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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Spatialised flood resilience measurement in rapidly urbanized coastal areas with complex semi-arid environment in Northern Morocco" *by* Narjiss Satour et al.

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We want to thank the reviewer for the constructive comments, which will surely improve the quality of this paper. We appreciate the quality of the reviewer's questions. All the comments will be positively considered in the revised Manuscript. Please find our responses to the comments raised in the discussion point of the review:

Discussion Point

Remark 1

**How do the authors define resilience? Since the paper is on measuring resilience,

the authors should define what is meant by resilience and what they aim to measure: resilience of what to what? This is not clear in the current paper. The authors first seem to have adopted the resilience definition of Adger et al.(2005) and Folke et al, (2002): "Resilience approaches aim to understand and manage the capacity of a system to adapt to, cope with and shape uncertainty", but then they mention that many definitions in various fields exist (which is true, but we need to know how the authors define it here).

=> As mentioned by the reviewer in the general comments, this work aims to measure the resilience of the urban system to floods. Resilience quantification allows monitoring and identification of the more and less resilient areas to flooding. From our point of view the resilience concept must address the following questions: 'resilient of what?' and 'up to what level?' (Carpenter et al. 2001). The definitions given by Adger et al. (2005) and Folke et al. (2002) are general and cover our specific definition of resilience. In developing countries, the lack of statistically robust data is the ultimate challenge, especially with the upcoming climate change impact. Resilience is the ability of urban flooded areas to maintain the activities during and after floods, where a coastal urban area will be able to absorb shocks (at an acceptable level) and adapt to the changes.

Carpenter S., Walker B., Anderies J.M., and Abel N. (2001). From metaphor to measurement: Resilience of what to what? Ecosystems, 4,765-781

** In line 94 they refer to urban resilience instead of flood resilience and the paragraph ends with a sentence on 'community disaster resilience frameworks'

=> This will be corrected.

** Although it is mentioned that indicators and frameworks exist, they are not provided or discussed. It is also not clear if the authors consider urban resilience as similar to disaster risk resilience and flood resilience

=> A paragraph providing a discussion of the most used indicators will be added. In the

context of this work, yes, they are similar in our paper. Indeed, flood resilience measurement in the urbanized coastal area is the aim. Therefore, “urban resilience” refers to the coastal urban area exposed to floods. Flood resilience refers to the resilience of these urban areas to floods.

** The resilience view is also not clear on line 102 where resilience is called a “multidimensional objective”, while in line 103 resilience is called “an approach”. Do the authors see resilience as an aim/objective, an approach, or a means to reach an aim (e.g. a better coastal community, smaller flood impacts, or better functioning economies)? Or both?

=> “Multidimensional objective” in Line 102 and “The approach aims to provide a synthetic measurement” in line 103 both refer to the composite indicator (line 101) which is an approach aiming at providing a synthetic measurement of resilience.

** The paper then mentions that there is a gap in knowledge on how to measure resilience, but also concludes that resilience needs to be enhanced, so some knowledge on the current resilience is present: at least enough to conclude that the resilience is currently insufficient.

=> The “gap in knowledge on how to measure resilience” in our paper refers to the specific case of Morocco (and could be extended to other similar countries) where quantifying resilience needs to be adopted and enhanced based on developed countries experiences. This does not negate the existence of knowledge or research on this subject.

** Then from line 113 onwards, it is not clear whether the paper looks at resilience to floods which may be affected by sea-level rise or coastal erosion or the resilience to floods, sea-level rise, and coastal erosion together. That should be clarified.

=> Our objective deals with resilience to floods, not coastal erosion nor sea-level rise. More clarification will be added in the introduction to avoid any possible confusion.

** On line 159 the paper states that resilience assessments can be classified into measuring persistence, recovery, and adaptative capacity. This makes the concept more concrete. However, these three terms or this distinction is not referred to anywhere else in the paper. Why did the authors put this sentence there? How does it relate to the proposed Flood Resilience Index?

=> More clarification will be added to the corrected version of the paper.

Remark 2

** The Flood Resilience Index used in the paper: how does it relate to existing frameworks? In chapter 3 on line 164, the flood resilience index is mentioned. Is that new and is that what the authors have developed? Is it related to the indicators and frameworks to which the authors have referred to? How, or why not?

=> More clarifications will be added, explaining how the FRI is related to the existing frameworks in chapter 3.

Remark 3

** The indicators and sub-indicators itself: The choice for the indicators is not motivated well.

=> More details will be added in section 3 to motivate the choice of the indicators.

** The authors state for example that areas with a higher building density are less resilient. Why is that? Or is that true in Morocco? Is it because the flood impacts may be higher than in rural areas or areas with less exposure? But perhaps there are also more funds to recover from that damage?

=> In many parts of the world, higher building density, especially in developing countries (like Morocco) tend to be densely populated, with many areas that have grown fast, often with insufficient infrastructure, resulting in environmental degradation and high damaging floods. That is why in this study we consider higher building density

areas as less resilient areas. Some references will be added.

** Why are areas with a better connection to sewage or drinking water system more resilient to floods (or to floods, coastal erosion, and sea-level rise, that is not clear in this paper)? There is a reference to Cutter there, but Cutter describes disaster resilience, and not flood resilience, which may be different.

=> Water drinking access and sewage connection are human development signs in developing countries. They are reflecting a certain social resilience against all kinds of disaster effects. Naturally, they also reflect social resilience to the impacts of the floods. A not being guaranteed access to water during and after floods may imply an inequitable aggravation of the situation. For example, using non-potable water after flood disasters evolves numerous health risks. This will be more clarified in the revised manuscript.

** Why is communication capacity an economic indicator and not a social one?

=> Communication can surely be viewed as a social component. However, in this study, we consider it as an indicator of the economic situation of the population. Wealthy people in countries like Morocco have more access to communication. This population can indeed remain better informed before, during, and after flood events.

** Is it fair to count both the percentage of old houses and the percentage of modern houses or is that double-counting the same aspect?

=> The old Buildings rate (OBR) and the Modernly Built Houses (MBH) aren't representing the same aspect. The first one is based on the age factor, while the second is based on the building materials. More sentences will be added to clarify this point.

** Is there a storyline to explain the indicators selected: how does unemployment rate, relate to flood resilience (I assume because less funds will be available for a quick recovery?, or is it based on statistical analysis of this factor and flood recovery? Or flood impacts?)

=> This is true. Unemployment is related to flood resilience because less funds will be available for a quick recovery, as it's mentioned on the tab "Unemployed people are faced with difficulties related to their disability to recover or rebuild their damaged property (Cutter et al., 2010; Sherrieb et al.,2010). This will be clarified in the upcoming version of the paper.

Remark 4:

** What is the use and what are the limitations of such a composite indicator: What if two areas would have the same low score, but one has a low score because it has many persons below 14 or above 60, while the other area has a low value because of it's low elevation, how would you use that score? What would be the value of a composite indicator if causes of low resilience could be completely different and therefore solutions or measures may be very different? What is the value for an area without inhabitants? (flood-prone or not) and what would be the value for a densely populated area which is not flood-prone? And what is the value for an area where floods cause impacts which are overcome within a year, or where sea level rise scenarios for the next 50 years can be coped with without a significant increase of flood risks? These questions are related to flood resilience, aren't they? How does this indicator relate to those? Why do you value all sub-indicators equally?

=> This is an important point, which is classically discussed in the community when choosing between the equal-weighted or non-equal-weighted composite index combinations. In our case, the reasons for the equal-weighted choice have been briefly mentioned in section 3.3. here we will try to resume the discussion about this question more explicitly. First, equal-weighting is the most common for composite indices with several sub-indicators (OECD, 2008) because of several arguments listed by Greco et al.2019 ("i" simplicity of construction, "ii" a lack of theoretical structure to justify a differential weighting scheme, "iii" no agreement between decision-makers, "iv" inadequate statistical and/or empirical knowledge, and, finally "v" alleged objectivity). In addition, allocating equal importance across different indicators is better suited when no knowl-

edge exists about the interactions among the sub-indicators and composite indicator at the local scale (Cutter et al.2014; Asadzadehet al.2017). We will add these details to the upcoming version of the Manuscript.

Regarding the question of what if two areas would have the same low score, but one has a low score because it has many persons below 14 or above 60, while the other area has a low value because of its low elevation, how would you use that score?

We believe that resilience depends on the location and on the context. Moreover, decisions made by stakeholders have also a direct impact on the resilience level. In our approach, we have taken into account these details in the design of the composite index in such a way that it is modular and adaptable accordingly. Finally, the remark about the limitations remains relevant. The limitations will be more developed on the manuscript with some discussion related to data availability and the integration of the climatic data (flood data or flood simulation data) and the validation step.

Asadzadeh, A., Kötter, T., Salehi, P., & Birkmann, J. (2017). Operationalizing a concept: The systematic review of composite indicator building for measuring community disaster resilience. International journal of disaster risk reduction, 25, 147-162. Cutter, S. L., Ash, K. D., & Emrich, C. T. (2014). The geographies of community disaster resilience. Global environmental change, 29, 65-77. Greco, S., Ishizaka, A., Tasiou, M., & Torrisi, G. (2019). On the methodological framework of composite indices: A review of the issues of weighting, aggregation, and robustness. Social Indicators Research, 141(1), 61-94. OECD. (2008). Handbook on constructing composite indicators: Methodology and user guide. Paris: OECD Publishing.

Remark 5

** The English and the writing style The English needs significant improvements. Sometimes sentences start with 'While x and y is going on.. and then they end without a second part of the sentence. Some parts are repeated several times e.g.that resilience is often quantified by composite indicators (around line 101, 137, 145,149)

=> A full proofreading of the English will be done in the revised form.

Remark 6

** The authors provide many references in the review, however sometimes improvements are needed. Sometimes the relation or the link between the referenced work and the work of the authors is not clear (e.g. if stated that they have a resilience indicator, it is not explained what indicator, whether it is useful or not and why just that there is an indicator), some references are missing in the reference list (e.g. Lutz & Samir, 2010) and some are perhaps less relevant? (e.g. for the claim that floods will occur more frequently in Morroco there are 3 references, one relates to a paper on climate change impacts on hydropower systems in California and is probably less relevant than the other 2). The reference formats are not in line with the journal's requirements.

=> Some irrelevant and related remarks will be revealed and improved. The format of the references will comply with the NHESS standards in the revised version of the paper.

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