

Reviewer 1: Wim Douven,

Dear Charles and team, I enjoyed reading your manuscript. I find the topic very interesting, and it is good to have another study on serious games. Below some comments, questions, that might be helpful in finalising the manuscript. [I am happy to hear you enjoyed reading the manuscript. Thank you for the positive remarks on the manuscript and constructive suggestions and comments.](#)

Comment 1: In the section on IWRM (line 66 and further), you mention that workshops do not promote different experts to engage with wicked problems. But doesn't that depend on how you design such workshops, like how you design serious games ..? [Thank you for the question.](#)

Response: Yes, we agree that there are many different participatory methods developed especially to promote the engagement of 'local experts'. One of the most familiar is focus groups, but many others are around including *hands-on' interactive activities e.g. participatory mapping, experimentation with art-based visuals, etc.* Designing serious game sessions may differ from designing workshop sessions. Firstly, serious games are co-designed where both the 'scientists' and 'local experts' are involved in the development of serious games (way before actual game sessions). In the workshop sessions, the scientists' are the most active persons, e.g. when making PowerPoint presentations, explaining an idea, reporting case studies, or simulating a model and its possible results. The participation of 'local experts' is relatively 'passive' in the workshop sessions e.g. sitting and listening to presentations made by scientists. Some workshops may divide participants into small groups for discussions, experimenting, and demonstrating workshop issues. But in most cases, the group discussions tend to have active and less active persons - *in Ln 659 of the manuscript, we have argued this could be due to power differentials among participants...* Workshops often are not the right way to deal with wicked problems.

There is a difference in the game sessions. Serious games provide a 'buffer' to mitigate powerplay and hierarchy, make it more easy for participants to express more freely, since it is 'just' a game. Serious games provide a boundary object commonly not found in workshops. The 'scientists' are less active, and tend to play the passive role of facilitating the process (especially at the start of the game rounds), while participants are the most active persons (in small groups) right from the start to the end of the sessions. The facilitation role tends to decrease as the game progresses, and at some point 'scientists' become the 'observers' of what is happening in the different small groups of gameplay. Scientists tend to learn more this way, as opposed to when they are the main presenters in conventional workshops. The game participants are vigorous as they interact directly with 'virtual systems' such as Board games and also actively engage one another (e.g. disagreeing, setting rules, seeking alternative strategies, etc), the scientists do not control the actual gameplay. *In Ln 654 of the manuscript, we have argued that '.....since each participant in the game has a role to play, they have a stake during the game. They tend to be active in pursuing their stake while focusing on their roles...'*

We agree that if we design workshops similarly to game processes (including having game-like engagements during small group discussions), then designs of workshops and game sessions could both promote different experts to engage in a meaningful way. Still, in most conventional workshops the 'scientists' are the main 'active persons' while 'local experts' are the 'passive' participants. By design game sessions reverse these roles.

Revisions made in the manuscript:

We have revised manuscript to expound our argument on conventional workshops in the (see Ln 93-103). In our revisions, we have compared conventional approaches and modelling to serious games (especially on the role of 'outsiders' dictating the processes), black-boxed versus open processes in games, included reported limitations in serious gaming.

Comment 2: I note that the lit. review on games is overall very positive on its effects on finding joint solutions etc., are there no limitations and challenges reported in literature? You mention one in your discussion in line 520. Did you come across other limitations, challenges in the sessions? [Thank you for the questions.](#)

Response: This study focussed on the literature that has attempted to report on the 'effectiveness of gaming approach'. Hence the purpose of this study was to 'investigate these opinions/claims' by assessing the potential role of serious gaming in strengthening stakeholder engagement. This study contributes to the debate on the 'effectiveness of serious gaming' including how some results contradict past studies see Ln 578.

Revisions made in the manuscript:

The following text has been added in the revised version (see Ln 103-125):

..... In their study, Flood et al. (2018) conducted a review of 43 serious gaming publications and identified the major shortcomings to effective game design and engagement as; one-off engagement (i.e. several game sessions are needed to enhance learning), capturing complexity without overwhelming the stakeholders, future planning (i.e. linking game results to plan an uncertain future). Serious games are also limited on the number of stakeholders who can be involved in a single game session, a constraint that raises the politics of who should attend the game(s) and why? (Wesselow and Stoll-Kleemann, 2018; Edmunds and Wollenberg, 2001). Studies have also reported that social differentiations and power asymmetries have greater influence on the outcomes of a participatory process (Barnaud and Van Paassen, 2013; Mathevet et al., 2014). Both the facilitators and the stakeholders have various degrees in which they can influence the participatory process (Jonsson et al., 2007). Serious gaming can also exacerbate the contests of power due to constraints of simplifying the complex real worlds, balancing the interests of the locals and the 'outsiders', and different perspectives of the present and future (Venot et al., 2022). A co-construction process also referred to as companion modelling approach where the designers and the participants collaborate to define the entire process is seen as a way to improve legitimacy of the participatory process and enhancing multi-stakeholder cooperation (Barnaud and Van Paassen, 2013; Barreteau et al., 2014; Basco-Carrera et al., 2018; Étienne, 2014). However, the companion modelling approach needs to be improved to clearly define the horizontal and vertical dialogues by involving all stakeholder at all levels (Barnaud et al., 2008). In general, the quality of participatory process depends on how biases and interests of all stakeholders, including 'outsiders' are balanced (Biggs et al., 2021; Daniell et al., 2010). As aforementioned, the politics that shape conventional processes (e.g. the influence of the 'outsider') are dealt with in the gaming approach through an iterative process that evolves with participatory modelling (Marini et al., 2018a; Speelman, 2014a; Speelman et al., 2019b; Rodela et al., 2019b; Barreteau et al., 2014). Hence, this study can be viewed to have done something different from the conventional participatory approaches (such as workshops, where 'outsiders' dictate the process) by creating a different type of collaborative engagement and a 'safe environment' for stakeholders.....

Comment 3: In game conceptualisation (Section 2.2), it might help the reader to give a brief summary about sessions, rounds, and phases, and how they relate to the catchment / sub-catchments. Thank you for the suggestion.

Response: During this stage of game conceptualization, there was no playing the games per se, but this is the 'setting stage', which involved bringing all possible ideas to the table, to help in crafting a serious game that fits the context of the case study area. The ideas were gathered from past studies, through the ARDI approach, and conducting community discussions with communities in three sub-catchments. Game testing sessions are described in sub-section 2.3, where feedback was key to help in refining the final game.

Revisions made in the manuscript:

To guide the reader on understanding this stage of game conceptualization, we have revised the manuscript by adding the opening sentence as follows (see Ln 248-249):

.....This stage involved gathering all possible ideas, to help in drafting a serious game that mimics the context of the case study area.....

Comment 4: Data collection (Section 2.4) is there after the step 'modeling the game solution space' not also a step where you collect data about discussion and feed-back, which might result in adjustments of positions and solutions .? As it is an interactive process, it is collecting data and providing data, right? (so feed-back, and giving space for learning)? Thank you for the questions.

Response: The data collection description in sub-section 2.4 focussed on data collection based on the final ENGAGE game_v1 described in Box 1 and Supplement 1. To ensure comparability of data across different game sessions, no further adjustment was made and v1 of the game was maintained (as developed) in the three sub-catchments. Yes, there is a feedback session at the end of playing the games, where participants are allowed to give their feedback and key lessons on the game sessions. The qualitative feedback was useful in crafting some of the reflections included in the discussion section e.g. in **Ln 638** ... *the game environment allows for real-time reflection through the creation of a fictional setting and a common pool for the stakeholders to explore decisions and impacts simultaneously'*.....in **Ln 654***'each participant in the game has a role to play, they have a stake during the game. They tend to be active in pursuing their stake while focusing on their roles'*.....

Revisions made in the manuscript:

We have revised the manuscript by adding the following sentence (see Ln 357-360):
....At the end of each game sessions, post-game feedback sessions were also conducted where participants were allowed to give their feedback and key lessons on the game sessions. This qualitative feedback was useful in understanding participants perceptions and reflections, which were critical in qualitatively discussing the game results of this study....

Comment 5: An important discussion point you touch upon is how the game results translate to real life situation (line 560 and further). I wondered was this discussed in the sessions, at the end? How the game was valued, also for real-life? That could already give some initial insights? [Thank you for the questions.](#)

Response: Yes, a conversation on translating game experience to real-life situations was a key discussion point at the end of the game sessions. There was high positivity on the usefulness of the gaming approach in promoting sustainable behaviors, and all game participants indicated they would adopt a few lessons from the game. However, this manuscript recommends further follow-ups to assess the impact of serious games on strengthening stakeholders' engagement and maintaining sustainable behaviors in real life.

Revisions made in the manuscript:

We have revised the manuscript as indicated below (see Ln 672-675):

....Whether the results realized in a gaming environment could impact reality is still unclear. Post-game discussion revealed positivity on the usefulness of the gaming approach in promoting sustainable behaviors, where game participants indicated willingness to adopt a few lessons from the game. However, it may require more game sessions and long-term studies to assess the impact of serious games on strengthening stakeholders' engagement and maintaining sustainable behaviors in real life....

Reviewer 2: Comment by Jean-Philippe Venot

This is a paper that investigates the use of a serious game to discuss issues of water management at watershed level in Kenya. I enjoyed reading the paper; a lot of work has gone into the design, implementation and analyze of the research. I think this type of paper reflecting on the use and scope of such participatory approaches for improving water governance is important.

That being said, I feel the paper shares what I see as a bias in the existing literature on games for sustainable natural resources management, that is, a rather positive outlook on the changes/transformations these games may trigger and a focus on their promises and potentials – that is only partly supported by what is actually described in the papers (that is what happens during “game sessions” as opposed to “in the real world”).

Response: *Dear referee, thank you for the acknowledgment of the relevance of our research exploring the potential of participatory approaches such as serious games for improving water resources management and governance. We plan to address your major five comments and specific comments as shown below:*

(1) MAJOR COMMENT 1: Better clarify how the process they steared was fundamentally different (or not) from other more classic participatory approaches notably in relation to co-production of the tool (as opposed to a contrasting active game with passive attendance to workshop).

Line 66 and following: The authors attribute some of the shortcomings of IWRM to the fact that IWRM projects and policies make use of “classic” participatory approaches that would not really allow different actors to engage with the “wicked problem” at hand. In other words, participation in IWRM is not real participation. This is a well-known critique of IWRM, which I share in part, but I think there is a danger of building a strawman for the wrong reasons here, just to make the point that games do not share these shortcomings. I agree when the authors answer the previous community reviewer that games allow a different, more active, mode of engagement than classic workshop based that use power point presentation. But there are many ways to conduct workshop that can provide meaningful engagement of participants: participatory mapping, experimentation with art-based visual, etc. are some of these options.

I think the issue is less about the modalities of facilitation of workshops (and the tools used) than how multiplicity of knowledge is handled and how/who decides on the terms of the debate. Notably, who ends up deciding what the ‘wicked problem’ is. Games can actually reify the ‘wicked problem’ on the basis of an outsider/expert view; if so I would argue that the nature of engagement of participants remains as limited as in other approach or at least is constrained in major ways.

What bothers me is that the phrasing of this paragraph (and many others) seems to indicate that the authors hold the view that there is ONE “wicked problem” (likely a lack of coordination between downstream and upstream users). It makes it seem as if this problem existed almost independently of the people who participate, being identified à priori by a subset of actors (though there is scope for refining the problem at hand through the use of the game itself). If that is the case, then, the game developed is likely to have very similar shortcomings than “classic” IWRM based approach.

I think the critique of IWRM approaches would be more powerful and convincing if it were to be done at the level of how are the terms of the debate/participation set and by whom (as opposed to looking at the specifics of interactions and their presumed passivity), and then to show, how this particular study did something different, hence created the room for another type of engagement by the people who participated in the game session. The point here is to pay a bit more attention to the politics that framed the entire research process and operated silently in the background as opposed to take the dynamism of the game sessions as a sign of pro-active engagement and changes to come in the watershed. The authors may want to look at <https://hess.copernicus.org/preprints/hess-2023-164/> currently under review in the same journal. This paper reflects on some of those issues around the practices of hydrological modeling not games, but I think there are many similarities.

I do not doubt the authors have done something quite different from “classic passive workshops”; my qualm is with the way authors describe the differences. Instead of making clear what the differences were, the way it is written points to fundamental similarities in the assumptions underlying the approach (which may not

have been there). I feel clarifying this point through some reformulation is important and would strengthen the argument of the paper.

Response: Thank you for the detailed comments. We agree with the referee that the lack of 'real participation' is a well-known critique on IWRM. We are happy to see the referee agreeing with our response to the community comment that serious gaming is a different, more active, mode of engagement than classic workshops. Interestingly, the reviewer also confirms that there are many ways of conducting workshops that can provide meaningful engagement of participants (particularly the inclusion of 'hands-on' interactive activities in the workshops e.g. participatory mapping, experimentation with art-based visuals, etc). This reaffirms our arguments on the need for 'hands-on interactive activities' in the conventional participatory approaches. And not just the inclusion of 'hands-on interactive activities', but those activities should yield results that can inform or indicate how people interact with their environment and opportunities for collectiveness and collaboration. The fact that there are no uniformity/standard ways of conducting participatory engagements in IWRM demonstrates the need to develop and evaluate different participatory approaches. Serious gaming is one of the possible strategies to be investigated more deeply given the growing complexity of human-environmental issues.

Given the context of the case study area, where there have been water-related conflicts annually (even fatal conflicts), and the fact that under normal circumstances, the downstream communities do not sit or see eye to eye with the upstream communities (**see Ln 534**); developing and testing an alternative participatory approach such as a serious game is timely. This is especially so since, the River Basin Organisations (i.e. WRUAs) in the case study area have been in existence for over 30 years now, and mostly the communities have been exposed to the conventional engagement approaches e.g. workshops, community discussions, group discussions etc (**See Ln 230**). And yet the situations are getting worse each year, with the national government 'reacting to calm the conflicts' but with no permanent solutions (**See Ln 239**).

In conventional engagement approaches for IWRM, the leading scientists have developed hydrological models that are presented to the stakeholders/participants to shape human-water discussions. Different scenarios can be tested and results presented during a workshop to allow deliberations on the way forward towards resilience. This in some way has a sense of 'top-down strategy'. In a serious gaming process, all stakeholders (scientists/non-scientists/ including low-educated) define the problems, priorities, and test scenarios themselves, and 'revise' their perceptions based on experiences from playing the game with less 'scientists' input'. Sometimes, the results from a gaming experience can be different from 'scientists' expectations as game participants bring 'reality into playing the game' as opposed to a 'stylized model'. During game sessions, it has been very common to hear stakeholders link game results to events in real life (e.g."oooh, could that be the reason, the river stopped flowing at point xxx"....."I see the reason why the rivers these days are brown these days compared to clean water we experienced during our primary school days, soil erosion from expanded cropland areas...". The involvement of catchment stakeholders right from game conceptualization to implementation, reverses the engagement to a 'bottom-up strategy'. The 'gamification' component is an important aspect, in our own opinion, any model can be 'gamified' to allow 'local stakeholders' to learn and understand the 'scientific models work (but scientists must be willing to 'unlearn' to 'learn'). It is this increased system understanding that can inform realistic catchment management plans.

Regarding the referee's comment that games can actually reify the 'wicked problem' on the basis of an outsider/expert view we argue is not the case with serious gaming. We argue that the outsider view is highly managed in the gaming sessions. (**See Ln 90**) The design of a serious game is an iterative process that evolves with the participative process whereby local stakeholders are actively involved in defining the 'wicked problem', and designing the questions, simulations, and outputs. During actual gameplay, the outsiders/experts are more 'facilitators' than the 'leads'. Hence the nature of engagement of participants is not as limited as in other conventional approaches e.g. workshops where scientists take the lead (see our responses to the community comment on this point).

We do not hold the view that there is ONE "wicked problem" in the case study area. We have actually defined what we mean by 'wicked problems' (**see Ln 47-51**). Just like any other modelling logic, the game tries to simplify the representation of the socio-environmental dynamics. We have stated that the ENGAGE game mimics the dynamics observed during the dry seasons in the upper Ewaso Ng'iro catchment. The downstream-upstream reactions result after the processes both in the socio and physical dynamics (it is not

just a lack of coordination between upstream and downstream communities, but an array of possibilities or outcomes that can be observed with serious games).

We agree with the referee's comment that the critique of IWRM approaches would be more powerful and convincing if it were to be done at the level of how are the terms of the debate/participation set and by whom and the politics that framed the entire research process. As mentioned earlier, the outsider has no exclusive power to dictate the process. We have revised the manuscript to make this important aspect of serious gaming. Right from the conceptualization of the game, the local stakeholders have been involved in defining the key actors, resources, dynamics, and interactions. And this is one of the ways that games differ from other conventional participatory approaches.

The pre-print shared by the referee [ter Horst et al. \(2023\)](#), actually re-affirms the politics around conventional approaches and modelling where the 'outsider' e.g. a hydrological scientist/modeler is the one defining the model components depending on the area of interest. This has been the norm for years, and conventional models have been used to shape discussions on water resources management and governance. It is very common to have presentations of model results e.g. during a workshop. Most of these models are 'black-boxed' and most of the specifics are left to the modelers. The opposite is true in serious gaming, the whole process is 'open' and defined in collaboration with stakeholders (scientists and non-scientists) at all stages, conceptualization, refining, and implementation. In other words, you cannot present or 'force' a game, that participants have no clue about or are not interested in (the game must mimic the real socio-environmental context of the targeted stakeholders).

We however recognize advanced game versions that go beyond a physical board game or use of cards into developing an Agent Based Model. ABMs can be helpful in understanding the 'system dynamics' through computer simulations, however, in situations where the interest is to explore ways of peaceful coexistence between worrying communities due to hydrological dynamics (i.e. strengthening engagements), the option of using 'real agents'/real participants in a 'safe environment' remains the better option since stakeholders can express their interests, concerns, test scenarios and explore possible way forwards. Therefore, investigating the potential of serious games in the context of strengthening stakeholders remains useful, which can be seen as advances in the field of water resources management and governance.

Revisions made in the manuscript:

We have revised the manuscript to make the case study context clearer. The following has text been included in the revised version (see Ln 224-226):

.....Violent conflicts exist between different water users at different levels: upstream versus downstream water users; competing irrigators; agro-pastoralists versus pastoralists; users versus authorities, environmentalists etc (Aarts, 2012; Ehrensperger & Kiteme, 2005).....

In addition, the following text has also been included in the revised manuscript (see Ln 244-246):

..... Given the context above and to explore possible alternatives to WRUA management styles (especially increasing stakeholder engagement), developing and testing an alternative participatory approach such as a serious gaming is timely.....

We have revised the text to expound our argument and also reflect more on serious games short comings, including a reflection on the politics around conventional modelling and gaming, and expound on 'black-boxed' and 'open' approaches (see additional text in the revised manuscript Ln 93-127).

(2) MAJOR COMMENT 2: They could also engage a bit more with the risks/limitations of games that have been discussed in the literature

Line 93 and following. The way to depicts serious games and what they can help achieve is overwhelmingly positive. I think this reflects rather well the existing literature on serious games, most of which is actually written by people involved in their design and implementation - which may make them a bit less likely to adopt a critical stance towards these tools. Yet, I think the authors could engage with some of the limits of games that have been discussed in the literature, notably by members of the ComMod collective they are

likely to know. There is some work in relation to conflicts and existing relations of domination (Barnaud & Van Paassen, 2013; Bécu et al., 2008; Mathevet et al., 2014), on the roles and postures of facilitators and modelers (Barreteau et al., 2003; Jonsson et al., 2007), or the risk of manipulation (Barnaud et al., 2008; Halbe et al., 2018). A recent overview recognizes “potential biases” (Barreteau et al., 2021). See also (Jonsson et al., 2007) on whether games are “truly participatory”. Also, the fact that games simplify complex problems (line 102) is presented as a positive thing (I suspect in relation to legibility of the said problem). This may be the case, but it also raises a lot of questions: who decides what is represented and what is not, what are the implications of those choices... In other words, what are the politics of the game itself? These questions ought to be at least mentioned I think.

Response: *Thank you for the comment. This observation on positive look on serious games was also raised by the first reviewer. I think the context of the study area where there are complex water-related tensions and conflicts, may have led to the language used sounding positive. Especially given that the River Basin Organisations have been in existence for over 30 years (engaging stakeholders using the conventional engagement approaches) and the passion for exploring alternatives to stakeholder engagement may sound overwhelmingly positive. We have revised the manuscript to include some of the limitations reported in the literature.*

Revisions made in the manuscript:

The following text has been added in the revised version (see Ln 103-125):

..... In their study, Flood et al. (2018) conducted a review of 43 serious gaming publications and identified the major shortcomings to effective game design and engagement as; one-off engagement (i.e. several game sessions are needed to enhance learning), capturing complexity without overwhelming the stakeholders, future planning (i.e. linking game results to plan an uncertain future). Serious games are also limited on the number of stakeholders who can be involved in a single game session, a constraint that raises the politics of who should attend the game(s) and why? (Wesselow and Stoll-Kleemann, 2018; Edmunds and Wollenberg, 2001). Studies have also reported that social differentiations and power asymmetries have greater influence on the outcomes of a participatory process (Barnaud and Van Paassen, 2013; Mathevet et al., 2014). Both the facilitators and the stakeholders have various degrees in which they can influence the participatory process (Jonsson et al., 2007). Serious gaming can also exacerbate the contests of power due to constraints of simplifying the complex real worlds, balancing the interests of the locals and the ‘outsiders’, and different perspectives of the present and future (Venot et al., 2022). A co-construction process also referred to as companion modelling approach where the designers and the participants collaborate to define the entire process is seen as a way to improve legitimacy of the participatory process and enhancing multi-stakeholder cooperation (Barnaud and Van Paassen, 2013; Barreteau et al., 2014; Basco-Carrera et al., 2018; Étienne, 2014). However, the companion modelling approach needs to be improved to clearly define the horizontal and vertical dialogues by involving all stakeholder at all levels (Barnaud et al., 2008). In general, the quality of participatory process depends on how biases and interests of all stakeholders, including ‘outsiders’ are balanced (Biggs et al., 2021; Daniell et al., 2010). As aforementioned, the politics that shape conventional processes (e.g. the influence of the ‘outsider’) are dealt with in the gaming approach through an iterative process that evolves with participatory modelling (Marini et al., 2018a; Speelman, 2014a; Speelman et al., 2019b; Rodela et al., 2019b; Barreteau et al., 2014). Hence, this study can be viewed to have done something different from the conventional participatory approaches (such as workshops, where ‘outsiders’ dictate the process) by creating a different type of collaborative engagement and a ‘safe environment’ for stakeholders.....

In relation to the question of who decides what is represented and what is not, we have revised the manuscript by adding the following (see Ln 93-102):

.....Compared to the conventional approaches and modelling, where the ‘outsiders’ (e.g. hydrological modellers and scientists) define the model components depending on the area of interest (Babel et al., 2019; Mayer et al., 2017), the ‘outsiders’ have no exclusive power to dictate the serious game components. While the conventional models are ‘black-boxed’ (Kouw, 2016; Melsen, 2022), the gaming process is ‘open’ and defined in collaboration with stakeholders (scientists and non-scientists) at all stages, from game conceptualization, game refining, to game implementation. This is one of major differences how serious gaming approach differs from other conventional participatory approaches such as workshops. There are different ways to increase engagement of participants during workshops, such as participatory mapping,

experimentation with art-based visuals, etc, however, these cannot be viewed as collaborative modelling. Basco-Carrera et al. (2017), attempts to differentiate what can be considered as 'participatory modelling' and 'collaborative modelling'....

(3) MAJOR COMMENT 3: Provide a bit more information on the methodology (including the link between the game and the computer model)

I feel there is a need to clarify the methodology. Notably, in the first paragraph it is not clear to me what the "solution space" of the game (what are 'responses' to rules?). It is also not clear what the authors mean by "overall performance of the game results" (how is performance assessed, is it in relation to water availability/sharing? In relation to how active participation was...)? In relation to that, section 2.4.3 discusses a modeling of the 'game solution space' and mentions a 1000 runs but what are those runs? I assume the authors used both a physical game and a computer version of it and that they used the later a 1000 times generating random actions; this to situate the results of the specific game sessions in the "realm of possible". But I can only assume this: the relations between game and model need to be made explicit and the authors need to explain, why the use of the model was useful, what did it allow to do?

Response: Thank you for the comment. In Ln 366 we have described the Solution Space asan envelope within which ENGAGE games operate, by understanding the minimum and maximum values of the various game metrics.....(i.e. the space of minimum to maximum of game results). The 'overall performance' mentioned in Ln 177, refers to actual game results plotted within the Solution Space. In other words, the general trends observed in the different rounds of the game. The solution space was constructed within a system dynamics modelling environment by a total of 1000 runs. Hence, this should not be seen as an independent computer model version.

Revisions made in the manuscript:

We have revised the manuscript to give a clarity on what we refer to as Solution space (see Ln 175-179):

...The solution space of the board game elements was developed to determine the realm of possibilities of participant choices in the ENGAGE game. The possible ranges (the minimum and maximum limits of game results) were explored in the modeled solution space. The overall performance of the game was assessed by plotting the actual game results within the solution space....

(4) MAJOR COMMENT 4: The mechanics of the game in the core of the paper (fez readers are likely to read the supplementary material)

A lot of key information on the mechanics of the game (including how the connections between actors and water flows are conceptualized) are included in the supplementary material. I think only few readers are likely to read the supplementary material and it might be a good idea if the authors extended the presentation of the game in the core of the paper slightly. I'm also not sure the game should be presented in a "box". Normal section numbering would do. In terms of presenting the game, I think it would be interesting to have a sub-section describing the board and the players, another one describing briefly the different action/decision each actor can make and how this impact water flows (at a conceptual level; not entering in the details of the calibration), and another one on the "typical" process followed during each session - this is already in large part in the box. I think the graph on the system dynamic modeling could support this presentation of the game, as opposed to be presented in relation to the "solution space" of the game. The supplementary file can then focus on the calibration aspect. Presenting the game as such would also allow having part of the discussion engaging with the key stage of game validation that is not really described at the moment (what hypothesis the authors made were validated, which one were not...? for instance deciding that water dries up from downstream when people abstract water from upstream is a strong choice. I would be curious to know if that triggered some discussion also because, materially, it involves taking a marble from one area of the board to put it in the other one, which is not really how water abstraction works in the real world.)

Revisions made in the manuscript:

Thank you for the comment. We have revised the manuscript by repackaging the information in the Box 1 into the following sub-headings (see Ln 261-315):

Gameplay description and process

- 1.1. Description of Boardgame and players
- 1.2. Game mechanics
- 1.3. Key actions and key outcomes expected in the game
- 1.4. Potential impact on water resources availability
- 1.5. Possible reactions expected by actors and feedback

Regarding the comment on validation, this is described in **sub-section 2.3 (Game pre-testing and validation)**. The type of validation described here is 'expert-based validation type' where the catchment stakeholders are involved to reinforce trust, ownership, and confirm the processes and game outcomes and assumptions made (i.e. legitimacy, credibility and salience of the ENGAGE game). The validation did not take the conventional route of testing hypothesis but collaboratively testing and refining the game to fit the context and interests of the targeted stakeholders.

- (5) **MAJOR COMMENT 5: Finally not only discuss the fact that the game seem to have enhanced communication among participants and their promises in general, but also issues related to the politics of the game themselves, that is, the extent to which the representation of the system was accepted/validated/discussed by participants and the scope for the game to change the broader rules of the game and conditions of operation of the WRUAs.**

The discussion focuses on what has happened during the game session and it is important. The game sessions are likely to have improved communication and cross learning among participants but to which extent did it actually provide ways to solve the structural issues faced by WRUA that are identified in line 188 (weak enforcement of policies/laws, water abstraction regulations, water metering requirements, protection of riparian corridors/forested areas, etc.)? Such structural issues are likely to relate to the institutional strength of the WUAs, how legitimate it is vis-à-vis other actors, the (human) and financial means it has... Even if it is not the objective of this paper to assess the scope of the game to change things in the real world, I think it is important for the authors to engage in a discussion around the promises and potential of games in relation to these structural hurdles.

Most of the literature on games tend to focus on the design process and on what is happening during game sessions, and that's why most of the literature is positive: there is a lot of interesting things happening, some of which do have transformative potential. But in doing so, the game and the overall research process is also "removed" from the overall political-economic context in which it is implemented while this context is pivotal for the promises of the game to actually materialize or not. While describing the overall political-economy that influences water management in the case study area is beyond the scope of this paper, I think it is important the authors reflect a bit on it and how this might influence the future of the game outcomes - to avoid falling in the trap of highlighting promises that may never materialize.

Revisions made in the manuscript:

We have revised the discussion to reflect more on these. See the added sentences below (Ln 564-570):

.....The WRUAs have been in existence for over 30 years employing conventional participatory approaches to engage catchment stakeholders, especially in minimizing human-water related tensions and conflicts. This study shows that the first two 'issue cycle' steps, agenda setting (acknowledging that there is a problem) and shared understanding of its causes and consequences, were readily addressed by the game in all three game sessions. As an alternative to existing conventional approaches, WRUAs can readily adopt the ENGAGE approach to engage catchment stakeholders in minimizing conflicts, promoting collectiveness and dialogues through active participation, increase knowledge on human-water interactions. The next steps on commitment to goals and means of implementation would depend on the way the game is part of a longer-term process of interactions....

I also have some specific comments:

Line 21 (Abstract): What do the authors mean by "shared understanding", and understanding of what exactly? Could it be clarified?

Response: Thank you for the comment. The sentence have revised as follows:

...Lack of common understanding on human-water perspectives by catchment stakeholders increase the complexity of human-water issues at the river catchment scale.....

Line 27 (abstract): This sentence seems to point to the fact that the objective of the study was to assess the potential of the game to strengthen stakeholder engagement "next" (that is, after the game sessions were held). I do not think the paper demonstrates this. It demonstrates rather convincingly that there was active engagement during the game session but does not engage with whether or not this translated in strengthened engagement outside of the game session. I understand from the exchange with the community member who commented on the paper that this is not the point of this particular paper but then, maybe this sentence needs to be rephrased to indicate that what is being described in the dynamics of engagement during gaming session. Similarly, some clarity may be needed on line 125.

Response: Thank you for the comment. In this study, we did not design to have comparisons e.g. comparing engagements with and without gaming sessions. Rather, we focussed on engagement patterns observed during gameplay given the context described in the paper and in the above responses. In this paper we did not follow up the engagements outside the game environment, but three pilot game sessions provide important highlights that can help reflect on the potential of using serious gaming as an alternative approach to stakeholder engagement, given the context especially the use of conventional participatory approaches that have been in existence for over 30 years.

We have revised the text to read as follows:

...The purpose of this study was to explore the potential role of serious gaming in subsequent steps of strengthening stakeholder engagement (agenda setting, shared understanding, commitment to collective action, and means of implementation) explored within a game environment toward addressing complex human-water-related challenges at the catchment scale.....

Line 47. The term "wicked problems" was first coined by Horst Rittel and Melvin Webber in a 1973 paper, which would be good to mention.

Response: Thank you for the comment. This reference has been included in the revised version.

Line 54 to 56: It is not clear how the 5 interacting phases of public debate had a bearing on the research conducted. Why do the authors refer to this work, and how useful is it to understand the process of designing and implementing game sessions? This is clarified around line 95. Consider slight restructuring on when this is mentioned so as to avoid repetitions?

Response: Thank you for the comment. We have revised the sentence to give a clarity that there are five stages in engaging stakeholders in natural resource management as follows:

....Five interacting phases in the public debate on engaging stakeholders in natural resource management were identified as (a) agenda setting, (b) shared understanding, (c) commitment to goals, (d) means of implementation, and (e) re-evaluation based on monitoring....

Line 58 and following: I would not call IWRM an "approach". In my view it consists rather in a policy and discursive model than an approach per se.

Response: Thank you for the comment. We have replaced "approach" with "process"

Line 63: can the authors briefly say what successes were actually achieved? In what terms was implementation successful and in which contexts?

Response: Thank you for the comment. We have revised the sentence to include the successes mentioned in literature as follows:

Line 107: improved efficiency of what?

Response: Thank you for the comment. This has been revised to improved efficiency of strategies

Line 101: what does "this" relate to?

Response: Thank you for the comment. I do not see 'this' in **Ln 101**, could you be referring to **Ln 112**? If this is the case, 'this' relates to 'studying communication patterns'.... The phrase has been revised accordingly.

Line 112 and following: I am not sure what those sentences are meant to bring to the paper. They look as quite general statements in relation to games (what others have said on games), but it is not clear how much of this is actually being used in this particular study. Maybe they do not belong here but should come earlier in the paragraph? I have a similar remark on communication: are the two sentences on that specific topic meant to discuss game "in general" or has this topic of communication during game played been a specific entry point of analysis of what has happened in the game session organized in this study?

Response: Thank you for the comment. The sentences appear immediately after describing the importance of 'communication analysis' especially during engagement sessions. These sentences are important to reflect on in the introduction section because, during communication/engagements this could be in line with relational logic (value attached on how stakeholders relate to one another) or instrumental aspects (economic perspectives) or both. Furthermore, it would also be important to study communication patterns and emerging patterns by looking further into 'pressures' or 'external factors' influencing changes in strategies and decisions made by participants. For instance ' a participant revising strategies due to a government fine. Yes, the communication analyses focussed on what happened during game sessions.

We have revised the sentences as follows (see Ln 144-157):

.....Communication is one of the social parameters that enable the manifestation of a group strategy, improved efficiency of strategies, and better decision-making (references). In a serious gaming environment, communication during gameplay is a key factor influencing game outcomes (references). Hence, studying communication patterns during gameplay can help evaluate the stakeholders' engagement and interpret emergent game results. This contributes to the body of knowledge on using the serious gaming approach as an 'alternative tool' to addressing complex 'wicked' problems. Studying communication patterns can help study relational logic (value attached on how stakeholders relate to one another) or instrumental aspects (economic perspectives) or both (references). In addition, games can explore multiple levels of internalization of external impacts of individual decisions, based on rules, economic incentives, co-investment, peer pressure to reduce one's footprint, or genuine concerns for impacts on others (references). Games can pose a challenge to the players who remain selfish as long as they only consider their direct interests, but emergent collective action can bring new solutions.....

Line 132: what do the authors mean by "sentiment" and how did they assess it. What do they mean by "active" participation and how was it assessed.

Response: Thank you for the comment. Sentiments refers to 'verbalized statements' expressed during gameplay. As stated in **Ln 195**.... The game sessions were video recorded to allow post-game analysis of sentiments. Each of the extracted sentiment/statement was subjected to a scoring scale described in **Table 1**. Active participation refers to 'enhanced communication among participants'-which was assessed by analysing the type and direction of sentiments e.g. directed to other participants, to the facilitator or as a spontaneous reaction to game outcomes.

We have added the word 'verbalized' to read as "verbalized sentiments"

Line 145 and following: why does the discussion focuses on "substractive dynamics" only and not on "constructive dynamics"?

Response: Thank you for the comment. It is not very clear what the referee means with only focussing on 'substractive dynamics'. **Ln 145** is an extended description of 'counterfactual thinking' concept. For instance, conflicts and tensions would trigger thoughts about alternatives to these problems. If that is the case, then it is logical to assume that substractive dynamics such as selfishness, tensions, conflicts would reduce with the build-up of constructive dynamics such as knowledge gain, collectiveness, cooperation, collaboration

etc. We have not only focussed on subtractive dynamics, if you look at **figures 7 and 8**, we describe and discuss both subtractive and constructive dynamics.

Line 160 and following: how many WRUA are there in the sub basin/case study area? One for each sub-river?

Response: Thank you for the comment. There are seven WRUAS in the selected study area. Yes, one WRUA represent one sub-river area.

Line 177 and following: This points to my first major comment. How was this suite of problems identified and by whom? And more specifically, have the people who participated to the game sessions been involved in the definition of these problems. This needs to be clarified as it is largely from this that one can assess to which extent the process followed is fundamentally different from classic "participatory activities" implemented under IWRM processes.

Response: Thank you for the comment. These comment has been addressed while responding to major comment no. 1. Yes, the catchment stakeholders were involved in definition of game components, refining of rules and processes that would increase interest in playing the ENGAGE game. However, it is important to point out that the actual participants involved in the three pilot game sessions were different from those involved in conceptualization of the game. As the referee mentions in this comment, this is one of the aspects why serious gaming approach differs from other conventional workshops where the 'scientists' seem to take full control. In gaming concept, the 'scientists' play the role of 'facilitators' (from game conceptualization to actual implementation).