A Summary of Revisions and Responses on "From scenario to roadmap: A web-based participatory watershed planning system for optimizing multistage implementation plans of management practice scenario under stepwise investment" (Manuscript JEMA-D-23-01828)

With regards to comments from Reviewer #1:

1. ***"This article proposes a web-based participatory planning system for optimizing a multistage implementation plan that can assist decision-making in watershed planning, but it reads more like a manual for information software than the literature on environmental management."***

   Thanks for the reviewer's comment. This manuscript focuses on the actual watershed management needs for multistage BMP implementation plans (the so-called BMP roadmap in this manuscript), considering realistic conditions such as investment constraints that involve multiple stakeholders. We concluded through the literature review on BMP scenario optimization methods that the state-of-art method could optimize BMP roadmaps from a specific BMP spatial scenario considering stepwise investment. However, the implementation and application of this method are over-specialized and complex for non-expert stakeholders to participate in. Therefore, this manuscript aims to design a web-based participatory system to assist various stakeholders in proposing investment constraints, analyzing and electing optimized roadmaps, and reaching the final consensus. The system design was implemented and demonstrated in an agricultural watershed planning case study for soil erosion reduction. The multi-stakeholder role-play experiment showed the effectiveness and practicality of this system design.

   Therefore, the main contribution of this manuscript is proposing the design of a user-friendly web-based participatory watershed planning system to assist diverse stakeholders in proposing stepwise investment plans and discussing and reaching agreed-upon roadmap(s). The system design is flexible and easy to implement for other case studies with different watershed management contexts.

   To clarify the main contribution and avoid unnecessary technical descriptions, we revised this manuscript thoroughly following the writing logic structure of "actual watershed management demands—system design—a case study with system implementation and role-play experiment—conclusion." Main revisions are outlined below:

   (1) We revised and expanded the abstract to clarify the above logic.

   (2) We reorganized the Introduction Section to focus on the issue to be solved in this manuscript, i.e., the state-of-art BMP scenario optimization method can address actual watershed management needs for multistage implementation plans but is over-specified and complex for non-expert stakeholders to participate in.

(3) We condensed the Basic idea and overall design Section to clearly state the basic idea of the system design that separates the easy-to-use interface for the participation of stakeholders with different educational backgrounds and diverse roles from the specialized modeling process of the simulation-optimization method.

(4) We revised the title of Section 3 to "Case study of an agricultural watershed planning system for mitigating soil erosion" to clarify this is an example implementation of the proposed system design. We also condensed Section 3 by removing some unnecessary detailed technical descriptions.

(5) We revised the Experimental design and evaluation Section to clarify this is a multi-stakeholder role-play experiment based on the analysis of three groups of stakeholders related to the investment in actual watershed management. Section 4.2.3 "Effects of other essential design" has been revised as Section 4.3 "Evaluation of the designed and implemented watershed planning system" for an overall qualitative evaluation of the system from stakeholder-, model-, and system-oriented perspectives.

2. ***"This article uses a case study of decision-making for soil erosion control in a small agricultural watershed as an example. Still, it is not necessary because such a case is too simple. The readers would wonder why such decision-making information support and network information sharing are required. The authors should let us realize the necessity of using such a decision-making system in a realistic policy-forming mechanism."***

Thanks for the reviewer's comment. As stated in the response to the reviewer's first comment, this manuscript designed a participatory watershed planning system for agreed-upon roadmaps and implemented in the Youwuzhen watershed case study for mitigating soil erosion. The multi-stakeholder role-play experimental design was based on the analysis of three groups of stakeholders related to the investment in actual watershed management, i.e., government, enterprise, and other stakeholders (e.g., citizens).

The system design and case study in this manuscript are based on the realistic policy-forming demands as illustrated in the Introduction and Basic idea and overall design Sections. For example, (1) the actual watershed management needs to find optimal multistage BMP implementation plans that requires the participation of multi-stakeholders; (2) the state-of-art BMP scenario optimization method can address this optimization issue but is hard for non-expert stakeholders to participate; (3) the web-based application has no barrier to entry for stakeholders with different educational backgrounds; (4) different stakeholders have diverse standpoints in proposing stepwise investment constraints; (5) different investment constraints could derive different optimal solutions for discussing.

Therefore, the case study with example implementation of the proposed system design and the role-play experiment in this manuscript are essential. We revised this manuscript thoroughly to show the above idea more clear for readers.

3. ***"The participatory watershed planning system proposed in this article is very suitable as a platform for distance learning of environmental management-related courses. Under the teacher's guidance, students can present decision-making thinking based on the***

simulations from this system, which can become excellent case studies for educational research papers but less impressive contributions as papers in environmental management."

Thanks for the reviewer's comment. This study was motivated by the actual watershed management demands for multistage BMP implementation plans (i.e., BMP roadmaps used in this manuscript). Such a roadmap should reflect the compromise between multiple potentially conflicting objectives, which make it a multi-objective optimization problem. To solve this problem, the specialized BMP scenario optimization method is required. The optimized results are affected by various proposals of multi-stakeholders such as stepwise investment constraints. Therefore, a user-friendly watershed planning system is essential to assist the participation of stakeholders and facilitate effective decision-making process.

Therefore, this manuscript provided a new decision support perspective for the field of developing successful environmental decision support systems. Meanwhile, as the reviewer mentioned, the proposed system is also a suitable platform for inspiring the simulation-and-optimization-based decision-making thinking of those students who take environmental management-related courses. We have added this sentence in the end of the second paragraph of the Conclusions and future works Section.

Please also refer to the response to the reviewer's first comment for detailed revisions made in the revised manuscript.

4. ***"This research adopts a multistage BMP implementation plan for decision-making of optimization. However, as we see, the content is only a scenario exercise of information simulation and lacks a test evaluation for potential users. So far, the existing research content needs to convince us of the practicability of this information system."***

Thanks for the reviewer's comment. We have made some essential revisions on this manuscript to highlight the three roles of stakeholders involved in planning multistage BMP implementation plans and the role-play experimental design for verifying the effectiveness and practicality of the system.

(1) We considered three stakeholder roles: investors, economic beneficiaries, and environmental beneficiaries and designed three groups to conduct the role-play experiment, i.e., the government stakeholder, the enterprise stakeholder, and the other stakeholders. See details on Section 2.5 "Stakeholder roles designed in participatory planning."

(2) We highlighted the positions of different stakeholders in proposing investment plans in the Section 4.1 "Experimental design."

(3) We revised the Section 4.2 "Experimental results and discussions" to clarify the effectiveness of the system from different perspectives, e.g., the progressive shifts in the optimized roadmaps from the three round optimizations by different stakeholder groups.

(4) We added the Section 4.3 "Evaluation of the designed and implemented watershed planning system" to qualitatively evaluate the practicality of the system from stakeholder-, model-, and system-oriented perspectives.

The system design and implementation proposed in this study can be regarded as a prototype system to facilitate the development and practical use of more comprehensive decision support systems.

5. ***"The authors should conduct a systematic analysis of this information system to analyze which parts are necessary and which parts must be adjusted according to environmental management needs so that readers can refer to their research."***

   Thanks for the reviewer's comment. We added Section 4.3 "Evaluation of the designed and implemented watershed planning system" to conduct qualitative evaluations of the proposed system from stakeholder-, model-, and system-oriented perspectives. We also added the development suggestions for applying this system design to other case studies with different watershed management contexts (see the last paragraph of Section 4.3): "When applied to other case studies with different watershed management contexts, except for the basic structure of the system including the encapsulated roadmap optimization suite on the back end and the user-friendly interactive workflow and spatialtemporal data visualization, many details of the system implementation can be adjusted by developers. For example, watershed management goals and the accordingly customized multi-objective optimization tool (e.g., Kumeda et al., 2021) and the watershed model (e.g., SWAT model), and selected BMPs and their representation in the watershed model."

With regards to comments from Reviewer #5:

1. ***"New contributions in field of optimization technique aren't clear."***

   Thanks for the reviewer's comment. The main contribution of this manuscript is proposing the design of a user-friendly web-based participatory watershed planning system to assist diverse stakeholders in proposing stepwise investment plans and discussing and reaching agreed-upon roadmap(s). The system integrates the state-of-art BMP roadmap optimization method proposed by Shen et al. (under review), in which the multi-objective optimization tool (i.e., NSGA-II) was introduced and customized for optimizing BMP roadmaps. By considering the spatial and non-spatial constraints summarized from actual environment management problems, the results generated by the optimization algorithm have more geographical meaning and practical value for decision-making. This contribution can be regarded as a novel application of optimization algorithms within a specific discipline, which is detailed explained in Shen et al. (under review) and beyond the scope of this manuscript. The system design has high flexibility in implementation. The watershed model and multi-objective optimization tool in the optimization suite can be replaced with components with similar functionality. Please refer to our responses to the first comment of the first reviewer.

   Besides, to avoid misunderstanding, we have revised the manuscript to use "BMP roadmap/scenario optimization method/suite" instead of "optimization method/suite."

2. ***"Highlights are weak. Graphical abstract needs to improve."***

   Thanks for the reviewer's comment. We rewrote the highlights to clarify the actual watershed management need being unmet by existing systems, the basic idea of system design, and the experimental design and result. The new highlights are as below.

   - System design meets practical watershed management needs for agreed-upon roadmaps
   - System separates easy-to-use interface for non-expert users from specialized models
   - Browser/Server system facilitates participatory processes of multiple stakeholders
   - Users participate in proposing investment plans and electing optimized roadmaps
   - Multi-stakeholder role-play experiment verifies system's validity and practicality

   We redrew the graphical abstract to clearly represent the new highlights.

3. ***"Abstract has to rewrite by focusing on new results."***

   Thanks for the reviewer's comment. We revised the abstract to clarify the logic structure of "actual watershed management demands—system design—a case study with system implementation and role-play experiment—conclusion."

4. ***"Introduction shall modify. Authors didn't explain benefit of optimization process. No indication to competitive methods of optimization techniques. I propose to see reference: "A hybrid optimization framework for road traffic accident data", International Journal of Crashworthiness. Taylor&Francis, Vol.24, No.6, 2019."***

   As responded to the first comment of the reviewer, the proposed system integrates the state-of-art BMP roadmap optimization method proposed by Shen et al. (under review), in which the multi-objective optimization tool (i.e., NSGA-II) was introduced and customized for optimizing BMP roadmaps. The aim of this study is to assist multi-stakeholders in participating the optimization process of roadmaps by proposing diverse investment constraints. The specific multi-objective optimization tool adopted by the professional modelers is beyond the scope of this manuscript.

   The reference provided by the reviewer can offer an alternative selection of multi-objective optimization tools when implementing the proposed system design. We added it as a reference and cited it in the last paragraph of Section 4.3.

   Besides, we also reorganized the Introduction Section to focus on the issue to be solved in this manuscript, i.e., the state-of-art BMP scenario optimization method can address actual watershed management needs for multistage implementation plans but is over-specified and complex for non-expert stakeholders to participate in. Please refer to our responses to the first comment of the first reviewer.

5. ***Section 2.3 is weak. Fig.4 needs to improve.***

   We rewrote Section 2.3 "Integrating BMP roadmap optimization method" to briefly introduce the flowchart (Figure 1a) of the newly proposed BMP roadmap optimization method. More details about the method design and implementation can refer to Shen et al. (under review), which has been submitted to *Water Resources Research* and is now waiting for Editor decision after a minor revision. The submitted version of Shen et al. (under review) can be download at https://1drv.ms/b/s!ArlCdI5ItU72_HH86kJ1U9-Dmtgg?e=0DqGPA.

   We redrew Figure 4 and modified Figure 2 to make it easier to understand the corresponding relationship between specific technical selections and conceptual design.

6. ***Formulating of optimization problems shall explain.***

   Thanks for the reviewer's comment. We have added formulas (4) and (5) to explain the optimization problem. More details can be found in Shen et al. (under review).

7. ***Fig.5 isn't clear. Fig.6 is unmeaning.***

   Thanks for the reviewer's comment. Figure 5 is a screenshot and rearrangement of the web page of the front-end user interface of the implementation system in the case study. We have modified the layout of Figure 5 to express the main functionality of the graphical interfaces as much as possible. The system can be visited via http://easygeoc.net:9091/.

The original Figure 6 shows the spatial location of the study area and the topographical information, which can be integrated with Figure 7. Hence, current manuscript integrated Figure 7 into Figure 6.

8. ***Discussion of Fig.8 has conflicted conclusions.***

   Thanks for the reviewer's comment. We wrote in the analysis of the third-round optimization "… the roadmaps in the first two rounds demonstrates that roadmaps with higher investment in the first year usually have higher environmental effectiveness… The reason for reducing investment in the fourth instead of the fifth year is to implement the prominent BMP, ABHMP, in the fifth year, which will produce better comprehensive effectiveness." that maybe mislead the readers as two conflicted conclusions. In fact, these two conclusions are not contradictory. We revised the second result as "The exploratory analysis of the previous results showed that among roadmaps with similar investment plans in the first three years, a higher investment in the fifth year than the fourth year often results in a slightly higher soil erosion reduction rate." in the first sentence of the fourth paragraph of Section 4.2.1. The differences in the environmental effectiveness of optimized roadmaps can be explained by the environmental and economic data of selected BMPs. We discussed this in the third paragraph of Section 4.2.2.

9. ***Fig.9: No validation for optimal results.***

   The Pareto fronts of the three round optimizations (Figure 8; now Figure 7 in the revised manuscript) provided the improvements of optimized roadmaps under the two objectives in a quantitively way. The spatio-temporal configuration maps, stepwise investments, and economic benefits of the three selected roadmaps among the potential area for agreed-upon roadmaps (Figure 9; now Figure 8 in the revised manuscript) presented the rationality and diversity in both qualitative and quantitively manner. For example, we discussed why the stepwise investment plans affected the environmental effectiveness of roadmaps in the last paragraph of Section 4.2.2. Stakeholders can explore the detailed information of each optimized roadmap. Through the comparison, stakeholders can reach a consensus that the roadmap #3 or similar roadmaps are more likely to become the final agreed-upon roadmap(s).

   The case study presented in this manuscript is a role-playing experiment that aims to verify the validity and practicality of this system. We hope this system can be used in practical watershed planning in the future to validate the optimal roadmap after actual implementation.

10. ***Conclusions shall rewrite by explanation of new contributions when compared with the previous works.***

    Thanks for the reviewer's comment. We rewrote the Conclusion Section to highlight the main contribution of this study, see the first paragraph of this Section. Besides, we have condensed this Section to avoid too many technical details.