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Dübendorf, 10. December 2021

Response to referee # 2 and editors

Dear Referee, dear Editors

Thank you very much for reviewing our manuscript:

Judit Lienert, Jafet Andersson, Daniel Hofmann, Francisco Silva Pinto, Martijn Kuller, "Can MCDA guide transdisciplinary endeavors? A framework applied to co-developing a flood forecasting system in West Africa". hess-2021-506

This manuscript was written for the HESS Special Issue **"Contributions of transdisciplinary approaches to hydrology and water resources management"**

We are grateful for the work that has gone into reviewing our paper. We do know that this takes a lot of time, which receives no direct reward. Your suggestions are very constructive and most welcome. We are very willing to improve the manuscript based on your inputs, wherever possible.

We have addressed your comments one-by-one below. *The referees' comments are given in Italics*, our response is given in normal font.

We have a general concern regarding coherence between the two referees. Referee # 1 asks for extending several parts (comments # 3 – 9). In contrast, referee # 2 has "major concerns regarding the text length" and proposes to "eliminate the unnecessary parts of the text so that the necessary ones can 'speak'" (e.g., comments # 3, 8, 27). At the same time, referee # 2 acknowledges that this paper contains a lot of information that could actually be presented in two separate papers (comment # 4).

We agree with referee # 2 that clarification and restructuring could be helpful to increase the papers' understandability and are willing to follow the concrete suggestions, e.g., to rewrite the Abstract and restructure the Introduction (e.g., comments # 3, 4, 5, 6, 8, 22, 26, 28).

Specifically, referee # 2 asks us to follow a traditional set-up for the Introduction (comments # 5, 6, 22, 26). We had not done this, because we are combining literature and research gaps from various fields and because we are following two main aims (as pointed out by referee # 2, comment # 4). However, we made a suggestion for restructuring, and kindly ask the **editors for advice; please see referee # 2, comment # 5**.

We emphasize that we do not wish to split the paper into two, because this was what we already had in an earlier version (focusing on the development of the flood forecasting system using MCDA). We think that the more holistic approach encompassing the

transdisciplinary framework and MCDA is beneficial and can raise broader interest, especially to readers that are not specialists (on MCDA and transdisciplinary projects).

Moreover, we propose to not add additional text, e.g., concerning an overview of different MCDA methods (see referee # 1, comment # 3; and referee # 2, comment # 9).

We are still uncertain how we can considerably shorten the paper. Reasons are:

a) The review of literature from transdisciplinary research and sustainability science, is needed as background information and for coming up with a framework.
b) Presenting MCDA is needed for readers of HESS that are likely unfamiliar with an MCDA process. We would not do this in such detail in a Decision Analysis journal. This includes a short review of MCDA in flood management, motivating a typical MCDA process, MCDA method explanations in the Methods section, and a brief overview of main MCDA results in the Results section. We kept this as short as sensibly possible, much additional information is given in the Supplementary Information. Several comments of referee # 1 indicate that more-detailed information of the MCDA method would be appreciated (comments # 3 – 7). We suggest to refrain from this for reasons of length.
c) The discussion is long, because we combine all these aspects. Especially section 4.3 “Suitability of the MCDA process for guiding large transdisciplinary projects (RQC)” is long. We can shorten it, of course, but this would probably make many insights difficult to understand, and we think that the explanations are needed to “add meat” to Table 4; the table was much appreciated by reviewer # 2 (comment # 34).

We kindly **ask the editors for a decision concerning length**, based on our explanations above. Is substantially reducing the length required? If yes, which sections would they want us to substantially shorten or delete?

Moreover, we kindly ask for advice, whether the **editors want us to follow a traditional approach for the Introduction**, which means taking apart the topics that belong to the transdisciplinary framework and those that belong to the MCDA (i.e., first we would present literature from TD research and MCDA, then the research questions, then methods from TD research and MCDA).

We much appreciate feedback. With best regards,

Judit Lienert

also on behalf of my co-authors, Jafet Andersson, Daniel Hofmann, Francisco Silva Pinto, and Martijn Kuller

Anonymous Referee # 2

***Citation**: https://doi.org/10.5194/hess-2021-506-RC2*

1) *In this interesting manuscript, the authors have conducted a brilliant participatory MCDA study. The topic is exciting and meaningful. Furthermore, the methodology applied is robust and innovative, and the final outputs are of good quality. The authors are thorough in their investigation (e.g. by conducting uncertainty analysis), which I really appreciate. The graphs and Figures produced summarize well the outcomes. In summary, the research conducted is outstanding.*

Response: Thank you very much for this very positive appreciation of our work.

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2) *However, the use of abbreviations for the different configurations of the FEWS system makes it very hard to follow.*

Response: We understand the issue. Please see details in comments # 7, # 30, # 31

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3) *Furthermore, I have some major concerns regarding the text length. It currently has 40 pages, which is too much. Because of that, the article currently lacks focus. Especially the abstract and introduction should be revised to reflect the work that was done. The ability to simplify means eliminating the unnecessary parts of the text so that the necessary ones can “speak”.*

Response: We very much appreciate this feedback. Since the paper contains many different aspects, it was difficult to keep the paper short; please see our comment to both referees and the editors in the letter above. We aimed to (a) provide a framework for analyzing MCDA by reviewing the literature from transdisciplinary research and sustainability science, (b) introduce readers not familiar with MCDA to an MCDA process and describe methods and results in sufficient detail; and (c) discuss these aspects, especially the suitability of the MCDA process for guiding large transdisciplinary projects (section 4.3).

Apparently, HESS does not have length limits; but simplifying is always a good idea. We will certainly follow the concrete suggestions wherever possible. We will re-write the Abstract and revise the Introduction. However, further length reduction requires probably means deleting larger parts of section 4.3 in the Discussion. We think that this might reduce the understandability, and kindly ask the editors for a decision (see above).

Main comments

4) *The abstract should be revised entirely. Currently, it is not possible to follow it due to vagueness. I understand that the authors have done some exciting research and want to show all of it. However, when reading it for the first time, I could not grasp what the paper was about. Please see the specific comments for details on how to improve it. In general, I would say your research has two main complementary goals: (1) the development of the FANFAR flood forecasting system using MCDA and problem structuring, and (2) analyzing the suitability of MCDA in transdisciplinary projects. These could even be two separate papers….*

Response: We will revise the Abstract and appreciate your specific comments. Despite the trend to increase the number of publications, we decided not to split the paper into two. We think the more holistic approach is beneficial and can raise broader interest, especially to

readers that are not specialists (on MCDA and transdisciplinary projects). Furthermore, we wish to point out that we added goal (2) specifically as a reaction to reviews of an earlier version of the paper, which focused on goal (1).

5) *The introduction follows a very fuzzy order that makes it harder for the readers to read. The authors come back and forth, which makes the text longer. I would suggest using the traditional "formula" for the introduction: (1) What is the problem? (2) Are there any existing solutions (i.e. in the literature)? (2) Which solution is the best? (4) What is its main limitation? (i.e. What gap am I hoping to fill?) (5) What is the goal of the paper. What do I hope to achieve?*

Response: Thank you for your suggestions. We fully understand the request, and we will consider restructuring the Introduction in the revisions according to a more traditional approach. However, as stated above, since we are combining literature and research gaps from various fields and because we are following two main aims (see your comment # 4), this might not increase the understandability. We suggest the following set-up, but if comprehensibility is not increased, we might need to follow another order:

- *We will first introduce the specific problem in West Africa (as is now): section 1.1 "Floods in West Africa".*
- *For better understandability, we think it is necessary to introduce the FANFAR project already here, which aims to address this problem in a transdisciplinary project (as is now): section 1.2 "The FANFAR project".*
- *Literature review, part (i) sustainability science and transdisciplinary research, because this type of large project in West Africa requires a transdisciplinary approach.*
- *Literature review, part (ii) MCDA, which can address the concrete problem of creating a flood forecast and alert system: section 2.2.1 "MCDA in flood risk research".*
- *Research gaps and research questions: section 1.3 "Aims, research questions" (we will address comment # 26 below regarding the sequence of research questions).*
- *Methods, part (i) framework for evaluating MCDA as transdisciplinary process: section 2.1.1 "Evaluation framework for transdisciplinary MCDA process*
- *Methods, part (ii) MCDA: sections 2.2.2 to 2.2.11.*

6) *Section 2.2 is, in general, very well written and is a good reference for PhD students. However, the authors mix review and their own methods. I suggest having it very clear when the review ends, and when your method starts. I recommend having a section called "2. Review" or something similar with the items 2.1 and 2.2. and a New section "3. Methods" starting on Line 230. It could be something titled "3.1 Proposed transdisciplinary MCDA" and then you should clarify that it is applied in FANFAIR.*

Response: We agree that it can be useful to bundle all literature in one section, including the MCDA literature in section 2.2.1. and the first part of section 2.2.2. We had not done this as we found it easier to follow "topics", i.e., sustainability science and transdisciplinary research, then MCDA. However, we are willing to re-group if you and the editors advise us to do so (see comment # 5, above).

7) *The coding system used for the objectives and configurations makes it very hard to read the paper. I suggest having real names instead of "a_fast.-dev" use "fast development".*

Response: We fully understand your concern. We used the coding system to avoid too long names in figures and tables. These would make especially figures unreadable. We tried to

find abbreviations that are understandable. Moreover, the letters a, b, c, … for system configurations, and the numbers 11, 12 etc. for objectives should guide readers. In comment # 30 you suggest to delete the "_". We used them for clarification, and are not sure that understanding is easier if removed. We will do our best to come up with better acronyms.

As compromise, we suggest (note: the suggestions make the paper longer):

- *Improve names of abbreviations in figures; but we probably need to keep abbreviations for reasons of length*
- *Remove "_" where possible without making abbreviations more difficult to understand*
- *Give longer names in the tables and possibly figure legends*
- *Alternatively, we could provide a new table with an overview of abbreviations*
- *We can certainly use the full names in the text.*

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8) In general, the text is too long to follow and read at once. It is, in most cases, easy to understand what the authors mean, so it is not a problem of the English, but of the length. The authors seem to have many ideas, but the text needs to be restructuredd to highlight what is more important.

Response: We will do our best to shorten the text and re-structure it. We are happy to follow concrete suggestions.

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9) I disagree with referee 2 that asks for a review of standard MCDA methods (there are several of these out there). On the other hand, I agree with referee 1 that the choice for the compensatory method should be clarified.

Response: Thank you for supporting a decision that we had made in an earlier version of this manuscript. For length reasons, and because we do not find it necessary, we will not introduce the many different possible MCDA methods. It would entail describing advantages and disadvantages of e.g., AHP, different outranking methods (PROMETHEE, ELECTREE, etc.), and newer approaches such as TOPSIS, additionally to MAVT/MAUT. We cite a classic textbook and a review paper from hydrology that both provide overviews of methods:

p. 8, line 208: "MCDA embraces various methodologies to support complex decisions (e.g., Belton & Stewart, 2002; de Brito & Evers, 2016)."

In the next sentence, we explain in-depth why we chose MCDA (points (i) to (vi)):

p. 8, line 209 – p. 9, line 225: "We chose MCDA, and specifically Multi-Attribute Value Theory (MAVT; Eisenführ et al., 2010; Keeney, 1982) for several reasons: (i) to develop a complex forecast system, many decisions had to be made. We needed to clarify, (…) thus reducing complexity and increasing transparency. For these reasons, we used MCDA to identify a "Good flood forecast and alert system" for West Africa."

We wish to emphasize that we did NOT choose a compensatory method. Rather, MAVT/MAUT is very flexible regarding the mathematical (aggregation) model. It is only fully compensatory if standard linear additive aggregation is used. We describe our non-additive, i.e., non-compensatory approach in the Methods section 2.2.9:

p. 14, line 383: "While easy to understand, the additive model entails strong assumptions, e.g., that objectives are preferentially independent (Eisenführ et al., 2010). Increasing evidence indicates that many stakeholders do not agree with model implications (Haag et al., 2019; Reichert et al., 2019; Zheng et al., 2016). Additive aggregation implies that good performance on one objective can fully compensate for poor performance on another. In the FANFAR weight elicitation sessions, we asked stakeholders (…)."

We agree with both reviewers that this was unclear. We will add this advantage to the **Introduction section 2.2.2, page 8:** MAVT/MAUT provides large flexibility in the mathematical model choice, including non-compensatory aggregation.

10) *In the conclusions section, the authors re-state many of the findings/discusssion, which was a bit repetitive. I suggest having some more "punching" conclusions.*

Response: We appreciate your feedback and will do our best.

Specific comments

11) *Line 11: it is not clear what is the „FANFAR system" here in the abstract. I suggest rephrasing to add "of the "FANFAR forecasting system". Perhaps you can use established acronyms such as FEWS to be more specific and avoid repetition/long sentences.*

Response: We will change this in the abstract and are willing to use the acronym "FEWS".

12) *Line 12: Again, it is not clear. Objectives of what? What are these configurations?*
13) *Line 15: "we investigated if problem structuring helps focus early technical system development." What is meant here? Early technical system?*
14) *Line 16: What is understood by "full" MCDA". What would a partial MCDA be? Please be more specific*
15) *Line 16: This last objective is a bit disconnected from the others. Hence, I would suggest rephrasing: "Thirdly, to support further research on xxxxx, we critically analyzed…"*
16) *Line 19: "MCDA met many requirements to achieve this framework" or something similar*

Response: Thank you for useful suggestion. We will consider all when rewriting the abstract.

17) *Line 27: projections of what? Of impacts? Of runoff quantities?*

Response: We will be more specific: "While the mechanisms and climate change projections remain uncertain for West Africa, there is growing evidence for increased frequency, magnitude, and impact of fluvial floods (Nka et al., 2015)."

18) *Line 30: I am not sure how meaningful is to add the information "double the number of 2019". Why is 2019 used as a reference? It would be more robust to have a comparison of the average the last 10 or 20 years.*

Response: We agree and will remove this information.

19) *Line 35: I suggest adding references to back up this sentence that there are problems in existing systems. These articles could be potentially relevant (please check in detail if relevant before citing):*
    - *https://www.sciencedirect.com/science/article/abs/pii/S2212420920312966*
    - *https://link.springer.com/article/10.1007/s11069-016-2537-0*
    - *https://onlinelibrary.wiley.com/doi/full/10.1111/jfr3.12664*

Response: We agree, will try to find references, and check the suggestions. Thank you!

20) *Line 43-53: If possible, I suggest cutting a bit of the text here, as the paper is already very long.*

Response: We are willing to shorten the description of the FANFAR project here.

21) *Line 54: Please start another line here*

Response: We can start a new paragraph here.

22) *Line 54 to 63: Here, you describe the methodology adopted, which, in my opinion, should be in the methods section. In the introduction you should rather focus on the problem at hand. Why it is important to address and how your proposed approach improves the status quo. The justification needed appears only later, in line 63. Perhaps you could invert the order? First the problem that exists and then how you want to address is. Also move parts of the text in lines 54 to the methods session.*

Response: We agree, will try to re-structure the Introduction following your suggestions, and move the suggested parts to the Methods section. Please see the general comments in the letter to editors and both referees, and response to comment # 5.

23) *Line 75. The aim of the project should be stated when you speak about the project in 1.1. Here, please focus on the aims of the paper.*

Response: We agree with this distinction. However, it is also an aim of the paper (i.e., of the actual MCDA) to find the best-performing FEWS configuration for West Africa. We will try to better disentangle project aims and paper aims in the revisions.

24) *Line 79-80. I would remove this sentence as it reads more as a project report than a scientific paper. Not sure how relevant this is*

Response: This statement leads to a research question. We think that it is important that "The IT specialists and hydrologists could not wait with technical system development (…)." We agree that it initially concerns a project point of view. However, in applied research projects it is often reality that results are needed before "science" is ready to deliver them. Hence, this leads to the research question RQB, whether early problem structuring can help overcome such a timing issue. We will reformulate this part to clarify.

25) *Line 87: which special issue? Please specify the name of it in addition to the reference. Here you are again stating the problem*

Response: We will add the name of the special issue (it is long, however). Regarding "problem", see next point 26).

26) *Line 99: why aren't the research questions together?*

Response: In section 1.3 "Aims, research questions, …" We had chosen a different approach to the one you propose. We first state one specific problem, directly followed by the respective research question. We found this easier for readers than a "classical" sequence. However, we do not have strong feelings about which might be better. We are willing to restructure this section and first develop all problems, followed by a list of research questions.

27) Line 100-109: I suggest removing this to reduce the text, but it's a suggestion only.

Response: We can remove the overview of the paper to shorten it.

28) Item 2.1. These topics have appeared in the abstract but not in the introduction (sustainability and transdisciplinarity). It should appear as one of the research questions too. In general, section 2.1 is well written. Still, I suggest reducing where possible.

Response: Thank you for appreciating the literature overview of sustainability science and transdisciplinary research. We will try to shorten it in the revisions, without losing information.

As we will revise the Introduction, the comment about "sustainability and transdisciplinarity" not being mentioned is probably no longer needed. However, we did mention them:

p. 3, line 72: "To the best of our knowledge, we are not aware of systematic assessment of MCDA processes from the angle of transdisciplinary sustainability research."

We do not quite understand the remark that it should appear in the research questions. It does (RQC and RQD):

p. 4, line 96: "**RQC:** How suitable is a structured, participatory decision analysis process based on MCDA for guiding large transdisciplinary projects? What worked well or less well in FANFAR? Could interests of a large number of stakeholders be integrated?
RQD: Is the proposed framework useful for this type of evaluation? What insights and recommendations can we provide for future transdisciplinary projects in hydrology research?"

To answer these two RQ, the literature review is needed. However, we could add an additional RQ, e.g.: "What are main characteristics of existing frameworks from transdisciplinary research and sustainability science for collaborative governance?" (or along these lines). The answer would then be the presentation of our proposed framework in Table 1, which could mean moving Table 1 into the Results section. We propose to follow this approach.

29) Line 138: why the need to emphasize "Nature Sustainability" here. I Would say that recent articles propose without referring to the journal as a measure of perceived quality.

Response: We agree and will change the sentence.

30) Table 2: It is quite challenging to read this table. Perhaps it could be in landscape format? Using the "ID" does not help as I had to return to the table multiple times Would it be possible to have the full description in the tables and figures "e.g. Fast development" instead of "a_Fast-dev"

Response: We can format table 2 in landscape format. We presumed that the typesetters would take care of this later. Regarding short names and ID, see our response to comment # 7, above. Specifically in Table 2, it is possible to give full names, but we propose to keep the short ID for the figures, either in Table 2, or in a separate table with all abbreviations.

31) Figure 4: Please remove the _ and add the full legend to the figure.

Response: Please also see response to # 7 and # 30 above. It will strongly increase the length to give the full names of objectives within the figures, and we would either provide these in the figure captions or in a separate table with abbreviations. Removing "_" might make the abbreviations even more difficult to understand, we will try whether it helps or not.

32) *Line 430: This should be in the results section, not in the methods.*

Response: We agree. We will move the number of respondents of the survey to the results.

33) *Line 567. 12 is a relatively low number of responses. It would be good if in Figure 1 you could add the number of participants in each workshop. This would be good to understand these 12 responses you got.*

Response: We can add the number of participants to Figure 1.

The 12 respondents from **p. 24, line 567** correspond to a fraction of 63% (12/19) of the total highest number of participants during this online workshop. We were unfortunately forced to hold the 4th workshop online due to the COVID pandemic, which posed some challenges to our organization. Due to connection problems (which are frequent in West Africa) and related dropouts, the workshop was attended by a varying number of participants over time (between 10 and 19). We consider a response rate of 12 as reasonably high given the challenging circumstances.

34) *Table 4: I enjoy the table, it provides an excellent summary.*

Response. Thank you, we appreciate your positive feedback.

35) *Line 839: Value Focused Thinking appeared for the first time here. It should be In the methods.*

Response: You are right; we will add VFT to the Methods.

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