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Hydrology and Earth System Sciences
Discussions

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 #3

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 aim to present a "new way of looking at and analysing socio-hydrological systems", and use a study area in the highly dynamic floodplains of the Jamuna river in Bangladesh. After reading the introduction, I wanted to know: -how

to construct and define a SHS -how the SHS improves or benefits the field of socio-hydrology, -how to apply the SHS to other research areas, or even to other areas within the country. I am impressed by the authors' knowledge of the study area. The methods used to construct the survey seem sound, the questionnaires (ESM1) suitable to the research question at hand. The topic is of interest to HESS readers. Overall, the paper seems to be a further development to the classification performed in Di Baldassarre 2013 and 2015 and rests on the assumption of two patterns of society river interactions. (see also p. 5, line 1-5). While I understand that the concept of SHS is new to the field in terms of vocabulary, I don't see why the classification from Di Baldassarre 2015 which is criticized by the authors cannot simply be performed on a smaller scale. Do we need SHS for that? How could the SHS concept be extended to the entire country? I am also not convinced by the results that this approach and the presented results draw "analytical attention to how flood dynamics co-evolve with societal dynamics".

Response: To use the concept of SHS empirically, we propose a two-step approach. First, a thorough understanding of a specific floodplain system (geography, history, technology, societal occupation etc.) results in a preliminary classification of the study area into distinct SHS. Second, the classification is tested for statistical significance using available or newly collected data. If the classification is not statistically significant, merging or splitting of categories should be considered where different social dynamics may be the reason for splitting (repeat step 1). 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. In one way, our classification is indeed a further development to the classification performed by Di Baldassarre 2013 and 2015, since it is based on two overall possibilities for response to flooding: protection or adaptation. However, in our case area we observed additional details in these responses that lead us to propose three human-river interactions rather than two. One bank is with man-made embankment and another bank is with natural levee. Because of the differential treatment of the right and left bank, and the existence of the chars in the middle of the river, three distinct system dynamic emerged. The third system is the char area which gained special attention in the SHS concept. The importance of using SHS as an intermediary step in the field data analysis 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 coworkers, 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. We argue that all spaces where humans interact with water are one or other type of SHS. However, not all SHS will occur in all places. The SHS concept suggests that the interactions between society and water are place bound because of differences in social processes and river dynamics, but also generalisable since similar SHS patterns may be found elsewhere. Rather than a generalized model for understanding how such interactions occur, the concept draws analytical attention to how flood dynamics co-evolve with societal dynamics. As for the Jamuna floodplain, Regarding the question of boundaries, we agree that bound-

aries 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. Patterns of SHS (such as the two options proposed by Di Baldassarre, or our three SHS) can be used to compare two different regions. 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. We argue that the concept "draws analytical attention" to how flood dynamics co-evolve with societal dynamics because the use of SHS forces the researcher to pay explicit attention to these interactions in his/her analysis.

Referee comment: My initial questions were only answered partly. I am unfortunately not sure how this method is an improvement or benefit to the field of socio-hydrology. I see the study's strong point in the extensive empirical field survey, but feel that this requires more work to show statistical relationships gathered from the individual SHS and then comparing those to hydrological data (flood extent, erosion, etc.).). I also cannot easily detect how the SHS approach is useful in specifying the interaction between sociological and hydrological processes in the sense of the two-way feedbacks

key to socio-hydrological approaches.

Response: We hope we have now answered the reviewer's questions to a large extent in our reply to the first comment. Regarding statistical significance, it is not our goal to determine statistical relationships between physical and socio-economic data; we suspect that this will not yield significant correlations. However, we can show that individual variables are significantly different between the three spaces, which is what we do in our paper. Combining such statistics with narrative descriptions provides, in our view, enough evidence for the existence of three different SHS in the Jamuna floodplain. Finding statistical relationships for variables describing human-river interaction would be a next step towards the mathematical modelling practiced by socio-hydrology. We do not believe that such modelling is feasible in the reality of data scarcity and indeterminacy of relationships.

Referee comment: At present, SHS still seems to be a rather descriptive and classical approach to me, with the statistical methods mainly from the field of basic exploratory data analysis. While there is no harm in that, the authors do stress that they present a "new approach". The extensive surveys should be brought into context with actual observed data (especially Sec 5.1-5.4), in particular if the authors consider using this approach to make predictions (although it is unclear to me what they wish to predict and how, this is only mentioned in the beginning of the paper and should definitely be elaborated on). The authors should also address the uncertainties in their work – there are a lot of biases inherent in conducting surveys, and I'm not sure the time span 1960-2016 is feasible due to the large number of external factors that could also contribute to e.g. migration or farm land area (such as the independence of Bangladesh in 1971).

Response: The reason we label our proposal of SHS as 'new approach' is not based on the methods we use. They are indeed classical. The reason we present socio-hydrological spaces aa a new approach is because of the methodological innovation it entails. We think SHS provides a methodological bridge between two contrasting approaches to studying human-water interactions: hydrosocial research based in so-

ciology 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 analysisâĂŤ: 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 socio-hydrological 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. We disagree with the reviewer that surveys do not yield ‘actual observed data’, as implied in his/her advice that “extensive surveys should be brought into context with actual observed data”. In sociological research surveys are an established way to collect objective data, especially when, as we did, protocols for representative sampling are followed. In fact, we contend that our survey data are at least as accurate as government statistics, which are also collected using the survey method. We refer to government statistics and other data such as satellite images where they are available, but there are indeed limitations on the availability and accuracy of such data for the whole period. For example, river level data are available at several sites, but cannot be related to inundation extent or depth since a detailed digital terrain model is not available. Also, population data are not available at the de-

tailed level that we require. This is why we used the survey to collect interviewees' recollections of flooding, migration and flood damage. We addressed the uncertainty of getting accurate information from the surveys related to human recollection by arranging focus group discussions to minimize the errors. We do agree that uncertainties related to external factors like independence of Bangladesh in 1971 and its effect on migration is probably substantial, but this should affect the whole study region equally. More important uncertainty is introduced by shifting boundaries: as discussed in our paper, both the physical boundaries of the river bed and the human population move in time, which makes for unclear boundaries of the SHS. This issue is irresolvable and will need to be kept in mind with any interpretation of our results. Again, our aim is not to provide statistically significant correlations, but to present a lens with which to analyse field data to find patterns, which can be used in subsequent research to look for such correlations. Our future publications will include more details on historical developments, where we will make more extensive use of these data and combine then with government records where possible. We do not set out to be able to make predictions, and we apologise if the reviewer has interpreted our intentions in this way. Our aim is to better understand human-water interactions, and to provide a tool that helps to do this for concrete situations. By extension, we hope this this tool is also useful for policy-related studies since it highlights that there is no 'one size fits all' solution. We will make sure there is no doubt about our goals in the revised paper.

Referee's minor and major remarks: Section 3.1: Not entirely sure why this specific study area was chosen. How big are the individual SHS?

Response: We targeted the Januma river for this research because of the variety on flood management options and related human responses. We selected the upstream part north of the coastal zone because the coastal zone exhibits too many factors to be able to grapple with in this phase of research: there are tidal influences and cyclones and different stages of flood protection through polders. We have chosen this specific study area initially for the reason of being able to arrange access to the sites, i.e.

obtaining government permissions was relatively easy here because of personal ties to the area of the lead author. However, we assert that the same SHS also occur along much of the Jamuna upstream (in India) and downstream until the coastal zone in Bangladesh. The area of SHS1 is 74 km2, SH2 is 295 km2 and SHS3 is 126 km2; we will make sure to mention this is the revised paper. 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.

Referee's minor and major remarks: Section 3.2: Why are socio-economic factors not relevant for the construction of the SHS? I would assume this makes a difference in how the livelihoods are affected by flooding in the individual SHS. (Add-on: on p.8, line 16 the occupation is listed as a delineating factor. I don't see this in section 3.2, where the delineation is based on "differences in geophysical characteristics and flood protection measures".

Response: During our delineation of SHS, we started with the physical and technical features in the landscape, and then found that socio-economic factors varied along with the physical ones, so they are definitely relevant. This sequence of defining a SHS is in accordance with the main direction of cause-effect relations in our case area: different SHS emerge due to differential degrees of protection. Theoretically, socio-economic factors could indeed be the logical starting point for the delineation of SHS in floodplain areas. We will make sure to remove the inconsistencies found by the reviewer in our

revised manuscript. We are currently exploiting our data further to investigate exactly this proposition. to be published at a later date. Within SHS1 the protection offered by the embankment varies according to rural/urban land use, and we are analysing whether this is a case of SHS being determined by socio-economic conditions.

Referee's minor and major remarks: Section 3.3: Is "evidence" the right word to use? Perhaps "data" is more suitable.

Response: We will replace "evidence" with "data".

Referee's minor and major remarks: Sections 4.1-4.3: can these be classified as Results? I would consider this to be part of the methodology/study area description. (VERY narrative)

Response: Section 4.1-4.3 are classified as Results because information within these sections are formulated from reconnaissance surveys and secondary data.

Referee's minor and major remarks: Section 4.2 Could benefit from references on chars. Sometimes, chars is in quotes, most of the time not. Please be consistent.

Response: We will be consistent in our reference to the chars in our revised manuscript.

Referee's minor and major remarks: Section 5.1 How was this verified? Using the household's answers can be deceptive, as there is a strong bias to the length of time since the last flood event. Also, of course a char in the Jamuna cannot be flooded by another river.

Response:. Sources of flooding resulted from household surveys and were verified with focus group discussions, since individual answers can indeed be deceptive. Further comments on our data collection methods were made in our response to the first comment.

Referee's minor and major remarks: Sections 5.4 Using only household surveys to

state that e.g. "riverbank erosion is experienced in each zone", and to comment on how high these rates are without presenting physical observations is in my opinion not conclusive. I strongly suggest backing these statements up with observed erosion data. Also, how far away from the river do your respondents live? This can bias the answers, making the statements even more inconclusive. Section 5.7: how is this section relevant?

Response: From time series satellite images it is possible to calculate the erosion in each spaces. CEGIS is doing this calculation for the whole Jamuna River every year. We mention the observed data in Sections 4.1-4.3 with the reference of CEGIS. People who are living near the banks or chars are experiencing with erosion and moving to other places. Though the river is very dynamic, many of them experienced erosion for several times. We captured their recollection using the surveys and focus group discussions. Regarding Section 5.7: depending on socio-economic conditions and flood damages, people's investments in their homestead is different. Homestead patterns are therefore an economic marker for human-river interactions in different spaces.

Referee's minor and major remarks: p. 3, line 24ff You state that the concept's importance lies "in its emphasis on how the interactions between society and water are always place-bound" Perhaps I use a different interpretation for the word place-bound, but the levee effect you mention afterwards is anything but place-bound. Rather, you describe yourself how this was introduced for the Po floodplain as well as by White in the US. Please clarify.

Response: The levee effect is a phenomenon that can indeed be observed to some extend across the world where society has decided to protect itself against flooding. It is the proposition of this paper that this phenomenon, in interaction with society, in turn gives rise to different socio-hydrological spaces in different places. SHS are thereby place-bound, but they also show patterns which can be turned into a typology, as we explained above. We will elaborate this dual character of SHS better in the revised paper.

Referee's minor and major remarks: P.5, line 3ff please clarify what you mean in this sentence – unclear to me.

Response: We agree with you that the sentence is not clear. We will rewrite the sentence as "We illustrate how the concept can be used in a more detailed way by doing refined analysis for the Jamuna floodplain in Bangladesh".

Referee's minor and major remarks: p.5, line 17: I am surprised that you do not mention any of the extreme flooding after 2007 – just last year severe flooding in the region occurred.

Response: We will add references in our revised manuscript.

Referee's minor and major remarks: On p.6, line 10 you do mention the flood of 2016, so please check for consistency. Perhaps it would also be good to just name those years in which the study area was extremely flooded, not "general" extreme flood years in Bangladesh. p.6, line 11: how much percent was flooded?

Response: We will ensure consistency in the revised manuscript and update the record. From household surveys we observed that our case area's extreme flood years were similar with the general extreme flood years in Bangladesh. Due to embankment breaching 100% of SHS1 was flooded in 2016.

Referee's minor and major remarks: p.8, line 1: when were the focus group discussions with respect to the study years and the flood season? Also, during which season/months were the surveys conducted? p.8, line 10: Frequency analyses for what? The following sentence is unclear.

Response: The focus group discussions were conducted in the January to April of 2016 and November of 2016. The household survey were conducted from October 2015 to April 2016 and September 2016 to December 2016. We will add this to the revised manuscript. We did flood frequency analysis. We will add the word "flood" in our revised manuscript. We also performed statistical analysis to check for relevance

of the differences between the three SHS on all data we used for the analysis.

Referee's minor and major remarks: p.8, line 26: how much of the bankline is eroded?

Response: The rate of bankline erosion is not fixed in the area. Along the right bank erosion started to reduce from the early 1990s. Erosion rate varies from 800 to 2,000 ha per year (CEGIS, 2007). We will add this information to our revised manuscript.

Referee's minor and major remarks: p.9, line 29: migration to where? Outside of SHS3?

Response: From surveys it is observed that most the people are migrating within the spaces. Very few of them are migrating outside SHS3 because they do not have access to land there. We will specify this in out revised manuscript.

Referee's minor and major remarks: p.10, line 17: is the unexpected flood frequency observed through e.g. data or satellite imagery?

Response: This information was obtained from our survey data. We have collected flood information from about 900 household respondents. All the respondent from SHS2 confirmed that they have faced flooding in every year while the respondents from SHS1 and SHS3 have informed us that they have faced flooding once in two years. The flood frequency (Figure 4b) is obtained from our survey data. We have also asked these information in the focus group discussion meetings to verify the frequency.

Referee's minor and major remarks: p.11, line 6: please include the flood damage information in the description of data and methods. How did you analyse what? How do the individual floods compare with respect to magnitude and flood duration in the individual SHS in each of those years? What about the study years?

Response: We will include the flood damage information in the description of data and methods in our revised manuscript. We have collected their assessment of damages for all the flood years that the respondents could remember. We analyse the average damages of households per year. Flood durations are not same for all years or in whole

area. The questionnaire was made available as supplementary information to provide all details on the data that was collected.

Referee's minor and major remarks: p.12, line 1: is there a citation for this? How low is the average elevation? It would be good to include this in the general description of the SHS.

Response: The value we showed in the text is produced from our data analysis. We will include this in the general description of the SHS in our revised manuscript.

Referee's minor and major remarks: p.12, line 13: how is the number of farmers with large households determined? If only from the questionnaire, how did you control for other biases such as migration, change of occupation? How certain do you think this number is? I would argue that the changes in SHS1 are not significant, and that they in particular cannot be attributed solely to consecutive flood events. Also, why 1960? Does it not make it more difficult to evaluate the results before/after Bangladesh became independent? When was the embankment in SHS1 built? Could the reduction of large farms not simply be due to other socio-economic developments in the region? Is this also solely based on information from questionnaire?

Response: Farm sizes are determined according to the classification by the government of Bangladesh. Details of farm sizes are available in "Census of Agriculture 2008, National series, Volume-1, Bangladesh Bureau of Statistics, published in November 2010, but these do not present the level of detail that we need. We collected data about migration and change of occupation at household level and also try to minimize error trough focus group discussions. The changes in agricultural farm land in SHS1 is indeed not significant while it is significant in SH2 and SH3. We took 1960 as starting point because the embankment was constructed in 1960s. Change in agricultural farms are solely based on information from household surveys. We will make sure to mention these details in our revised paper. We do agree that uncertainties related to external factors like independence of Bangladesh in 1971 and its effect on migration is

probably substantial, but this would affect the whole study region, though probably not to the same degree. The same applies to the reduction in farm size: due to growing population, the available land per family has reduced everywhere. We will make sure to mention these caveats in the revised paper.

Referee's minor and major remarks: p.12, line 24: this is a major concern I also share in these types of studies (and I am not convinced this can be verified through a focus group discussion- how?). This is also why I stress the need for observed data.

Response: As indicated above, we disagree with the reviewer that surveys do not yield 'actual observed data'. In sociological research surveys are an established way to collect objective data, especially when, as we did, protocols for representative sampling are followed. In fact, we contend that our survey data are at least as accurate as government statistics, which are also collected using the survey method, and definitely more detailed and extensive than the statistics that are available from the government The large number of surveys and the objective sampling method do compensate to a considerable extent for uncertainties in individual responses.

Referee's minor and major remarks: p. 13, line 7: increased by how much over what time period?

Response: Population density has increased from 600 to 1500 person per km2 in SHS1 during the period of 1960 to 2011, while in SHS2 it is from 200 to 400 person per km2 and SHS3 it is from 330 to 800 person per km2. We will make sure to include these details in our revised manuscript.

Referee's minor and major remarks: p. 13, line 15: Did the respondents arrive or leave? Response: In this case the respondents have arrived. We will make sure to clarify this in the revised paper.

Referee's minor and major remarks: The last two sentences of this paragraph are unclear to me. p. 14, line 11: which interactions between sociological and hydrological

processes did you identify? Which two-way feedback are you referring to?

Response: The hydrological processes we have identified are flooding and river bank erosion and the social processes are migration, livelihood changes of the households. We will mention this as such in the revised manuscript.

Referee's minor and major remarks: p. 14, line 20: when do you consider the initial selection of the SHS to have "statistical meaning"? How is this transferable? How can you be sure they are consistent over time? What is the added value of SHS if their boundaries are mobile?

Response: Because the identified SHS show statistically significant differences when selected variables are compared we call the SHS to have "statistical meaning". The boundary of the SHS are not consistent over time as the Jamuna River is very dynamic and erosion occurs in almost every year. This is a limitation for delineating the SHS boundaries. However, the main purpose of proposing and using the concept of SHS is not to define once and for all the exact boundaries of the SHS. Its main purpose lies in providing a lens through which to analyse the complex reality of human-river interactions, and to find patterns in this that can help to understand these relationships. Regarding the question of boundaries, in research 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). 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. Put differently, in the words proposed by reviewer #4: the SHS we define are defined by the characteristics of the system, not by the exact coordinates. For example, SHS 2 is define as a char within the river; if the river moves a kilometre 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, it just changes its location. 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.

Referee's minor and major remarks: p. 15, line 18 ff: I agree. Please expand your methodology to include when your selected SHS need to be updated – for now, this is not quite clear.

Response: We could envisage that the description/typology of the three SHS need to be changed when one of the main subsystems changes extensively. For example, if major flood management measures are brought in, if the river course changes suddenly, if economic development enables most char dwellers to find work elsewhere. Otherwise, the exact boundaries are not a major concern – see our previous reply.

Referee's minor and major remarks: p. 15, line 22: what advance did you show? Which questions did you now answer that could not be answered before? How can you apply this in a broader sense?

Response: We hope that we have replied to this comment by our extensive replies above. We will summarise these arguments in the conclusions. As to the broader use of SHS, The use of SHS forces the researcher to actually go to the field, talk to inhabitants and officials, and obtain a thorough understanding of the specifics of the location. This also means that the use of SHS will make socio-hydrological analyses more policy-relevant by highlighting that there are no 'one-size fits all' solutions. In terms of practical use, it can for instance be added as additional element to rapid rural appraisals, or other social assessments, to draw attention to how material conditions (hydrological and technical/infrastructure) co-shape social situations.

Referee's minor and major remarks: p. 16, line 16: To which policies, for example? What is a "rapid rural appraisal“?

Response: The policy could relate to disaster management, migration, flood management. Unfortunately, there is no generally accepted definition of rapid rural appraisal. Rapid rural appraisal is most commonly described as a systematic, semi-structured activity out in the field by a multidisciplinary team and is designed to obtain new information and to formulate new hypotheses about rural life in an intensive, short campaign.

Referee's minor and major remarks: Literature cited: the work largely cites and even uses figures from the same two papers (Di Baldassarre 2013a and b). While this is of course expected when developing the work of one research group further, what exactly is the point referencing literature such as the authors did in p.3, line 14 or p.4, line 15? I suggest to simply let the reader know where to look for the information or statement in the sentence before. FICHTER and nhc, 2015 does not look correct.

Response: we will simplify the references as requested by the reviewer. We will correct the error in the reference to FICHTNER and nhc (2015) Morphology: Feasibility Report and Detailed Design Priority Reach: Final Report, Annex A, Vol 1 River Bank Improvement Program.

Referee's minor and major remarks: Language is mostly good, but could definitely benefit from a careful read-through by a native speaker or a language editing service. E.g., p 2 Line 30 sees three uses of the word "different” in one sentence, and there are numerous grammatical or typographic mistakes throughout the paper. Be careful to introduce abbreviations before you use them (e.g. in abstract). p.5, line 27: "To evidence and understand: “ sounds a bit awkward p.8, line 21: "inundated“ instead of "ponded“? p. 15, line 14: what is "people mobility“?

Response: We will do a detailed revision of the text to eliminate grammatical and typographic mistakes in our revised manuscript.

Referee's minor and major remarks: Figure 2: cannot decipher the black names when printing out copy, perhaps resolution needs to be better. I had to look really closely to detect the boundaries of the individual SHS. Why is the land colored red? Figure 4: please include the number of respondents for each subset. Figure 5: Perhaps consider labeling all axes outside of plot or all inside plot (consistency). Also, it should say "SHS3“. Starting when can a farmer be considered to sustain the own household? Figure 7: why is the land red? Why was the dry season chosen? A different coloring would greatly benefit the readability of the figure.

Response: We will replace the figures in our revised manuscript.

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