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Interactive comment on "Socio-hydrological spaces in the Jamuna River floodplain in Bangladesh" *by* Md Ruknul Ferdous et al.

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Replies to Anonymous Referee #4 We would like to thank our anonymous reviewer for his insightful and constructive comments. We apologize for our long silence; the lead authors were not aware of the HESS interactive method so we waited for all reviews to have been sent before replying. The comments from the reviewer have been reproduced in italic below, interspersed with our responses.

Referee comment: The authors propose a new concept to study the interactions between humans and floods in a socio-hydrological system. They introduce the concept of Socio- Hydrological Spaces to describe a system that shows specific interactions between social, economic, hydrological, etc. factors that result in a certain behaviour

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of the system and apply this to a case study in Bangladesh. Although I can understand the advantages and potential of a comprehensive systematic approach to the study of "Socio-Hydrological Spaces" (which the authors seem to be aiming at) this new approach is quite poorly defined and explained. The authors merely give human-flood systems a different name (i.e. Socio-Hydrological spaces) and proceed to describe a case study as if this is a new approach. Mostert (2017) recently published an article in this same journal, arguing for case-study research as an alternative approach for socio-hydrology and while his example of a case study is perhaps more qualitative than the one presented here, the authors should perhaps try to relate to his paper. Also, a very similar approach to the one presented in this manuscript for describing a case study of how humans and floods coexist, is presented by Hazarika et al. (2015). The concept/approach would be new and in my opinion useful, if a general framework would be presented to analyze a case study/SHS in a comprehensive and consistent way, which would allow for the comparison of different Socio-Hydrological Spaces, their specific characteristics, and the feedbacks and phenomena that arise from the characteristics of this particular system. However, after reading the manuscript I did not really see how the method/concept that is presented here adds something new and useful to the already existing approach of a case study description.

Response: From all four reviewers' comments, we have come to the conclusion that the article in its current form does not yet convincingly define (and explain the need for) the concept of socio-hydrological spaces (SHS). We think SHS provides a methodological (and possibly paradigmatic) bridge between two contrasting approaches to studying human-water interactions: hydrosocial research based in sociology and human geography, and socio-hydrology based in hydrology and physical geography. These are described and discussed in Wesselink, A., Kooy, M. and Warner, J. (2017) "Socio-hydrology and hydrosocial analysisâĂŕ: toward dialogues across disciplines", WIREs Water 4(2) 1–14. Hydrosocial research take the messiness of the socionatural world as a given and results in location-specific narrative case study analyses with limited or no attempt at generalisation. Socio-hydrology looks to generalise findings from

case studies through a system-approach using conceptual and mathematical models. “Socio-hydrological system” is thereby an abstract entity detached from the reality on the ground. We propose “socio-hydrological space” as a tool that helps to make the necessary intermediary step between the messy reality of the specific location (space) and the abstract system of conceptual and mathematical models. The primary function of SHS is as a lens through which to view the complex reality of specific cases in order to find patterns in human-river interactions, which can then be compared to patterns in other locations to see if further generalisation towards universal models is possible. Its use invites the researcher to have an open mind to the existence of expected or unexpected patterns in location-specific data using a thorough understanding of the location: society, economics, natural system, technical interventions, etc. Subsequently, other cases may be analysed in order to explore whether the same or different patterns occur. These patterns can then be generalised through the more formal conceptualisation of socio-hydrological systems. On the one hand SHS thereby relates to a specific space, on the other hand it helps to find general patterns of human-river interactions: is serves as a methodological intermediary step or bridge between hydrosocial research and socio-hydrology. The importance of such an intermediary step is illustrated by the differences between our findings on human-river relations in the Jamuna floodplain and those by Di Baldassarre et al. published in several papers for the Po valley. From Di Baldassarre et al.’s analysis of human-river relations in the Po valley it appears that two alternative responses exist in time and space (levees or adaptation). This same pattern would also be broadly recognisable in other high income countries where control of the river is a financial and technical possibility, such as The Netherlands (levees) or USA (some locations have levees, at others adaptation is required). However, society along the Jamuna show both responses at the same time in one region, but at different locations (SHS1 and SHS2), with a third intermediary response (SHS3). We speculate that the greater variety in Bangladesh is due to less government budget and more difficult technical circumstances (the Jamuna is of a scale that renders most civil engineering works unsuccessful), but this remains for now an unexamined suggestion.

If Di Baldassarre's findings are therefore taken to derive a general conceptual model for socio-hydrological systems along rivers, as in his subsequent publications with co-workers, the resulting models may be applicable to other rivers in similar conditions, but not to the Jamuna floodplain. Distinguishing socio-hydrological spaces in the field is therefore an important step in the search for generalisation of human-river interactions as they combine a place-based analysis with a presumption of the existence of generalisable patterns, without assuming that these patterns will be the same across the world. The proposition of using SHS to examine field data thereby also helps to overcome a bias towards high income, moderate climate regions in the study of (socio-) hydrology that was identified by James Linton (2008) in "Is the Hydrologic Cycle Sustainable? A Historical-Geographical Critique of a Modern Concept". Annals of the Association of American Geographers 98(3) 630-649. Boundaries around a system are always arbitrary and selected in an attempt to analyse and address specific research questions, and a system can be also nested within a higher level system. However, the field data do suggest some boundaries as more logical or useful. In our case, the number of SHS that we found (three) is in first instance a result of the scale at which we explored the Jamuna human-river interactions (i.e. it is a result of the research scope/funding, not of the research question). However, we observe that the same pattern occurs along most of the Jamuna going downstream, until physical circumstances change too much and the river becomes tidal and under influence of cyclones. Going upstream, too, the pattern continues into India. While the three SHS we found are therefore first of all based on patterns in location-specific data, they can be generalised and used as a typology that can be applied elsewhere – but like the Po SHS they cannot be applied everywhere. It remains to be seen whether the same pattern of these three SHS occurs along other rivers and in other socio-economic conditions. However, patterns of SHS (such as the two options proposed by Di Baldassarre, or our three SHS) can be used to compare two different regions, as suggested by the reviewer. We could then find some regions where the options are similar to the Po valley, and other where they are similar to those in the Jamuna floodplain. And we think other patterns will exist. We

contend that these patterns do not constitute (formal, mathematically conceptualised) systems, but this may be an matter of vocabulary only. Thank you for pointing out the publications by Mostert (2017) and Hazarika et al. (2015). We will make sure to discuss these in our revised manuscript. Their work is indeed closely related to ours. However, as discussed above with SHS we are proposing a tool to rise above single cases studies, to help the comparison across cases. SHS offers the bridge between a specific case study, to identify patterns that can be compared to cases elsewhere.

Referee comment: On page 2 in line 24-26 the authors state that "interactions and feedback mechanism between hydrological and social processes in floodplains remain largely unexplored and poorly understood" citing Di Baldassarre et al. 2013a. However, since this paper in 2013 there have actually been quite some studies that have explored these interactions (just a few examples: Viglione et al. 2014, Chen et al. 2016, Ciullo et al. 2017, etc.) and in fact the authors do acknowledge this later in the manuscript (page 3, line 5-6).

Response: We will rephrase out statement, as it is indeed a little out of date. We will make sure to discuss Viglione et al. (2014), Chen et al. (2016) and Ciullo et al. (2017) in our revised manuscript.

Referee comment: On page 2 the authors state that there are currently two approaches to sociohydrology: qualitative studies and conceptual mathematical modelling studies. As I mention above, there are in fact other approaches (e.g. Mostert et al. 2017 and Hazarika et al. 2016) very similar to the approach that is presented here as a new approach.

Response: We will make sure to discuss Mostert et al. (2017) and Hazarika et al (2016) in our revised manuscript (see also our reply to the first comment).

Referee comment: The authors repeatedly state that running a conceptual mathematical model based on differential equations is much more data-demanding than the approach taken here. However, running a conceptual model like that does not re-

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quire any data at all! Unless one wants to compare the model with real data, which would indeed make it more data-demanding, but I would argue that it would be just as data-demanding as the approach taken here. In fact, in my opinion, using surveys and interview data is a very data-demanding approach (although a very valuable and useful approach).

Response: We agree with the reviewer and will phrase our assessment more carefully in the revised paper, also taking into account his/her previous remarks on other socio-hydrology studies.

Referee comment: In the discussion the authors state that the division into SHS and the testing is an iterative process. From the descriptions it seems that the “low char” and the “high char” are quite different from each other, so I wonder why the authors did not update their SHS based on the analysis?

Response: We agree that low char and high char are quite different in elevation and population density because of their ages. As with the other SHS that we distinguish, we are here looking at general patterns of human-river interactions as compared to the other SHS. In comparison to SHS1 and SHS 3, both types of char are located in the river bed and their inhabitants are exposed to more regular flooding and river erosion (as the bar diagrams show). If we zoom in further using our extensive data set, we expect to be able to distinguish sub-SHS within the current three SHS. This is indeed what we are planning to do in the near future for SHS1 and SHS3. We will be publishing further research that finds differences in human-river interactions within SHS1, depending on the level of protection offered by the levee and the degree of urbanisation. These differences could be argued to constitute different SHS, but here it is the research objective that indeed determines whether further splitting up of one SHS is useful. So the scale of analysis to some extent determines the level of detail included in the SHS that are recognised, but not absolutely since merging the three SHS we distinguish does not make sense. This does not undermine the usefulness of looking for SHS in a specific area, it merely shows that it depends on the scale of

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investigation which differences can be distinguished.

Referee comment: In the discussion the authors state that: “Each SHS shows distinct features when comparing flood-society interactions, proving that the dynamic interactions of floods is dependent on different hydrological and societal characteristics along the Jamuna River.” The authors do indeed describe the different hydrological and societal characteristics of the three SHS, however, I miss the translation to the different dynamic interactions that follow from these characteristics. The description stops at describing the characteristics and does not describe the interactions and feedbacks that we are interested in in socio-hydrology. Are there in fact different ways of coping with floods in these three SHS? And if so, why do they behave differently? Which societal and hydrological combinations of characteristics lead to which kind of interactions?

Response: In the paper we described the different hydrological and societal characteristics of the three SHS as a narrative in which we showed how different flooding events co-shape societal behaviour (migration, livelihood changes, homestead type, etc.) of the SHS. Inhabitants of these areas have adapted to these different physical conditions. Each SHS therefore has different coping strategies with flooding. We will expand our discussion of this issue in the revised paper, as suggested by the reviewer.

Referee comment: In the conclusion, the authors conclude that the concept draws attention to how historical patterns of coevolution of social behavior, natural processes and technological adoptions give rise to different landscapes, different styles of living, and different ways of organizing livelihoods, while in fact the concept as it is presented here and applied to the case study, does not do this at all. It leaves me wondering what the different patterns, different styles of living, etc. are that emerged in these three SHS.

Response: We are a little puzzled by this comment. We think that our narrative description of the three spaces together with the statistical analyses of survey data show that three distinct socio-hydrological spaces with different landscapes, different styles

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of living, and different ways of organizing livelihoods. Since we have not convinced the reviewer, we will expand the descriptive section accordingly.

Referee comment: A large part of the discussion is about the spatial boundaries. The authors stress the point that the boundaries of the SHS move in time and that the physical boundaries between the three SHS are not fixed in time. While this is true, I do not really see why this is of importance. The SHS you define are defined by the characteristics of the system, not by the exact coordinates. For example, the authors define SHS 2 as a char within the river, if the river moves a kilometer and the char moves with it (or a different char forms), this does not change the definition of SHS 2 as a char within the river. The same holds for the social boundaries, if one person moves to another SHS and adopts the strategies of that SHS, then the SHS does not change, does it? I think the authors could spend less attention on this in the discussion.

Response: We agree fully with the reviewer that the exact boundaries are not important for the use of SHS. Interestingly, reviewer 3 voiced exactly opposite concerns, namely that the exact boundaries are important. In anticipation of this second concern, we added this discussion to the paper. We will make this clearer in the revised paper. The boundaries are not fixed in time because the Jamuna River is very dynamic. The SHS definition will not change if the boundary changes over time but for this research we collected and analysed primary and secondary data based on 2016 bankline of Jamuna River. If the boundary changes and respondents move from one space to another space then it might affect the results we showed in this paper.

Referee comment: Figure 4 is not really consistent. The legend is placed in different locations, some graphs do show the total percentage on top of the bars and others don't (and some do but miss the %). Also, when printed in black and white, the difference between the color of SHS 1 and SHS 3 is not clear.

Response: We will replace figure 4 with an update version in the revised manuscript.

Referee comment: The format of figure 5 does not really allow for an easy comparison

between the three SHS, I would suggest choosing another type of figure.

Response: We will try to find another type of figure to show easy comparison. If possible we will replace it in our revised manuscript.

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