see our response to Reviewer 2 number 5.
	A clear theory of change is one of the evaluation criteria and it needs to be expressed in a more explicit way. In lines 42ff, the authors argue that knowledge supports commitment (intention?) supports responsibility, supports innovation. It is not clear which type of knowledge, commitment, responsibility, and innovation the game intends to support. The learning outcomes are formulated rather vaguely. In the model framework, the authors include the assumption that income drives decisions. In the discussion, you argue that the enabling environment is the key

	driver and no behavioral change can be expected if regulations etc. are not adjusted. Considering all these thoughts and assumptions, what did you intend to change by letting stakeholders play the game? Answer: Thank you for your concern. We agree that we have not written down specifically what form of knowledge we want to convey in this form of game. We revise the sentence in section 4.2 to: " As hydrological problems are usually quite complex and fundamental, their solution requires quite a long time for integrated planning, which requires all stakeholders to have the bigger picture (Medema et al., 2019). The H2Ours game tries to simplify the space so that it makes it easier for players to be aware of the conditions of neighboring players and to get the entire perspective of socio-hydrological problems. Improving player knowledge by looking at socio-hydrological problems in a broader context encourages responsible behavior towards the environment which is directly proportional to commitment (Keles et al., 2023). We also revised the third lesson learned to reduce miss interpretation: "Third, based on the evaluation and debriefing results, even if they stated they can apply the ideal collaborative actions that are simulated in the game, in real life, it still needs to build the enabling condition that supports it (e.g. regulation, integrated planning strategies, etc.). Because the game is a simplification of the system, forms of collaborative action can be discussed directly by the players. In real conditions, the parties who are expected to collaborate may not find it easy to meet and discuss. Therefore, the implementation of the collaboration in real life requires guidelines and mechanisms that can be followed by the parties to achieve common goals, and the commitment, as referred to in the four knowledge-to-action chains, still cannot be carried out directly unless there are enabling conditions that exceed space limitations"
5	*Based on the provided information, it is difficult to understand the structure of the game. Key aspects are not explained, such as:* *Number of players per session; who was selected to play the game (relevant also for theory of change)* *Types of roles; in section 3.2.2 is described that there are two roles namely communities and a multi-stakeholder forum. But then one finds statements that there are upstream and downstream actors, different villages etc. Is the role definition linked to the diagnosis? Who in Table 2 creates pressure? Who is involved in the responses and dynamics? Are the relevant actors included as roles? Such game development decisions are critical for the theory of change.* Answer: Thank you for your concern. We elaborated Section 2.4 (Game implementation) to add more information about the players in this study. Please see our response to reviewer 2 number 1 about the game participants We added more explanation on section 3.2.2 (roles): "Based on the stakeholder identification survey in Rejoso Watershed and Pawan-Kepulu peatland, we defined two key roles for this game, namely local communities and a multi-stakeholder forum. In the Rejoso watershed, local communities can be grouped into people who

	live in the upstream village, midstream village and downstream village based on the village elevation. Meanwhile in Pawan-Kepulu peatland, local communities can be grouped into four groups of people living in 4 neighboring villages (Village 1 – Village 4). The local communities represent land owners and their goal is to live happily by fulfilling their needs (food and taxes). The multi-stakeholder forum is a forum that consists of public stakeholders (NGOs, university, etc.) and policy makers (local governments). Their goals is to prevent natural disasters (water scarcity and floods in Rejoso watershed, and fires and floods in Pawan-Kepulu peatland). The H_2Ours game brings the various interests of these actors together and shows how they make their decisions regarding the management of land and water resources to meet their economic and environmental expectations." In the section 2.3.2, we already mentioned that how we defined the roles based on the ARDI framework: "According to the ARDI framework (Sect. 2.2), we defined the roles in this game based on the main actors involved in water management. Related to these roles, we designed goals that players must achieve during each simulation based on discussions and interviews with the related stakeholders according to their actual goal in the reality". We revised section 3.1 (result: Diagnosis of the study areas and issues) based on your input: "Based on the results from the DPSIR and ARDI analyses, we found that the Rejoso Watershed and the Pawan-Kepulu peatland have similarities in the socio-hydrology context (Table 2). Expectations on better economic conditions led local communities to changes in land cover, and excessive extraction of water resources (groundwater) caused disruption of the water balance. This disruption resulted in local communities and multi-stakeholder forum experience various hydrological problems, such as water shortages (or decreasing the groundwater level) and flooding. However, these two sites are also different regarding their hydrological contexts, such as hydrological boundaries, topography, and water management, and interactions among stakeholders and landscape (Fig. 3, Appendix C). Two solutions (responses) were identified to restore hydrological functions in watersheds and peatlands, namely better land use management and (ground) water management (Table 2; component 7-Response) by the local communities and multi-stakeholder forum".
6	*Which decisions can be taken by which player role? Table 3 and Figure 3 give the impression that only crop and forestry related choices can be made. But then it is mentioned that players can block channels. The choices of the multi-stakeholder forum are formulated very unclear and are not included in Figure 3.* *How could the forum make regulations or programs to prevent environmental programs.* Answer: Thank you for your concern. We added a paragraph in section 3.1 (p.2) related to Figure 3 and Figure D1 to explain what the types of decisions they make that affect their landscape. "In more detail, the interaction between stakeholders and the landscape is represented by the types of decisions taken by local communities and the multi-stakeholder forum regarding their

	landscape. Local communities (farmer from upstream, midstream and downstream village in Rejoso Watershed and farmers from Village 1 - Village 4 in Pawan-kepulu peatland) have the authority to make decisions regarding their land which consists of land use types and water management types (artesian wells in Rejoso watershed and canal blocking in Pawan-Kepulu peatland). Multi-stakeholder forums have authority over regulations and programs applied to local communities to achieve their goals. Multi-stakeholder forum can refer to their existing document for the regulation and program or based on the game session with multi-stakeholder forum (Section 2.4) ” We revised Section 3.2.3. (Rules) to give more explanation about the option of land use types and options of regulation and program by multi-stakeholder forum. “At the start of the game, all group of players (local communities and multi-stakeholder forum) received a limited amount of money. Community members were asked to manage their land by arranging the land use type combination and water management in their area with the money provided, while multi-stakeholder forum was asked to run programs or to help reduce the local community’s economic problems. Once players decided on how they would manage their land or community programs, the economic and environmental rules linked to those land use decisions were applied (Table 3). These rules then defined the dynamics of the economic and environmental conditions (Table 3, and for the Pawan-Kepulu peatland in Appendix D).” *Please also better explain how you decided on the players’ choices in the game.* Answer: We invite the players through village leaders and farmer group leaders, and let them decided who would attend the simulation. However, in the invitation we gave the criteria of the participants. We already added this information in the section 2.4 (game implementation). Please see our response to reviewer 2 about the participants and their criteria. *In the discussion is mentioned that the game could not capture the complexity of the system and that few issues had to be selected to be included in the game. Please describe the process from diagnosis to selecting the issues to be included in the game. Such game development decisions are again critical for the theory of change.* Answer: In the discussion we mentioned that based on several publications, these two research studies have more complex socio-hydrological problems than played in the H2Ours game. In the beginning, we wanted to include all problems in one game such as erosion, landslides and sedimentation. However, during the game development process, especially in the preparation of rules and the quantification systems, the game becomes very complex. Considering the background of the targeted participants and the game duration, we decided to only highlight one hydrological problem. We determined which issues to raise based on the national priority issue in that location. We add more information on how we chose the issue for the game in the discussion.

	Are decisions taken collectively (a group represents one role and decides based on some agreement) or individually, creating collective outcomes. In line 433 is stated that the game demonstrated the value of collective action. How is collective action implemented in the game? Answer: Yes, a group represent one role. When we started the game, the facilitator asked to choose a leader to represent their group. *Did the players receive real money? If yes, how was the payout determined? Did it depend on the game dynamics as is common in behavioral games? If not, make clear in Section 3.2.3 that you talk about a game endowment/play money.* Answer: I am sorry, i do not really understand your question. I assume your question is about the use of real or play money and how to determine it. We revised section 3.2.5 (game properties) to explain about the play money and water balance miniature. "To make the game more interesting and stimulate engagement, we prepared some game materials such as a game board to represent the landscape, land-use tiles according to the existing and future land cover types, play money token, and water infrastructures token (Fig. 5). We also created water balance miniatures (Fig. 6) to demonstrate how surface water flows and becomes flood and water infiltration become ground water supply. Each round after calculating the economic condition and environmental conditions based on Table 3, we asked players to pay production costs, taxes, etc. and get income, incentives, etc. using play money and fill the water balance miniature with real water according to the produced surface water and groundwater."
7	*A more comprehensive explanation of outcomes resulting from choices would be important for understanding the game. For instance, in Table 3, can you provide likelihoods of flooding, water shortage, and fire events for different land use options?* Answer: We add more explanation in Section 3.2.3 explaining how we determined environmental impacts (floods, fires and water shortage). "When the total of surface water in the downstream of Rejoso watershed and in the shallow peat of Pawan-Kepulu peatland exceeding its capacity (>800 ml) during the rainy season, it caused flooding. When the groundwater exceeding its capacity (>700 ml), it flowed to springs in Rejoso watershed and to sea in Pawan-Kepulu peatland. But, when the groundwater was less than its requirement (<200 ml), it caused water shortages in the Rejoso Watershed and potential fires in Pawan-Kepulu peatland. These environmental impacts decreased the community income. As the consequence of this situation, they might not have enough money to manage their land, buy food or pay taxes in the next round of the game. The multi-stakeholder forums with their limited budget could then choose to help them by providing financial help or making regulations/programs to prevent these environmental problems. Through this gameplay, we expected to promote all actors to work together and collaborate to achieve their goals. "

	The choices in Table 3 indicate that unsustainable options provide highest income. At the same time, your model (Figure 3) works with the assumption that income mainly drives choices. How do you address the risk of unsustainable learning outcomes? A player's answer in the evaluation survey that she can apply the game learnings could mean that she learnt that an upstream-all-crop strategy is best. Answer: I understand your question and concern. When we talk about the best scenario at the landscape level involving many stakeholders, there may be a conflict between the best scenario for whom and for what. Hence, the H2Ours game tries to convey this issue through one of its objectives related to a shared understanding by bringing the socio-hydrological system as one system. By understanding condition, we expect that a commitment will emerge to overcome their common problems through negotiation and coordination between stakeholders. This game was designed to resemble actual conditions, so it could provide an illustration of the solution to their real problems. However, to achieve sustainable learning outcome, other efforts are still needed such as implementation (adapting what they learnt from game simulation to real life), monitoring and evaluation.
8	I do not understand the step of the game solution space analysis. What does it mean that the solution space was explored based on 3, 10, 30, 100, 300, and 1000 games with random choice? How did these 1000 games differ? Just explain this better for readers not familiar with your modelling and game development approach. Answer: We elaborate on section 2.3.4 to explain in more detail about the solution space and the method used to generate it "Solution space is defined as a set of all possible decisions made by players. The solution space of the game was explored based on the average of economic and environmental conditions obtained from 3, 10, 30, 100, 300 and 1000 games with random-choice. One random-choice game consisted of 10 rounds in which climate conditions and land use decisions made by players are completely random. The random-choice of land use and climate condition were generated in R, then simulated using Excel spreadsheet as an imitation of the real H2Ours game to calculate the economic and environmental conditions. In addition, we assessed the probability of outcomes within the solution space under random decision-making as a point of reference for the actual game implementation."
9	*Line 74f: I challenge the statement that models and games have rarely been combined. There are numerous examples for instance on the website https://games4sustainability.org/gamepedia/. I am also aware of the following study: Lohmann, D., Falk, T., Geissler, K., Blaum, N., & Jeltsch, F. (2014). Determinants of semi-arid rangeland management in a land reform setting in* Answer: Thank you – our text was indeed inaccurate here. We corrected to:

	"Socially interactive games and models that explore larger spatial and temporal horizons have complementary strengths. As reviewed in Villamor et al. 2023, games and models can 1) seek a conceptual triangulation of representing the processes behind complex realties, 2) strive for numerical consistency between games and empirical models, 3) use games in the development of scenario models, or 4) use models in the design of games that trigger players to learn by experiencing manageable complexity. As an example of the letter, Lohman et al. (2014) designed and tested model-based role-plays with Namibian land reform beneficiaries, simulating 10 years of rangeland management. In this paper, we explore the feasibility of transforming a hydrological model into a serious game to provide socio-hydrological dynamics to stakeholders with diverse backgrounds in order to develop restoration plans."
10	*Line 80f: As a complementary approach, the authors may want to consider providing guidance on context conditions which need to be fulfilled for meaningfully using the games. Also, can you estimate the size of the areas which share socio-hydrological conditions which are featured in the presented games?* Answer: The current games rely on hydrological units without major unrecognized in- or outflows. In many cases groundwater flows into or out of agriculturally used areas may be relevant uncertainties in the use of water balance models. In both the mountain-to-sea and peatland hydrological units groundwater flow issues are internalized in the game. In many landscapes the social systems don't match the hydrological boundaries; spatially explicit social subsystems, such as upper, middle and lower watersheds can be accommodated, while interactions with social systems beyond the game boundaries may be represented by economic (supply, demand, prices) parameters and their (exogenous) fluctuations.
11	*Line 185f: On which basis do you assume that decisions of players in the game represent their real-life decisions? Did you ask them to do so? Why do you need this assumption?* Answer: Sari et al. (2023) tested for the plot-level FORCES game whether farmers land use system and tree choices matched their actual conditions outside the game. For H2OURS we don't have the same detailed comparison yet. However, during the game simulation process we see whether players play according to their actual conditions based on the choice of land cover they choose or not. We compared how they selected land use during the game simulation with the actual land use. Part of the game properties, we provide land use types according to their actual conditions and some other land uses that may be options in the future. We did not directly ask them to play according to reality, but in the beginning we created conditions in accordance with their reality. In this study, we expected participants to play according to their reality at the beginning because one of the goals of this game is to facilitate negotiation and collaboration between stakeholders to achieve the hydrological restoration target.

12	*Can you please better link your discussion and conclusions to the objectives of the paper and the presented results.* Answer: Thank you for your input. We will look again the link between objectives, discussion and conclusion
13	*Now that you have developed the game, can you share some thoughts on how your games could be applied to support sustainable development? Who could facilitate games with which target groups? What would be required to implement the game with a larger group of stakeholders? Ideally this way forward should be linked to the theory of change.* Answer: My research has a significant correlation to SDG 6 (Clean water and sanitation), SDC 13 (climate action) and SDG 15 (Life on land), but also supports SDG 16 (Pace, Justice and strong institutions) and SDG 8 (Decent work and economic growth). The complexity of water resource management arises from many stakeholders who have different backgrounds, interests, targets and knowledge have to make decisions related to the same system. Because they do not know that they are working in the same system, they do not know that their decisions might affect other stakeholders. Therefore, changes in point of view of stakeholders to realize that they are actually working in the same socio-ecological system are needed. H2Ours game simplifies a landscape that has the same hydrological system, allows stakeholders to see the same system and makes it easier for them to collaborate to solve problems or achieve common goals. For broad stakeholder groups, it requires identification of key stakeholders who are participants in the player. In the game development process, we mentioned in the roles of the game. The facilitator's ability and knowledge in leading the game also plays an important role in briefing, implementation and debriefing
14	*I hope my comments help to improve the paper. I think my concerns can be addressed in the frame of a major revision. I very much hope to see an improved version of the paper being published.* Answer: Thank you and we really appreciate your time.

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