

Interactive comment on “Costs of sea dikes – regressions and uncertainty estimates” by Stephan Lenk et al.

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1. In their manuscript, Lenk et al. use data on the cost of sea-dike construction from the Netherlands and Canada with the aim of producing typical unit costs for use in further studies. Such an effort is very much required, and therefore I believe this paper to be of potentially great value to the field. There has been a great deal of attention in recent years for the needs to assess adaptation costs, yet this aspect remains very much undercovered in the scientific literature compare to studies on the damages caused by natural hazards. The information in this paper can help researchers to start to make the important step towards also including the costs of the adaptation in their analyses. I believe that the paper is well-written, timely, succinct and therefore I would recommend publication subject to the author's addressing several points below.

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> We appreciate the positive evaluation of our manuscript.

2. The lack of good quality costs estimates has hampered progress in the advance of large scale flood risk modelling. Whilst many advances have been made in assessing large scale flood risk (e.g. Hinkel et al., 2014; Ward et al., 2013; Arnell and Gosling, 2014), these studies either do not address the costs of adaptation, or do so in a simplified way (e.g. Hinkel et al., 2014). The need for data on the location and costs of dikes is called for also in a recent commentary by Ward et al. (2016). It would be useful to mention how the current manuscript can support such efforts (in the introduction or the discussion), which would make further explicit the wide implications of this paper.

> We agree with the reviewer (also a similar point was raised by RC2) and would add a paragraph that the transfer of our findings and conclusions to other countries needs to be done with caution. Although plausible, we have no prove that the analogous parameters and consequent conclusions hold true in other countries. Especially it cannot be excluded that fixed costs could represent a significant contribution in countries with weaker tradition in coastal protection or in countries that so far have not been threatened by sea-level rise. Similar arguments could also apply to the unit costs. Further research will be necessary to better understand the unit costs and potential fix costs so that they can be transferred to arbitrary countries. In the context of riverine floods, the lack of good quality cost estimates has hampered progress in the advance of large scale flood risk modelling. There is an urgent need for data on the location of dikes as well as their costs and uncertainty (Ward et al. 2015). Given the information of flood management in place (i.e. existing protection levels), this need could be fulfilled by automatised identification of the required protection courses, so that our results could help to estimate dike costs. Certainly, coastal and riverine dikes have different requirements in particular regarding wave run-up and duration of floods. However, it is plausible that our main conclusions regarding linear cost function and uncertainty also apply to riverine dikes.

3. The abstract states that the paper provides recommendations on how to improve the

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reporting and estimating of the costs (of sea-dikes) in order to support future adaptation studies worldwide. However, I did not really find anything in the manuscript to warrant such a statement; I was expecting some vision of how a database should be further developed. Whilst I don't think this is required in this paper, I believe that this statement in the abstract should be dropped.

> We agree and would drop the statement from the abstract (similar point was raised by R2).

4. I think that the paper would be improved by a more explicit discussion of how operation and maintenance costs are included in the datasets. The paper is intended to provide some kind of information and guidance for assessing adaptation costs. In terms of sea-dikes, O&M costs can be extremely high over the lifetime of a dike, perhaps as high as the investment costs. How should decision-makers deal with this? Are there rules of thumbs that can be prescribed, like taking a percentage of investment costs per year to represent O&M costs?

> We agree and would add a paragraph to the discussion. Operation and maintenance is another example. Maintenance costs can vary significantly and over an order of magnitude (Keating et al. 2015). Such costs depend on frequency of inspections, annual maintenance requirements, and long-term intermittent maintenance activities (Keating et al. 2015). Typical activities include repairs, vegetation cutting, weed and vermin control, and others. While the Netherlands data does include maintenance, the Canadian data and the Great Britain estimates do not. The annual operation costs are usually given by a percentage of the construction costs over the lifetime of the dike. If we assume 1% of annual maintenance costs over a lifetime of 100 years, then maintenance adds up to 100% of the construction costs (disregarding any discounting) so that maintenance can represent a substantial contribution to the costs. The reason why maintenance sometimes is included and sometimes not, is probably budgeting. In terms of accounting, construction costs usually represent one-time expenses and operation costs spread out over many years.

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5. Similar discussions to those sketched here are taking place in the field of river flood modeling. It would be worth mentioning to what extent this research is / is not useful for such studies.

> Again, we agree and would discuss this issue together with above mentioned paragraph around (Ward et al. 2015).

6. Small comments - Page 2, line 6. Insert "the" between "While" and "climate" (i.e. "While the climate. . .") - Page 2, line 16: Replace "Using historic construction costs are. . ." with "Using historic construction costs is. . ." - Page 3, line 27. "Replace ". . . affecting the exact shape to the dikes" with ". . . affecting the exact shape of the dikes".

> We appreciate finding these mistakes. All mistakes will be corrected.

7. - Page 12, line 3: "Nevertheless, we do find neither statistical signatures of fixed costs nor of non-linearities for the costs of dikes we have analyses." This sentence does not flow well, I am not sure what point the authors are trying to make.

> We agree would simplify this sentence.

References Arnell, N.W., Gosling, S.N., 2014. The impacts of climate change on river flood risk at the global scale. *Climatic Change*, 134, 387-401. Hinkel et al., 2014. Coastal flood damage and adaptation costs under 21st century sea-level rise. *PNAS*, 111, 3292-3297. Ward, P.J. et al., 2013. Assessing flood risk at the global scale: Model setup, results, and sensitivity. *Environmental Research Letters*, 8, 044019. Ward, P.J., Jongman, B., Salamon, P., Simpson, A., Bates, P., De Groeve, T., Muis, S., Coughlan de Perez, E., Rudari, R., Trigg, M.A., Winsemius, H.C., 2015. Usefulness and limitations of global flood risk models. *Nature Climate Change*, 5, 712-715, doi:10.1038/nclimate2742.

> We thank the referee for providing these references and refer to these at appropriate places within the paper.

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