

Response to Referee #3

We thank Referee #3 for the profound evaluation of the paper and the helpful comments, which will further improve this paper. We are confident to adequately address each comment and our reply describing the planned revisions of the manuscript are highlighted in blue and italic type.

The authors aim to address an important issue: Identifying Ramsar riparian wetlands that exhibit current and future variations in ecologically consequential inundation patterns as a result of human-modified flows (e.g., dams). They ask three particular research questions to best identify these wetlands. These questions focus on the impact of current water resource management on riparian wetland flows, the effect of future climate change on inundation of these wetlands, and the implications of low government and societal infrastructure and capacity to make changes to future management.

The goal and research questions the authors attempt to address are broad and could be impactful if addressed and translated well. However, a major revision is required to ensure both the quantitative work behind the research and the communication of this work is effective. Below, I provide major suggestions for the manuscript followed by some general comments.

Major Point 1: The Introduction reads somewhat like a full literature review that continues for quite some time without a direct point. It was well into the sixth paragraph that the goal and research questions were stated. I would suggest tightening up the Introduction, providing only key points throughout, and early on (perhaps at the end of the first paragraph) allude to the main point of the paper (e.g., “We aim to. . .”). Then, the authors can safely state the full objective and research questions at the end of the Introduction.

As already stated in the reply to Reviewer #2, the Introduction section provides information on the relevance of the topic and 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 the reviewer that the introduction should be shorten and allude the main points of the paper earlier in the text. We intent to shorten the text by e.g. removing the paragraph on ecosystem services of wetlands and/or condensing the text by addressing key points which will be underpinned with references. The revised introduction will be less like a literature review but more focused on specific examples to derive the novelty of our approach.

Major Point 2: Something is very misleading and incorrect about discussing a “natural” flow regime in knowingly modified watersheds and aquatic systems. Also, the word “natural” is used throughout the Abstract and Introduction (ala Poff et al. 1997), and it is not until the Methodology that authors define natural flow. The authors describe natural flow for this paper as “simulated taking into

account current climate and landcover conditions, but no further anthropogenic impacts.” This, by no means, would constitute a “natural” flow regime as described in past literature. I would recommend modifying terminology and the discussion throughout the paper to consider this as your “baseline” flow regime from which the analyses aims to understand current water resource management implications on the riparian wetlands and project changes of these regimes due to climate change

We will make use of the terminology “reference flow regime” as we agree with Reviewer #3 that the use of the terminology ‘natural flow regime’ is misleading due to the fact that current climate change and land cover conditions are considered. The new terminology will be applied in the main body of the manuscript as well as in the Abstract.

Major Point 3: The goals of the paper and research questions are poorly worded need more information. What, specifically, are the “riparian wetlands?” In the Abstract, the authors suggest they look at 93 Ramsar sites. Are the “riparian wetlands” the “93 Ramsar riparian wetlands?” For Research Question 1, why are 6025 dams selected? Are these dams specifically located upstream of Ramsar riparian wetlands? What are the “different water use sectors”? Also, delete “Thereby” at the beginning of the second sentence. For Research Question 2: “Inundation” cannot be “impaired” because “inundation” does not necessarily denote a positive quality. The authors could replace “impaired” with “exacerbated or diminished” or “modified.” Also, delete “Therefore” at the beginning of the second sentence. Research Question 3 is stated in a grammatically incorrect way, so it took a few re-reads to understand it. Move “could” after the word “sites.” Also, what is a “low capacity to act?” This is definitely not clear.

Thanks for these remarks. We understand that the research questions need to be rephrased. The proposed corrections will be implemented and the objectives will be described in more detail.

Major Point 4, WaterGAP3 runs: Streamflow, for what the authors term “daily natural flow regimes” (1981-2010), is simulated with 2004 land cover. Using 2004 land cover is okay; however, going back to the use of the word “natural”. . .how can this be considered natural flow when the landscape for each area is likely highly modified and streamflow is a reflection of these anthropogenic activities? Also, there is no mention of calibration and verification of the model, which admittedly would be difficult a global scale. Therefore, is the entire paper a thought experiment using an uncalibrated global model to help explore hypotheses? It would be okay if so, though this framework should be characterized as such throughout the paper. Also, the results (maps, in particular) should emphasize the paper’s overarching approach (i.e., the thought experiment – a “screening tool” is mentioned in the Discussion, hypotheses testing, and/or a conceptual model). If calibration and verification did occur at some stage and is not referenced, again, measured streamflow would reflect the managed conditions, not some unattainable “natural” or “near natural” condition. The model scenarios are therefore a bit confusing and need some rethinking, definitely in the presentation of what they are but potentially in which ones should be used. For example, consideration should focus on whether only the managed scenario and future climate/management conditions should be used since the true “natural flow regimes” aren’t captured.

Also, the authors talk about the database of dams that are used, but how does that relate back to the Ramsar wetlands? Are these dams all upstream of Ramsar wetlands? As I read on, it became a bit clearer that this is simply a global database, and Ramsar wetland areas within the global domain are analyzed. However, this information (spatial domain and selection of dams) needs to be clearer up front.

The authors likely have all the information mentioned in this Major Point. There is simply a need for better and clearer communication regarding these bits of information. As a result, the Methodology section seems quite disjointed and leaves the reader guessing at how the authors conducted the analyses.

We want to thank Reviewer #3 for these valuable comments. First, the comment on terminology has already been addressed under 'Major Point 2'. Second, the WaterGAP3 model is calibrated and validated which is described in the manuscript at p.7 line 32 to p.8 line 3. For the verification of the model, we refer to p.8 line 15 and the reference Schneider et al. (2011a) given in the text, which contains details of the model performance with regards to bankfull flow events. However, given this comment we think there is the need to improve the structure of the Methods section and to better explain the model used in this study. We will address this comment by including sub-headings and an extra paragraph on model calibration and validation to increase clarity, transparency and understanding of the paper. Furthermore we will add another reference on WaterGAP3's ability to represent maximum flow magnitudes (Schneider 2015).

The entire paper is far from being a thought experiment, although any model experiment could be understood as a 'thought experiment'. To be more precise, in this paper we used a model to estimate the hydrological threats for riparian wetlands today and in the future (2050s) under the conditions of a selected scenario. Hydrological models are useful tools to mirror the reality, i.e. river discharge, in an abstract manner. The higher the agreement of simulated and observed data records the better the model performance. In the calibration process, WaterGAP3 model simulations take into consideration human impacts in terms of managed reservoirs and dams, water abstractions and return flows from 5 different sectors, urban water transfers and land use conditions. In general, the model is calibrated against an observed discharge record by adjusting one free parameter (runoff coefficient) and validated to an independent period of the same discharge record. Based on the calibrated model the 'reference flow regime' is represented by a model simulation driven solely by the meteorological forcing of the respective time period, i.e. 1981 to 2010. Human interventions in form of managed dams and reservoirs, water abstraction, return flows, urban water transfers are omitted in this model simulation. This model simulation can be compared to the respective time period including the human interventions to evaluate their impacts. However, we want to mention that this approach as well as the terminology 'natural flow' is commonly used in the community of global hydrological modellers. Recognising the misunderstanding of the information given in the text we will improve the manuscript by providing model-specific information and references to the model calibration and validation and conduct a thorough revision of the entire text. This will also include the description of the scenario selected to identify future hotspots under varying climate and socio-economic conditions.

The dam database (GRANd) used by the model is initially independent of the Ramsar wetlands. GRANd contains the information on the location, storage capacity and main purpose of the largest dams of the world (about XX% of the total dam storage) which are not necessarily located upstream of Ramsar wetlands. We decided to focus on the Ramsar wetlands because of their importance and description found in scientific literature. We will communicate this in a clearer way in the text.

Major Point 5, Discussion and Conclusions: Be careful here. Because this is thought experiment using a global model (again, unless calibration/verification happened but wasn't mentioned), your conclusions need to be balanced with a statement of the conceptual aims of the paper and

associated limitations/assumptions. The quantitative analyses isn't incredibly quantitative, and I wince a bit with the use of numbers like "8% are significantly impaired" and flood volume is likely to be decreased at 41% of the sites. . ." when those are all relative numbers with no basis in reality. Please mention up front in the conclusions or make a separate section of the limitations and assumptions with regard to what the analyses can actually provide.

We will improve the discussion and conclusions section taking into account a cautious valuation of our model outcomes and resulting conclusions. An improvement of the discussion part will be achieved by comparing our key findings with other studies preferably related to the selected Ramsar sites. This includes the studies already mentioned in the introduction section but will be extended through systematic literature search.

Major Point 6: In general, the English is okay as written. However, it's important that someone extremely proficient in English re-review this paper for odd placement of verbs, adjectives, modifiers, etc., and poor word selection. One small example, on Page 5, Line 14 "For Europe, a higher number of sites "were gained" as the European wetland geodatabase. . ." This should be "were selected" or "were chosen". There are many instances like this throughout the paper, and I do not list them all below.

We agree that the language of this manuscript needs to be improved. We will check again grammar, wording and spelling. Thanks for the given examples.

Specific Comments

Page 1, Line 9 – Recommend changing all references of "mankind" to "humankind" and "man-made" to "constructed"

Thanks, we will modify all terms, respectively.

Page 1, Line 9 – These eco services are provided not only via the regular patterns of inundation but also regular patterns of drying – so actually, it's the *variability* inundation patterns that is important.

Thanks, we will modify this.

Page 1, Line 26 – Need to review and add Dixon et al (2016) as well. Dixon, MJR, Loh J, Davidson NC et al. 2016. Tracking global change in ecosystem area: The Wetland Extent Trends index. Biol. Conserv. 193: 27-35.

Thanks, we will include this reference.

Page 2, Lines 18-19 – Is this true for all "larger cities?" What spatial scale is this referring to? Are these global or regional estimates? If regional, what regions?

Thanks, we will specify this and add a reference (Mc Donald et al. 2014).

Page 2, Line 25 – Again, what are "natural sites?"

Thanks, we will provide a definition in the revised manuscript.

Page 2, Line 30 – Not all floodplains are wetlands, which is how this sentence reads. Please correct.

Thanks, we will correct this.

Page 2, Line 32 – What ecological processes are initiated? Some of these processes may be initiated by drying not wetting.

Thanks, we will include examples..

Page 3, Line 2 – What is engendering what? This clause doesn't make sense.

Thanks. This sentence will be rephrased to make clear that a periodically flooding and drying "engenders one of the most dynamic, diverse and productive systems in the world".

Page 3, Line 4 – That's a very broad statement, that all floodplain wetlands contain more species than any other landscape unit. Need more specifics here because it's likely not what the authors intended to say.

Thanks. We will be more specific in the revised manuscript.

Page 3, first paragraph – The Roman numerals are not needed when providing full sentences after them. Suggest removing all Roman numerals here.

Thanks, we will remove the Roman numerals. (However, this paragraph will most likely be removed in order to shorten the introduction.)

Page 3, Line 24 - What are "fellow riparians?" Please be more specific.

Thanks, we will replace it by "upstream/downstream water users"

Page 3, Line 25 – What projections? Please be more specific.

Thanks, we will specify this.

Page 4, Lines 12-16 – Break up this sentence into two or more sentences.

Thanks, we agree.

Page 5, Lines 19-20 – These sentences can be deleted and are unnecessary.

Thanks, we agree.

Page 5, Line 23 – "percent change in flood volume": from what period to what period? Please provide time frame.

Thanks, we will specify the time period.

Page 5, Line 28 – It is not clear at this point what "sufficient capacity to act" means. Suggest modifying this or adding some clarification here to lead the reader to the more specific methods discussion.

Thanks, we will add an explanation at the beginning of the respective section.

Page 5, Line 3 – The simulation of daily natural flow regimes would still be an expression of a modified landscape, so how are these natural?

Thanks, we will change the terminology.

Page 5, Lin 9 – Need clarification of what type of “daily river discharge” is being simulated here – “natural” or “managed”? (After reading on, it becomes obvious it’s “natural” but that needs to be mentioned straight away.)

Thanks, we will add a sentence for clarification.

Page 5, Line 20 – Switched to “near-natural” from “natural” in this sentence. Please be consistent.

Thanks, we will change the terminology.

Page 7, Lines 6-9 – Need to be clear here why the simulation includes these specific 6025 dams. Why were they chosen? Intuition would tell me they are all upstream of Ramsar sites, but further reading seems to suggest that they are simply part of the global database. These questions regarding methods also suggest that clear summary statements of what the quantitative analyses is up front in the Methodology should be added – meaning state your steps: exact simulations, the spatial scale, how dams were selected, how the Ramsar sites were overlain on the global map, etc. Then, details can be added after this summary.

See reply to Major Point 5

Page 9, line 14 – What selected sites? The Ramsar wetlands? Again, details are needed here.

Thanks, we will revise the text.

Page 9, Lines 14-15 – This sentence is a bit wonky and needs to be reworded.

Thanks, we will reword the sentence.

Page 9, Line 18 – How were the cutoff thresholds for Table 2 selected?

Thanks, we will include the missing information.

Page 9, Line 20 – Again, clarify what the “low capacity to act” is.

Thanks, we will specify this.

Page 9, Line 27 – Define blue water

Thanks for this remark. The term “blue water footprint” is used in the cited literature and probably unnecessary jargon. We will rephrase this and describe that the scarcity threshold is reached when 20% of the streamflow is depleted.

Page 9, Line 30 – Again, how were the Table 3 thresholds derived?

Thanks, we will include the missing information.

Page 10, Lines 25-27 - Cut these sentences. Too much introduction here.

Thanks, we agree and will remove the mentioned sentences.

Page 11, Line 4 – These wetlands are “moderately impacted” – as far as the map seems to read.

Thanks, we will be more specific about the location to avoid misunderstandings.

Page 11, Line 17 – N=2, though, correct? So this is only discussing two wetlands, right?

Thanks, we will rephrase the sentence to avoid generalisation.

Page 12, Line 28 – Is this the ensemble median for the GCMs as input to the WaterGAP3 model or the ensemble average of the output of the WaterGAP3 model?

Thanks for this remark. We will be more precise and rephrase the sentence. It's the ensemble average of the output of the WaterGAP3 model.

Page 13, Liens 16-17 – Now that is a very interesting finding!

Thanks.

Table 1, change “not/slightly” to “none/slightly” – same with the figures: “not/slightly” does not make sense.

Thanks, we will change the text as suggested.

Table 2, delete “the number of” in the caption.

Thanks, will be deleted.

Table 4, define “formal institutional capacity” in the caption to make the table stand alone.

Thanks, we will include the missing information.

The final edits for the paper are included in the Major Points listed previously.