

Response to Referee #2

We thank Referee #2 for the profound evaluation of the paper and the helpful comments, which will further improve this paper. We are confident that we can adequately address each of these comments. Please find below our responses describing our planned revisions (highlighted in blue and italic type).

Through data synthesis and model interpretations of RAMSAR wetland sites across the world, this paper addresses the issue of past to expected future adverse effects on riparian wetlands from pressures such as climate change and water regulation. In particular the focus is on the available flooding volume - how it has been modified today and how it may change in the future due to these pressures. The magnitude of these changes is taken as a measure of potential ecological impacts.

The authors combine and use multiple methods (e.g. to simulate impact of flow regulation of various dam types etc), many of which have been thoroughly developed in previous work. Although results are associated with considerable uncertainties, the approach is quite reasonable and the outcome is logically synthesised and presented as maps showing e.g. the magnitude of flow alteration impact. Such global state-of-the-art syntheses is certainly of scientific interest; I would recommend publication of the work if main shortcomings (see below) can be addressed, which is likely to require at least moderate revisions.

In summary, these shortcomings are (1) lack of clarifications regarding novel aspects of the present study, apart from the novel global synthesis perspective, (2) partial lack of information regarding past experiences of the proposed methods, (3) language issues, (4) lack of sufficient results comparison to previous studies, and (5) unfocused conclusions. Overall, this study has high potential and I hope that the detailed comments below can be useful in addressing the current concerns.

1. Presently, the focus of the introduction is on the relevance of the topic, including what is known about vital ecosystem services of floodplain wetlands, effects of dams in a more general sense, and the need for maintaining flow variability etc. This description is on the lengthy side and could probably be condensed. However, more concrete (state-of-the art) regional examples that presumably exist in the scientific literature regarding today's impacts (or expected future impacts) on floodplain wetlands are essentially missing. Such examples should be included in the introduction, such that the readers can understand what is novel about the presented result-maps, in addition to the novel global synthesis perspective. In other words: which previous indications exist in the scientific literature regarding key results, such as the result showing that the degree of overbank flow alteration due to current management is very low in Europe (essentially green in Figure 1) whereas Australia comes out as seriously altered (or other results that are the authors think is important). I would recommend the authors to go through what they consider to be the main results of their study and make sure that the introduction informs sufficiently about the current knowledge. This would provide a necessary basis for enhancing the discussion (see bullet point 4)

Currently the introduction is on the relevance of the topic and provides the rationale for the applied indicators. It describes the situation of wetlands worldwide, the dimension of flow regime modification due to dams, water abstractions, and water transfers (rationale indicator 1), the ecological consequences, the ecological function of floods, the ecosystem services of floods, expected future impacts on flooding regimes due to climate change and new dam initiatives (rationale indicators 2 and 3), potential measures to counteract flow regime modification, and the difficulties to

implement such counteractive measures, which requires legal and institutional capacity to act (rationale indicator 4). The introduction ends with three research questions describing the goal of this study.

We agree with Reviewer #2 that the introduction is currently too long and will shorten the section by e.g. removing the paragraph on ecosystem services of wetlands and/or condensing the text by providing only the key points and referring to the literature. Actually we provide 5 regional examples (Hughes, 1988; Maheshwari et al., 1995; Barbier and Thompson, 1998; Kingsford, 2000; Nislow et al., 2002). But we agree to the suggestion to include more regional studies and make them more prominent in the text. Following the description of current knowledge, we will derive our research question(s) and highlight the novelty of our study. In the last years, different authors have assessed ecologically relevant flow regime modifications on larger-scales. In addition and complementary to the published papers, our study considers the following points which have never been applied before in their combination and in its detail to create a screening tool for assessing hydrological threats for riparian wetlands.

- 1. Environmental flow provisions that are defined as a percentage of mean discharge can be allocated in many different ways throughout the year. However, complex flow-dependant ecosystem habitats and functions are provided by specific flow characteristics. Consequently, rather than long-term average flow conditions, our approach focuses on a specific, ecologically relevant flow event.*
- 2. Most large-scale environmental flow assessments focused on in-channel river flows. Riparian wetlands depend on overbank flows leading to inundation. They are (in combination with subsequent drying) the main driving force for ecological processes in riparian wetlands. Our assessment is the first that applies the flood pulse concept (Junk et al., 1989; Bayley, 1991; Tockner et al., 2000; Junk and Wantzen, 2004) on a global scale.*
- 3. In order to address trade-offs between human and ecological water demands, multiple stressors on human water security and ecosystem conservation need to be considered. The applied approach is able to consider different drivers of change such as dam operation, water use as well as climate change.*
- 4. Next to the flow regime modifications, the threat for riparian wetlands also depends on the society's capacity to act to the changes. In order to fill this gap, we combined quantitative with qualitative results. The implementation of counteractive measures depends especially on the legal and institutional framework in place. Therefore, we collected 6 different criteria (legal environmental flow provisions, presence of RBOs, at least one relevant treaty, and specific treaty provisions such as water allocation mechanism, conflict resolution mechanism, and flow variability management). In addition, new dam construction is likely to further modify flow regimes in the future, but currently no large-scale dataset on major dam initiatives (including planned storage capacities) is publicly available. Therefore, we collected the number of dams that are currently planned, proposed or under construction in the upstream areas to give a first indication, where future dam construction is likely to affect the inundation of specific riparian wetlands.*
- 5. Our discharge simulations were done on a daily time-step. This is important as many ecological functions and habitats are facilitated by hydrological events that last only up to some days (e.g. strong precipitation events, bankfull flow, and flood formation).*

6. *Today, river flows are considerably affected by human activities worldwide, and the speed of river ecosystem destruction and biodiversity loss is exceeding the ability of scientists to review applied water management practices and ecological consequences for each river. Therefore this study assesses flow regime modifications on a global scale. The approach is performed on a detailed river network with a spatial resolution of 5x5 arc minutes and can be applied for single reaches of larger rivers with a global coverage.*
7. *The approach will allow new applications related to riparian wetland flooding. Examples include the quantification of specific ecosystem services provided by intact riparian wetlands (e.g. forest production, water purification, fish production, flood control, etc.) and how this is likely to change in the future. The framework could support policy makers at international level (e.g. at forums like UNEP, OECD, European Union, Convention on Wetlands of International Importance, and Convention on Biological Diversity) in balancing water allocations to humans and nature, implementing global conservation efforts, and planning of water infrastructure location and design.*

2. It is stated in the introduction (p. 2, line 26) that a new approach is needed to water resources management, which among other things should allow for sufficiently high flows for sustaining floodplain wetlands. However, in line with comments of bullet point 1 (above), this proposed novelty remains unclear to the reader. For example, haven't we gained some relevant knowledge from regulation schemes applied to the principal Colorado River in the US (Stevens et al., 2001; Stromberg et al., 2007; Cross et al., 2011)? These schemes have included controlled floods as part of the strategy to minimise adverse impacts to downstream ecosystems. Perhaps there other relevant examples.

Thanks for this remark. The aim of this paragraph is not to claim that the "new approach" on water resource management is our idea. Rather we want to state that both flood protection for people and controlled floods for riparian wetlands are important and need to be considered in practice within the framework of integrated water resource management. We will revise this paragraph and argue with the references mentioned by the Reviewer #2.

3. The language of the manuscript is overall good. There are some exceptions though, including the introduction. In particular, the research questions and the related text include awkward formulations (e.g., multiple sentences starting with Thereby. . ./ Therefore. . .), please check.

We understand that the language of this manuscript can be improved. We will check grammar, formulations and word spelling. Thanks for the given examples.

4. There is a lack of results comparison to previous studies in the discussion section, which should be addressed before publication. The now included references do mainly not relate to the results (study outcomes) and need therefore to be complemented. For instance, are the results regarding impacts on the 93 Ramsar wetlands in different world regions (p. 17, lines 3-11) consistent with previously reported results for these regions? Alternatively, do the results partly contradict or point to new and previously unnoticed aspects? (Also, the reader is not well informed about the existence or absence of similar studies, see bullet point 2 above regarding the introduction). The same questions can be asked for other key results, such as impacts of climate change and the related identified hotspots (p. 17, line 12-15), and competition of water (p. 17, lines 31-32). Overall, the discussion section is rather

general and would benefit from an extended discussion of results. The aims of the study need not to be reiterated in the beginning of the discussion section.

The discussion and conclusions section will be revised according to the advices given by the three reviewers. With regards to the specific comments of Reviewer #2 we will substantiate the discussion part by comparing our key findings with other existing studies on a regional basis or even for specific wetlands which forms again a bracket with the introduction section. This will be done not only for the findings but also for the interpretation of the data and new insights gained by our quantitative-qualitative approach.

5. The main conclusions of the paper are not clearly presented. Maybe a separate conclusion section could help?

Thanks for this remark. In our revised manuscript we will put particular attention on the revision of the conclusions section. We ensure to clearly present our conclusions aiming at the novelty of this study identified in the Introduction section. Additionally we will include a sub-section on future research and the potential of our approach to be applied to similar questions related to other ecosystems at risk.

References

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