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Reply on RC1

Md Feroz Islam et al.

Author comment on "Physical controls and a priori estimation of raising land surface elevation across the southwestern Bangladesh delta using Tidal River Management" by Md Feroz Islam et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-300-AC1, 2021

Referee comment on "Physical controls and a priori estimation of raising land surface elevation across the southwestern Bangladesh delta using Tidal River Management" by Md Feroz Islam et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-300-RC1, 2021

Reviewer's comments:

This study aims to quantify the potential effects of Tidal River Management (TRM) in elevating low-lying areas (beels) in southwestern Bangladesh, building upon an existing work by Adnan et. al. (2020). The study addresses the non-linear nature of sediment deposition during TRM, which underpins its main contribution. However, I have a few observations in terms of motivation, clarity, and justification of this study. I would like the authors to address the following comments diligently before the manuscript can be considered for publication.

Authors' response

We thank the reviewer for the suggestions. The reviewer comments (in italic) and point by point response of the authors' to the comments are presented in the following section.

Reviewer's comment

Line 19-20: "Beels in the western part retain more sediment because of lower average land surface elevation". Does sediment deposition only depend on the existing elevation of the selected beels? Sediment concentrations in adjacent rivers of the select beels vary, which may also cause heterogeneity in the deposition. The authors have also acknowledged this fact in the discussion section.

Authors' response

The authors thank the reviewers for pointing that out. Sediment deposition and sediment delivery inside the beels depend on numerous factors including the average land level but also indeed for instance the sediment concentrations in the adjacent rivers. The line is adjusted as:

"Lower average land surface elevation is one of the reasons for the beels in the western part to retain more sediment."

Reviewer's comment

Line 376-377: "This means that sediment deposition in beels depends mostly on suspended sediment concentrations (SSC) in the feeding river". They should revise the abstract to provide a clear message from their study.

Authors' response

The abstract is adjusted to provide more clarity by adding the following sentences:

"Our model results indicate that these five variables and their interaction are significant for sediment deposition per day where SSC and BA have high impact, TR and ID have moderate impact and IW has low impact on sediment deposition."

Reviewer's comment

Line 22-23: "Thus, the length of time of TRM application in cyclic order will need to vary across the delta to counterbalance RSLR". It is not clear what type of variation in the length of time of TRM application that the authors are referring to.

Authors' response

The line is adjusted as:

"Thus, the length of time of TRM application in cyclic order will need to vary across the delta from one to multiple years to counterbalance RSLR, depending on current beel land surface elevation and local TRM sediment accumulation rates."

Reviewer's comment

Line 94-95: "Although their regression model had a coefficient of determination (R2) of 0.88, it remarkably did not include tidal range (TR), suspended sediment concentration (SSC) and surface area of the beel." I think this statement is partially correct. The authors have only referred to the criteria for flood susceptibility modelling in Adnan et. al. (2020), ignoring the indicators used for simulating sediment deposition in 234 beels. Section 2.5.1 in Adnan et. al. (2020) includes the following statements: "To identify suitable TRM sites, five indicators were selected: i) tidal prism; ii) river salinity; iii) flood-prone areas; iv) crop production; and v) size of the 'beel'." So, I would suggest the authors revise the statements written in lines 90 – 95.

Authors' response

Authors thank the reviewer for the suggestion and the lines have been adjusted as:

"Adnan *et al.* (2020) considered tidal prism, river salinity, flood-prone areas, crop production and size of the beel to identify suitable TRM sites. Although their regression model for flood susceptibility had a coefficient of determination (R^2) of 0.88, it remarkably did not include tidal range (TR) and suspended sediment concentration (SSC)."

Reviewer's comment

The contribution of this study needs to be clarified. I feel the authors should clearly write the main argument of their study. They could summarize the key research gaps in the existing relevant literature at the beginning of the last paragraph in the introduction section.

Authors' response

To clarify the research gaps and objective of the study line 99-101 is adjusted as:

"To evaluate how TRM may help to raise the land in polders in southwestern Bangladesh, a quantitative understanding is needed on how different boundary conditions, beel topography and geographic setting determine sediment deposition, and how these vary across the SW Ganges delta. This understanding is currently lacking."

The objective and the relevance of the study are presented in line 101-104 as:

"In this study we aim to determine the effect of physical controls related to the hydrodynamics of the river and how geo-morphodynamics of beels control the sediment deposition in those beels using TRM. We hereby evaluate the possibility to raise the land surface elevation of the beels in the southwestern region of Bangladesh through sediment deposition using TRM to counterbalance yearly RSLR."

Reviewer's comment

This study used a range of datasets. It would be convenient for readers if the authors provide a summary table (including sources and resolution where applicable) of data used in this study.

Authors' response

The data set used in this study was collected from Islam *et al.* (2020 and 2021) where tables are presented with the source and resolution of the data. A table has been provided following the suggestion of the reviewer. Authors have also referred the articles in lines 183-184 as:

"For the scenarios, we used the TR and the SSC that occur within the three flow regime regions during the different seasons as defined by Islam *et al.* (2020, 2021)."

Reviewer's comment

Figure 3: How were the spatial boundaries of four sample beels determined? It is not clear in the manuscript.

Authors' response

To clarify how the spatial boundaries of the beels for different scenarios were selected the following sentence has been added at line 188:

"The boundaries of the beels for different scenarios were selected in such a way that the surface area of the beel met the criteria of the scenarios presented in Table 1."

Reviewer's comment

The policy implications of this study are not clear. In the discussion section, the authors have critically evaluated the effects of the physical controls on sediment depositions across various beels, and their impacts on land elevation. However, it is equally important to provide a clear message to the policymakers by translating the scientific finding into policy measures.

Authors' response

The reviewer has rightly pointed out that this study discusses the physical controls of the sediment deposition inside the beel. We have briefly indicated the implications of our findings to the policymakers by taken into account the socio-economic aspect of TRM, as now presented in lines 506-509. It is beyond the scope of our paper to translate our scientific findings into detailed policy measures. The text prepared reads as this:

"The regression model presented here can provide a priori estimation of sediment deposition and the potential to raise land surface elevation for the beels. This can assist the decision makers to prioritize the location of TRM operation. However, TRM operation is not only understanding all physical constraints but should include socio-economic aspects as well. Therefore, sediment deposition processes as well as socio-economic aspects of TRM should be considered to determine an optimum flood rotation scheme for the beels in southwestern Bangladesh. A master plan is needed to implement TRM as a prolonged period of time and a large region should be covered. This may be part of the implementation of the Bangladesh Deltaplan 2100."

Reviewer's comment

This study quantified TRM's impact on land elevation only from the perspective of physical environment. But historically the success of TRM was interrupted by various social factors such as social unrest, conflict, and issues related to compensation. I understand these are *outside of the scope of this study. However, I would like the authors to provide a few statements on potential uncertainties in the results.*

Authors' response

The reviewer has rightly pointed out that this study discusses the physical controls of the sediment deposition inside the beel. We fully agree that the success of TRM is not only depending on physical constrains, but socio-economic factors are essential for TRM as well. However, the socio-economic aspects were beyond the scope of this study. Therefore, we have included this point as discussed in the earlier remark explained in lines 149-161 as:

"Islam et al. (2020) calibrated the 2D hydro-morphodynamic model for Pakhimara Beel by comparing the observed water level, discharge and SSC with simulated ones. Manning's coefficient, shear stress and settling velocity were the primary parameters for calibrating the hydrodynamic and morphodynamic models. Sensitivity analysis of the model was carried out with varying Manning's coefficient from 0.1 s $m^{-1/3}$ to 0.01 s $m^{-1/3}$, shear stress from 0.01 N m^{-2} to 0.1 N m^{-2} and settling velocity from 0.0001 m s^{-1} to 0.001 m s^{-1}. To understand the uncertainty of the model, the coefficient of determination (R^2) and the normalized root mean square error (NRMSE) were calculated by comparing the modelled results with the observed data for the different input variables. Best model performance was obtained using a spatial average value of 0.032 s $m^{-1/3}$ for the Manning's coefficient, shear stress of 0.08 N m^{-2} and settling velocity of 0.0005 m s^{-1}. The related R^2 for water level, discharge and sediment concentration were 0.87, 0.88 and 0.84, respectively. The NRMSE (%) for water level, discharge and sediment concentration were 9.7, 16.6 and 18.3, respectively (Islam *et al.*, 2020). Islam *et al.* (2020) also captured the effect of spring and neap tide during different seasons by making simulations for three tidal conditions and time period of 14 days. For this study, we carried out the similar range of 14 days simulations and similar parameterizations to capture the full range of tidal cycles for three flow seasons. The resulting sediment deposition in a beel was calculated in tons per day."

The uncertainty of the regression models are described in table 5 and in lines 318-330 as:

"NLM1 shows a larger spread and seems to overestimate SPD for low and higher values when compared to the other two regression models. The coefficient of determination (R^2) of the three regression models ranges between 0.61 to 0.84 for the training sets and 0.29 to 0.94 for the testing sets (Table 5). The averages for the two sets are, however, highly comparable. The predictive skill of the models generally increases with increasing number of variables. NLM1 using only BA and SSC as predictors for SPD, results in relatively moderate average R^2 of 0.61 and 0.71 for the training and testing data sets respectively (Table 5). NLM2 using TR, SSC, ID and BA and NLM3 using TR, SSC, ID, BA and IW produce better results. The mean R^2 for NLM2 are 0.77 and 0.74 for training and testing data sets respectively and the mean R^2 for NLM3 are 0.77 and 0.76 for training and testing data sets respectively (Table 5). Although IW correlates statistically significant with SPD in the ANOVA test (Table 2), it hardly contributes to better prediction of SPD with exponential coefficients of 0.02 -0.14 (Table 4). The normalized root mean square error (NRMSE) ranged between 0.3 to 0.5 for the training datasets and 0.15 to 0.49 for the testing datasets (Table 5). The mean of NRMSE for NLM1 for the training samples is higher than obtained for NLM2 and NLM3. The mean NRMSE obtained for the testing dataset is almost similar for all three NLMs."

To describe the uncertainty related to the parameters the following lines have been added in section 4.2:

"Among the parameters considered for non-linear regression models, SSC is the most difficult one to have measured data across time and space and, has large uncertainty. Tidal range (TR) and ID also vary in time and space and, are estimated from observed water level which has lower uncertainty compared to SSC. The width of the inlet (IW) and BA are related to the geographic setting of the beels and have well-defined values when a TRM is operated. Therefore, SSC has the largest uncertainty while it is a major parameter with the highest correlation with SPD."