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Comment on nhess-2021-144

Anonymous Referee #2

Referee comment on "Considering human-water-environment impacts holistically in flood management by combining spatial MCDA with cost-benefit analysis" by Cyndi V. Castro and Hanadi S. Rifai, Nat. Hazards Earth Syst. Sci. Discuss.,
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The manuscript presents a MCA analysis of different flood mitigation options for a complex basin in Texas, USA. Topic is interesting and fits the scope of the journal. The idea itself is (obviously) not new in the literature, nor relevant methodological issues are here developed, but the case study is interesting and potentially deserves for publication, once a series of points are modified and/or clarified.

MAJOR POINTS

Equation (1) – Composite Risk.

Factors R (Environmental, Social) are weighted averages of evaluation scores. Concept is clear, but we have no information on how such scores are given, we only know about their general meaning (sources of contaminants, soil erodibility, medical facilities ...). Lines 256-261 provide a long list of items to be considered in the risk evaluation. However, it is not clear which of them has been really considered in the environmental and social criteria, and how.

In different words: what do factors "e_j" exactly represent? Are they binary quantities

(e.g.: presence of a source of contaminant in a cell), extensive quantities (e.g.: length of inundated road in a cell), intensive quantities (percentage of flood insurances among residents)? How the scoring 0-100 is attributed to each factor for each cell? Do cells have a uniform extension?

In particular "Stream samples were obtained from field campaigns following Hurricane Harvey, which were used in this study to validate the areas of environmental burdens associated with contamination in local waterways." I have not understood how such data were used to define values for the environmental factors in each cell.

Finally, I strongly suggest providing a short description of the SoVI (Social Vulnerability Index) and variables involved in the index.

Equation (2) – Impact Functions.

1) what are the "zonal statistics for the composite risk and the modeled inundation area of each alternative"?

2) what are the "zones"? the inundated areas for each scenario? I understand that " a_i " are the corresponding inundated surfaces, is this correct? Or do they also comprehend the areas impacted by the "ancillary risk" (see below)?

3) what is the summation index in equation (2)?

At the end of the story, I cannot understand IF. If " R_{bar} " is an average (I guess, spatial average) over the zone and " a " is the area of the zone, than R_{bar} is constant over the zone and $IF=R_{bar}+ancillary\ risk$. But this has no sense, therefore I conclude that I was not able to understand equation (2).

Section 3.2.2 - Ancillary risk

I see conceptual inconsistencies here. Soil use / buyouts due to mitigation measures are not risks, are deterministic impacts; they have 100% probability along the lifetime of the mitigation measure, and they last for all such time. On the other hand, the damage from a flood scenario has a probability of exceedance less than 100% in the given period. What is here called "ancillary risk" is not a risk at all, and should not simply be added to the flood risk by assigning certain values of R-scoring for the areas impacted by the measures, as here done.

On the other hand, the extra-flooding expected along the Cypress Creek is an additional/ancillary risk, and it is correct to handle it as such. Why is such area simply accounted by a $R_s=100$ scoring? It should be added to the flooded area, and evaluated with respect to CB and IFs.

Section 3.2.3 – Weight determination

This is THE key point of any MCA, making the difference between an exercise and a relevant field case. I cannot really understand how the authors determined the weights. I read about "discussions with Houston-area flood risk stakeholders, including governmental entities, interest groups, and specialized consulting firms"; the description continues with principles derived from the literature (lines 302-307); authors conclude by saying that "As participatory modelling is inherently qualitative, individual criterion weights will differ according to local conditions and stakeholder goals". All this is true, but what did they really do? From lines 308-312 I may understand that weights in table 2 are somehow just a reasonable proposal, not yet evaluated by stakeholders?

It is also very important to clarify that weights are not general, but linked to the definition (and consequent variation ranges) for the indicators to be weighted. All this information set should be part of the discussion (with stakeholders) devoted to fixing the weights.

Again, weights are the key point. Selection criteria should be discussed. If such criteria are not robust, an extensive sensitivity analysis should be provided in order to give real value to the MCA.

Section 3.3 – CBA

Benefits are evaluated in terms of a fixed damage/hectare, without considering any specification for the soil use / exposed elements (residential, agriculture, industrial, ...). Please, add some consideration about the accuracy and robustness of the used fixed value (=0.478 M\$/he).

Section 3.4 – Integrated CBA + MCA

“Since the unique indicators contained different units of measurement (\$/hectares, 0-100 risk) we used z-score normalization to transform the values to equivalent scales”: this is not fully true. CB is non-dimensional (ranging 0-1 if benefits exceed costs, but later I understand expressed as 0-100); R and IF are also non-dimensional (ranging 0-100). Why was then the z-normalization used? This point should be clarified.

Moreover, the choice of the uniform weighting of the three indicators (CB, IF_E , IF_S) is an important part of the weight determination: what is the rationale under such choice? was it discussed with stakeholders? Was any sensitivity analysis performed?

I have a wider doubt here, about the consistency of T, presumably as a consequence of not having understood how factors IFs (or Rs) are formed. Let us take two mitigation alternatives (A_1 , A_2), with different costs C, different benefits B, different impacts IF which, for simplicity, we here limit to the number of people affected by the flood (we call it N). Let us imagine that $C_1 > C_2$ but also $B_1 > B_2$ (A_1 reduces the flooded area more than A_2) so that $CB_1 = CB_2$. Thus, the CB component of T will be equal for the two cases, thus suggesting that T is an indicator of efficiency (intensiveness) rather than of efficacy (extensiveness). Let us imagine that $N_2 > N_1$ (as A_1 reduces the flooded area more than A_2): what would happen to IF_1 and IF_2 ? Is their contribution to T consistent with an indicator of efficiency? What for all the other components of IF_E and IF_S ?

MINOR POINTS

Line 25: "Hurricane Harvey": add date of the event.

Line 150: "Wealthy and middle-income populations face higher risks when located outside of federally-designated floodplains where flood insurance is voluntary". I cannot understand the reason of this higher risk.

Analysed mitigation strategies (tab. 1) are those proposed in the USACE 2020 report. In particular, costs of the mitigation actions are derived from such reports. The reader would expect that also hydrological / hydraulic scenario are derived from the report but, apparently, it is not so, as modelling of such scenarios is discussed along the manuscript. Authors should clarify this point and discuss consistency of scenarios with associated costs. In particular, for scenario A₇ I read (line 400) that the authors used a wider channel extension with respect to the USACE proposal: what about costs, were they modified accordingly?

Line 235: "To standardize the point and polyline feature classes into spatially varied datasets, the Euclidean Distance method was applied. Euclidean distances convert feature layers into gridded datasets by assigning a value to each cell that indicates the distance of that cell to the nearest criterion, thus standardizing space and creating hotspots in multi-criteria decision making". Meaning and impact of this procedure is not clear to me.

Line 271: "The spatial risk associated with flood insurance was derived from national flood hazard zones and a repository of damaged structures in the community. It was assumed that residents within the FEMA 1% and 0.1% flood zones carried flood insurance, while 20% of all other residents had purchased voluntary insurance". Please, provide comment about soundness of such assumption.

Table 3: I cannot reconstruct values for CB. Let us take alternative A_3 for Addicks as an example. Reduction of flooded area is 466 he; when multiplied by 0.478 M\$/he we obtain a damage reduction $B = 223$ M\$; cost is here $C = 5000$ M\$ (please, make indication of units coherent in tables 1 and 3) with a consequent $CB = C/B = 2200\%$... not comparable with values in table 3 and with common sense. This clearly means that there is something I have not understood (I honestly tried) ... please, clarify.

Figure 6: I cannot understand spider graphs (c) and (d); I expect the same values as in plots (a) and (b) to be represented, but there is no coherence.

SOME SUGGESTIONS ON THE ORGANIZATION OF THE MANUSCRIPT

Section 2.1: this relatively long paragraph appears as a continuation/specification of the literature review provided in the Introduction rather than a description in the methodology here used. Moreover, the scheme for "integrated flood management decision-making" in fig. 1 is here presented but not really used (or, perhaps, not clearly explained). Consider better focusing all information within lines 18-104 with respect to the specific aim of the paper (case study).

Along the manuscript discussions are alternated between the hydrological / hydraulic scenarios (sections 2.2.1, 3.1, 4.1) and the impact/damage/cost scenarios (remaining sections). I suggest to re-organize the material so that the sections for the two groups are presented all together, and the flux of information should become more coherent. This would also avoid some repetitions.

Lines 314-319: here a general discussion about principles of a CBA is provided. However, here a simplified version of benefits evaluation is used. The general discussion could be omitted or moved to some introductory section.