

Letter to the editor

Dear Christina Prieto,

With pleasure, we submit the second revision of our manuscript (nhess-2018-325) with a new title: "Towards multi-objective optimization of large-scale fluvial landscaping measures". The new title represents the core of our conceptual innovation better and includes the multifaceted trade-offs.

The first revision was based on the comments of the four reviews that we received on the initial submission of our paper. The first revision balanced the positive feedback that we got from R3 and R4 and the critical remarks from R1 and the minor comments of R2 on the initial submission. To maintain the positive aspects of the paper as noted by R3/4, we did not make major changes to the methods section in the revision. This is a multidisciplinary paper that integrates aspects from social sciences, ecology, and hydrodynamics within the framework of flood risk management. The integrative approach fits well with the topic of this special issue of NHESS.

The first revision was positively evaluated by R2 and negatively by R1, but unfortunately R3 of the initial submission did not review our paper again. This has skewed the balance in the review of the revision towards the negative. Still, we want to honour the positive feedback of R3/4 of the initial submission in the second revision that we now submit.

The take-home message has been worded much more strongly, both in the title as well as in the conclusion, as was requested by R1 and by you as the manuscript editor. We revised the manuscript point-by-point, see the reply below. We believe that this has improved the clarity of the message of the paper significantly and hope that it is now suitable for publication.

Regards, on behalf of all authors,
Menno Straatsma

Manuscript editor comments,

although your manuscript has been improved (mainly in the discussion section) and the topic is of high interest, i.e. moving from traditional hydraulic analysis to multi-disciplinary, multi-parametric, multi-objective analyses for supporting negotiation among stakeholders and decision-making, based on the revisions i have received, your manuscript still requires major revision to make the paper publishable on NHESS.

Main concerning points with the paper are: what is the conceptual novelty? are the results generalizable?, what is the message that the readers should take home from the paper?, and why the readers should read the paper?.

Also, Reviewer 2 highlights that the results are very obvious and conclusions are not strong, please if this is not the case for the results on ecological indicators, the latter should be clearly stated on the paper.

Reply: Related to your comments:

- What is the conceptual novelty? You summarized that very well: “moving from traditional hydraulic analyses to multi-disciplinary, multi-parametric, multi-objective analyses for supporting negotiation among stakeholders and decision-making.” A reworded version of this line has been added to the abstract and the conclusion.
- Are the results generalizable? Yes they are: Reviewer 3 of the initial submission mentioned that explicitly. The specific values for the different evaluation parameters will vary of course, but the conceptual challenges are identical in many rivers. This is now explicitly mentioned in the conclusion.
- What is the message that the readers should take home from the paper?
 - We present a method for quantification on multiple factors.
 - Ecological improvement is possible without major negative effects on the flood hazard. This is now listed as number two in the list of conclusions.
- Why should the readers read the paper? Flood hazard management is embedded in a larger framework of river management. So, if you want to have societal impact with and adjust to changing boundary conditions, you need evidence-based and quantitative trade-offs to weigh the different stakes in society. A reworded version has been added to the conclusion.

Reviewer 1

R1: Apart from local corrections and integrations, the new version of the manuscript has been modified essentially in the "discussion" section. Indeed, the discussion is now better focalized. However, the essence of the paper has not been modified.

Reply: We revised our paper based on the comments of the four reviews that we received on the initial submission of our paper. The revised version balances the positive feedback that we got from R3 and R4 and the critical remarks from this reviewer and the minor comments of R2 on the initial submission. To maintain the positive aspects of the paper as noted by R3/4, we did not make major changes to the methods section in the revision. This is a multidisciplinary paper that integrates aspects from social sciences, ecology, and hydrodynamics within the framework of flood risk management. The integrative approach fits well with the topic of flood risk management of this special issue of NHESS.

R1: Main points are:

1. Evaluation of the strategies for flood hazard mitigation is based on a variety of tools. Complexity of the approach requires a variety of input variables. All this is indeed positive, as multi-parameters / multi-objectives analyses are important tools for decision making in complex societal problems. I consider this the most interesting part of the paper but, I explained in my previous review, I find the

results of the present stage of the process little conclusive. Methodology is OK, but its efficacy and significance is still to be validated.

Reply: Good to get this feedback that the methodology is sound and that we are indeed working on an important aspect of flood risk management within a complex society. Whether the implementation of the method will indeed be efficient in a multi-stakeholder session will be tested in a follow up from this project. We are currently in the process of setting up a Living Lab for the Rhine branches to bring together different stakeholders to plan additional interventions to adapt to the expected increase in discharge to 18 000 m³/s. Only after the Living Lab the method can be evaluated on efficacy. This was outside the scope of this study and for the follow up the results of this paper will be very valuable as it gives a proof of principle plus the boundaries of the solution space. We have added the following sentence to the conclusion: "Application in real life stakeholder sessions is required to prove this point."

2. A specific point of interest with respect to the methodology is table 4 and related discussion. The issue is not trivial and has some general validity.

Reply: We thank you for this observation. Our findings suggest that, despite varying views of stakeholders, it is useful to model stakeholder preferences based on factors, such as their role, responsibility and visions on floodplain management. This provides valuable knowledge for stakeholders prior, or during engagement in multi-stakeholder platforms. This was also elaborated in the discussion section:

"This provides the stakeholders with a better understanding of the possibilities and limitations of the solution space. It has the potential to accelerate the decision-making processes, because the stakeholder preferences and their interdependence are concisely visualized and immediately apparent with our methodology. Mutual recognition of interdependence and a shared understanding of the possible solutions are essential elements in the decision making process (Ansell and Gash, 2008)."

In the revised version, we have extended the section to:

"The owner-specific areas for measures served as a proxy for the complexity of implementation in terms of governance, because more owners imply longer implementation times. It created insight in the possible contributions of the stakeholders for large scale interventions. Decision-making in integrated river management is more complex and dynamic in reality, because of the number and diversity of stakeholders and sectors involved, each with their own views, interests and resources (Mostert et al., 2007; Robinson et al., 2011). The outcome of stakeholder sessions, the preferred measure, will vary depending on the individuals involved in the debate, which possibly leads to a suboptimal solution. We determined the stakeholder preferences a priori (Table 4) and used their preferences and land ownership to position and parameterize the measures. Our findings suggest that despite varying views of stakeholders, it is useful to model stakeholder preferences based on factors, such as their role, responsibility and visions on floodplain management. This provides valuable knowledge for stakeholders prior, or during engagement in multi-stakeholder platforms from the perspective of social learning (Borowski, 2010). The scores per land-owner group (LS and

AS) provide the stakeholders with a better understanding of the possibilities and limitations of the solution space. It has the potential to accelerate the decision-making processes, because the stakeholder preferences and their interdependence are concisely visualized and immediately apparent with our methodology. Mutual recognition of interdependence and a shared understanding of the possible solutions are essential elements in the decision making process (Ansell and Gash, 2008).”

3. As already said, I am not able to judge novelty and significance of results related to the ecological part.

Reply: We have now highlighted one of the results: roughness smoothing with natural grassland or production meadow. This presented large increase and decrease in potential biodiversity, but led only to small differences in water level reduction, due to the similarity in hydrodynamic roughness. We dedicated a separate paragraph to it and iterated it in the conclusion. Also the abstract was revised to highlight this point.

4. The use of Delft3D Flexible Mesh may be not standard from a technical point of view, but does not represent any conceptual innovation from the scientific point of view.

Reply: True, it could have been any other 2D flow model. Large scale manipulation of the geometric input and land cover is new from a methodological point of view as described in Straatsma and Kleinhans (2018). Also the use of BIOSAFE is not innovative at the conceptual level. We still kept a short description of the various models as a service to the reader.

5. I am not very sure which are the "findings [which] will be surprising for many readers". As said, I consider the hydraulic results (figure 6 and related comments) as just obvious from a qualitative perspective, while their quantitative values have no generality. Expected effects of changing downstream boundary condition, roughness, cross-sections width, flood plain elevation are described in any textbook of river hydraulics. I do not personally know all the authors, but I am sure that Marteen Kleinhans can agree on this. As a consequence of these hydraulic relations, many of the trade-offs are also obvious. It may be that results on ecological indicators are not obvious, I have already admitted my ignorance on this.

Reply: R1 is right in that the basic qualitative insights are not novel. However, qualitative results in themselves are also not useful. All projects in river floodplains that we know of and read about in the literature either quantify the trade-offs for very specific cases or do arm-waving. Our approach is novel in that it quantifies the trade-offs that are not directly comparable. Our visualisation allows for the first time a quantified idea of what it costs in terms of biodiversity to reduce water levels by a set of methods, and what it costs in terms of stakeholder processes to reduce water levels, and so on. This analysis provides a rational basis for compromises between stakeholders and optimisation of tax money spending. This is especially relevant since spatial demands on the floodplains are contrasting for the Water Framework Directive and Natura2000 and the Flood Directive.

In fact, it could be argued that the basic relations from textbooks on river hydraulics have led to the degraded status of the Dutch main river system, and many other river systems worldwide, because

they ignore and exclude similarly basic qualitative insights from ecology and from governance studies. The novelty is in the integration, and societal impact is made possible by integration only, and Maarten Kleinhans entirely agrees with that too. The integrative approach presented in this study seeks to provide the tools for a multiobjective optimization, in which river hydraulics are essential but only a part of the analysis.

R1: At the end of the story: I fully agree on the potential of multi-disciplinary, multi-parametric, multi-objective analyses as a tool for supporting negotiation among stakeholders and decision-making. I appreciate this manuscript for the description of the approach with respect to traditional hydraulic-only analyses. I see some useful methodological suggestions which may be of use in a variety of contests. I cannot see any general conclusion.

Reply: We have now made the general conclusion explicit at the end of the conclusion section: "Flood hazard management is embedded in a larger framework of river management as guided by international legislation (e.g. EU Flood Directive and Water Framework directive). To achieve societal impact and adjust to changing boundary conditions, we need evidence-based and quantitative trade-offs to weigh the different stakes in society. With our approach, we are moving away from the traditional hydraulics-only analyses and towards multi-disciplinary, multi-parametric, multi-objective optimizations for supporting the negotiations among stakeholders in the decision-making process."

R1: I do not consider anything written in the paper to be wrong, nor necessarily trivial. I see this as a weak paper for publication on NHESS in terms of take-home message. Evaluation of its potential interest to the readers of the journal is obviously left to the editor.

Reply: We have now stated the take-home message explicitly, see previous reply. Based on the positive feedback that we got from presentations with some of our preliminary results, we feel that there is sufficient interest for the readers of NHESS as well.

Reviewer 2

R2: In the text you talk about difficulties if too many stakeholders are involved in the proposed solution. Please explain this. Is it a political problem or the question of the cost, or what ever?

Reply: When a measure should be implemented at the location of many land owners, there are two issues: (1) aligning the majority of the stakeholders with a single plan, and (2) expropriation of the other land owners. This is now stated explicitly in the text. The governance of more stakeholders is complex, because everyone has legal rights, but this can not be modelled explicitly. Therefore, we use the number of land owners involved as a proxy.