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Discussions

Interactive comment on "Low-hanging fruits in large-scale fluvial landscaping measures: trade-offs between flood hazard, costs, stakeholders and biodiversity" *by* Menno W. Straatsma et al.

Menno W. Straatsma et al.

m.w.straatsma@uu.nl

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R3: General comments My thanks to the authors and editors for the opportunity to review this manuscript. There are many aspects of the processes reported in this manuscript that resonate deeply with my experience working with government agencies and stakeholders in floodplains of large rivers of North America. I think it is a useful manuscript that will provide a good example for numerous other planning efforts.

Reply: We are grateful of the characterization of the paper as useful and that it will provide a good example for many planning efforts. We highly value this characterization, because R3 has personal experience with planning and government agencies.

R3: Specific comments I would start with a request to define some terms to gain a broader understanding among an international audience. Different river-management communities and languages have different terms for river features, and it would help improve communication if the authors invested in a few words to define terms. For example: For many – but perhaps not all – North Americans would expect that “landscaping” means planting flowers and shrubs for aesthetic purposes. Landscaping in the context of this manuscript is reconfiguration of the channel-floodplain geomorphology, essentially terraforming. Similarly: groynes = wing dikes, or more generically, channel-training structures. Embankments = levees. Braid hedge = I have no clue. Etc. I do not recommend abandoning the European terms; I’m simply requesting a parenthetical definition to help in the translation.

Reply: We recognize the difference in terminology and we struggled at times reading the American terms. Parenthetical definitions were added to the revised version.

R3: I found the scale, scope, and approach were very useful in the context of regional planning. The value was readily apparent in the multiplication of scenarios as channel configurations, roughness, upstream hydrology, and sea-level rise scenarios were combined. Granted, the hydraulics are simplified, but I believe the modeling would be useful in other at a planning level to filter scenarios for efficiency and to educate stakeholders about the opportunities and constraints.

Reply: This is exactly the function of this type of model, and we are happy that its value as such is perceived.

R3: I was surprised that floodplain sedimentation was not a bigger issue in scenarios, especially with floodplain lowering. Toward the end of the manuscript the authors assert that the sediment load of the river is diminished due to upstream reservoirs, but presumably is not zero. Would lowering scenarios also require long-term maintenance

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to continue to clean out sediment? It would be beneficial for the authors to address sediment and sedimentation dynamics.

Reply: This is a certainly a relevant remark, but we saved this topic for a follow-up paper, limiting the scope of this paper to implementation of the measure. Temporal effects due to sedimentation were considered out of scope. Morphological changes in the distal parts floodplain are small, around 0.1 mm of silt and clay for each day the floodplain conveys water. Increasing the inundation frequency to 50 days per year, the most extreme floodplain lowering scenario, only raises the distal part with 0.5 cm per year. The proximal parts of the floodplain and side channels behave quite differently. Depending on sediment availability and planform geometry, geomorphological changes have been observed of 20 cm per year. Unfortunately, the numerical modelling of the sediment entrainment and deposition with a range of grainsizes is still in its infancy. We know of a few PhDs that are working on this topic at the moment, but their results are not sufficiently conclusive to include in this paper. In addition, computation times would dramatically increase. A recent study by Van der Deijl et al. (2017) showed that sediment trapping just downstream of our model domain, sediment trapping is very low due to limited sediment concentration in the water.

Morphological modelling has been included as one of the current limitations of the research and as a potential future inclusion in the discussion.

van der Deijl, E.C., van der Perk, M. and Middelkoop, H., 2017. Factors controlling sediment trapping in two freshwater tidal wetlands in the Biesbosch area, The Netherlands. Journal of Soils and Sediments, 17(11): 2620-2636.

R3: The ecological scoring for floodplain vegetation seems limited, as the scenarios included only two treatments. North American floodplains left fallow are normally rapidly colonized by successional tree species which can have additional ecological value, especially as bird and mammal habitat. The tradeoff, of course, is that the woody communities can impart substantially greater flow resistance. The authors assert (p. 9) that stakeholders view flood safety as the main objective, but it is not clear that the tradeoff with a broader range of ecological value was adequately evaluated. It would also be useful to evaluate a "natural" roughness condition as a reference condition.

Reply: Vegetation succession after the measure implementation was indeed left out, assuming the vegetation is managed in such a way that the ecotope and trachytope distribution does not change over time. In the floodplains of the River Waal very strict rules apply for the maximum hydrodynamic roughness that is allowed, although spatial differentiation is taken into account in these rules. Exceeding the roughness prompts action from the ministry of infrastructure and water to reset the vegetation by mowing, or deforestation. Not included in the paper were try-outs with other vegetation types following a natural succession (meadows at the start, herbaceous vegetation after five year, shrubs at 10 and forest at 30 years), where herbaceous vegetation gives an increase in water level of around 25 cm, but shrubs dramatically increase water levels during design discharge with more than 1.5 m, leading to dike breaches. We did not want to extend the paper with additional methods and results due to the current length of $\sim$10 000 words excluding references and chose to refer to Makaske et al. (2011) for water level lowering and provide an indication of the potential biodiversity increase. See the new discussion section below with list of limitations/extentions, as they are not limited to morphology and biodiversity.

Our methods are limited to the implementation of the measures and the effects on the peak water levels and several extensions would create additional value for decision support. Firstly, extending flood hazard to flood risk of the protected land would provide insight in the costs of the measures in relation to the avoided loss in case of a dike breaching flood. For this the failure probability of the embankment should be assessed (Marijnissen et al., 2018) as part of a full flood risk assessment (Vrijling, 2001). Secondly, the altered flow patterns from the measures will give a morphologic response over time in the floodplain and in the main channel. Increased floodplain inundation affects the sediment deposition with a mean sedimentation rate of 0.13 mm day 1 inundation for the floodplains and 2 mm day 1 inundation at the entrance of fast aggrading secondary channels (Baptist et al., 2004). Geerling et al. (2008) found a deposition rate of 3.7 cm year-1 for a lowered floodplain next to main channel. The increasing elevation reduces the conveyance capacity and limits the longevity of the measure. For the main channel, opposite effects are projected: the Rhine delta has a reduced sediment supply due to the storage in upstream reservoirs for hydropower, which led to erosion of the main channel over the last decades (Frings et al., 2009). For the future, Sloff et al. (2014) predicted a main channel erosion of 0.25 m in the lower reach and 0.4 m sedimentation in the middle reach of the Waal, based on a 2D morphological study spanning the period 2015 to 2055. We assumed that the 1.8 m sea level rise translated into a 1.8 m rise of the downstream boundary condition and ignored the long-term morphological changes. Under natural conditions, the bathymetry would follow the rising sea level, but the results of Sloff et al. (2014) justify our assumption. Thirdly, vegetation management strongly affects the development of the hydrodynamic roughness. If the land is left fallow, vegetation succession will lead to herbaceous vegetation, shrubs and floodplain forest after 5, 10, and 30 years, respectively leading to a maximum increase in water level of 0.6 m for the IJssel distributary of the Rhine (Makaske et al., 2011). The succession positively affects the biodiversity with maximum increase of around 10 % after 30 years. BIOSAFE needs to be updated to include these succession stages, as no ecotope succession model is currently available and more detailed models (Asaeda et al., 2014;Sanjaya and Asaeda, 2017;Oorschot et al., 2016;Camporeale et al., 2013) can not yet be linked to BIOSAFE. Fourthly, compensation of land owners that have increased inundation of their land due to the removal of minor embankments could be included just like avoided damage from lower exposure to flood risk in a full cost-benenit analysis. See Mechler et al. (2015) and Di Baldassarre (2015) for further discussion on risk management. Finally, we assumed that all measures are implemented instantaneously, whereas the timing could be made dependent on updated sea level rise projections to optimize the measures under uncertainty and avoid unnecessary costs (Postek et al., 2018;Kind, 2014). These potential extensions were

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out of scope for this paper.

Asaeda, T., Rashid, M. H., and Abu Bakar, R.: Dynamic Modelling of Soil Nitrogen Budget and Vegetation Colonization in Sediment Bars of a Regulated River, River Res. Appl., 31, 470-484, 10.1002/rra.2802, 2014.

Baptist, M. J., Penning, W. E., Duel, H., Smits, A. J. M., Geerling, G. W., Van der Lee, G. E. M., and Van Alphen, J. S. L.: Assessment of the effects of cyclic floodplain rejuvenation on flood levels and biodiversity along the Rhine River, River Res. Appl., 20, 285-297, 2004.

Camporeale, C., Perucca, E., Ridolfi, L., and Gurnell, A. M.: MODELING THE INTERACTIONS BETWEEN RIVER MORPHODYNAMICS AND RIPARIAN VEGETATION, Rev. Geophys., 51, 379-414, 10.1002/rog.20014, 2013.

Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Yan, K., Brandimarte, L., and Blöschl, G.: DebatesâĂŤPerspectives on socio-hydrology: Capturing feedbacks between physical and social processes, Water Resources Research, 51, 4770-4781, doi:10.1002/2014WR016416, 2015.

Frings, R. M., Berbee, B. M., Erkens, G., Kleinhans, M. G., and Gouw, M. J. P.: Human-induced changes in bed shear stress and bed grain size in the River Waal (The Netherlands) during the past 900 years, Earth Surface Processes and Landforms, 34, 503-514, 10.1002/esp.1746, 2009.

Geerling, G. W., Kater, E., van den Brink, C., Baptist, M. J., Ragas, A. M. J., and Smits, A. J. M.: Nature rehabilitation by floodplain excavation: The hydraulic effect of 16 years of sedimentation and vegetation succession along the Waal River, NL, Geomorphology, 99, 317-328, https://doi.org/10.1016/j.geomorph.2007.11.011, 2008.

Kind, J. M.: Economically efficient flood protection standards for the Netherlands, Journal of Flood Risk Management, 7, 103-117, 10.1111/jfr3.12026, 2014.

Makaske, B., Maas, G. J., Van den Brink, N. G., and Wolfert, H. P.: The influence of floodplain vegetation succession on hydraulic roughness: is ecosystem rehabilitation in Dutch embanked floodplains compatible with flood safety standards?, Ambio, 40, 370-376, 2011.

Marijnissen, R., Kok, M., Kroeze, C., and van Loon-Steensma, J.: Re-evaluating safety risks of multifunctional dikes with a probabilistic risk framework, Nat. Hazards Earth Syst. Sci. Discuss., 2018, 1-24, 10.5194/nhess-2018-295, 2018.

Mechler, R., and Bouwer, L. M.: Understanding trends and projections of disaster losses and climate change: is vulnerability the missing link?, Clim. Change, 133, 23-35, 10.1007/s10584-014-1141-0, 2015.

Oorschot, M. v., Kleinhans, M., Geerling, G., and Middelkoop, H.: Distinct patterns of interaction between vegetation and morphodynamics, Earth Surface Processes and Landforms, 41, 791-808, 10.1002/esp.3864, 2016.

Postek, K., den Hertog, D., Kind, J., and Pustjens, C.: Adjustable robust strategies for flood protection, Omega, https://doi.org/10.1016/j.omega.2017.12.009, 2018.

Sanjaya, K., and Asaeda, T.: Application and assessment of a dynamic riparian vegetation model to predict the spatial distribution of vegetation in two Japanese river systems, Journal of Hydro-environment Research, 16, 1-12, https://doi.org/10.1016/j.jher.2017.05.002, 2017.

Sloff, K., Van der Sligte, R., and Ottevanger, W.: Morfologische pakketsom Waal: morfologische effecten Ruimte-voor-de-Rivier maatregelen, Deltares, Delft1208454-000, 188, 2014.

Vrijling, J. K.: Probabilistic design of water defense systems in The Netherlands, Reliab. Eng. Syst. Saf., 74, 337-344, https://doi.org/10.1016/S0951-8320(01)00082-5, 2001.

R3: For context, it would be useful to add whether or not there is aggregate extraction (or other dredging) from the channel as well as the floodplain.

Reply: We now provide this information in section 2: “The main channel, 250 m wide, is fixed in place by groynes (spur dikes, wing dikes) for navigation and prevention of ice dams. It incises in its own deposits due to limited sediment supply from the catchment. Maintenance dredging in the insides of the bends is required to maintain the minimum navigable depth. The dredged material is dumped again in the deep parts of the outer bend. Excavation of floodplain sediments occurs mainly in combination with interventions for flood hazard reduction.”

R3: There is an apparent miss-citation of a figure on p. 6. Figure 3e should be figure 2e.

Reply: Correct, this has been changed now.

R3: On p. 8 the citation of 2.5% probability for the 1.8 m setup of downstream water level should be clarified. Is this an annual probability? What additional climate change assumptions are behind this?

Reply: The 1.8 m sea additional setup was assumed to be caused by sea level rise only and excludes the possible setup from wind storms on the North Sea. The probability mentioned is due to the scenario and model uncertainty and not the annual probability as it could be interpreted from the perspective of storms. If it were an annual probabilty, the probability of the co-occurrence of a river flood with a storm should be taken into account, which we did not do. We expect to clarify with the following adjustment to the manuscript: “Sea level rise (dh) was implemented as a 1.8 m additional setup of the downstream water level (dh1.8) for 2100. We did not take additional increase in water levels into account from storms on the North Sea. We chose a rise of 1.8 as a high-end projection based on two probabilistic studies that included scenario and model uncertainty: Le Bars et al. (2017) reported a median rise of 1.84 m (95% confidence interval = 2.92 m), which included the possibility of Antarctic ice sheet collapse (DeConto et al. 2016) and De Winter et al. (2017) reported a 2.5% exceedance probability for dh = 1.5 m for the North Sea.”

R3: This also brings up my final comment: in reality the objectives would probably be subjected to additional weighting, as is typical in multi-criteria structured decision making. Explicit weighting would change the scores and tradeoffs. If flood-risk reduction is the dominant objective, it would be weighted accordingly. In the US it is often the case that ecological objectives get weighted much higher than some of the socio-economic objectives because of special treatment for threatened or endangered species.

Reply: In practice, the results of our study could function as a reference for more detailed designs. The final weighting of of interventions would indeed be based on preferences, lobbying, and legal status of protected species etc. In the methods we stated: “No attempt was made to select a single optimal measure by means of minimizing an objective function, because such techniques require weighing factors for the four aspects and these are currently unknown. The weighing factors can also change quickly due to changing public opinions and political will.” Based on this comment though, we added the following to the discussion: “In the final stages of intervention planning, additional weighing of interventions is required in practice using a multi-criteria analysis. Changing the weights will alter the trade-offs between the evaluation parameters. For example, the single objective of flood hazard reduction would rank embankment raising, floodplain lowering, side channels and roughness smoothing as top priorities, whereas conversion to natural grassland would be favoured from the river restoration perspective of protecting threatened and endangered species.”

See supplement at R1 for the revised version

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