

Interactive comment on “Determining regional limits and sectoral constraints for water use under climate change” by T. K. Lissner et al.

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1 Reply to Reviewer # 3

We wish to thank the reviewer the several comments, which will improve the conciseness and clarity of the presentation of our method and add some important aspects to the discussion.

The biggest concern is that some variables are allowed to change overtime (e.g., water availability), while others (e.g., water demands, etc.) are held constant to what was estimated in the literature (e.g., Vorosmarty et al 2010a,b, ICF 2013, Smakhtin 2004, Howard and Bartram 2003). Ideally all variables/indicators should be allowed to evolve

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temporally following the two RCP scenarios. For example, water demands are likely to increase and using a range from the literature is not sufficient especially that there are numerous models that generate those following the RCP scenarios. The WaterGAP, GCAM, WBMplus, H08 are a few of those models. When the modeling capability is lacking, this needs to be stated clearly.

We agree, that it would be preferable to include projections of all variables in the calculation. However, to our knowledge at present projections of the variables included in the analysis, other than water availability as well as populations projections, are not available.

For our assessment, we have focussed on addressing water requirements, rather than water use or water withdrawals. To our knowledge, the models the reviewer refers to assess the current and future development of water use and water withdrawal, but do not actually reflect on how this relates to the requirements of different sectors. If less water is used in a region, this may also be due to limitations in access or availability. Certainly, more detailed assessments of regional to local water requirements would be advisable, to account for local water needs in more detail and also assess potential future requirements, however this outside the scope of the assessment.

We have revised several aspects of the manuscript:

- the paragraph on water requirements now more explicitly refers to the distinction between water use and water requirements, discussing why we chose to represent water requirements rather than water use/withdrawal
- we also discuss the raised points and the consequent limitations to the approach in more detail in the discussion section

There are several questions that pertain to how the authors handled water availability. For example, how is water availability defined in this study? Is it runoff or stream-flow, or something else? How does the paper distinguish between internally renewable

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water vs the inflows that come from upstream basins? Also the seasonality of water availability and demands are missing from the analysis, e.g., rain may occur during the non-growing season. why not compare the agricultural water demand to water availability during the growing season instead of the entire year?

We have extended the respective paragraph to more precisely state the definition of water availability for the study. Briefly, water availability refers to the mean annual internal renewable water resource (blue water) and is represented by total runoff (surface and subsurface).

With regard to the question of including seasonality: the current aims at showing how water needs of different sectors can be accounted for and provides a first implementation of the approach. More detailed assessments of sector-specific needs would be interesting, but would require further adjustments of the method to a specific regional setting, which is outside the scope of the present implementation. We now discuss this point more specifically in the discussion section.

There needs to be a more elaborative explanation of the various indicators that are used in the fuzzy logic step. Simply citing a paper to get the variables is not sufficient. I would suggest to at least describe how these indicators were computed in an appendix or supplemental materials.

We have restructured and extended Section 2.3.1, which provides details on all indicators and their preparation, in order to ensure that the data preparation becomes clearer. To this end, we have also added more specific references to Table 1 throughout the Section.

I am less familiar with the Fuzzy Logic theory, but the results seem to be very much sensitive to the weights assigned to the various indicators. The paper is full of subjective assumptions of what weight factor is used (0,0.2,0.4,0.5,0.6,0.8,1.0) and it is not clear how sensitive the results are to those assumptions.

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The reviewer raises a very important point here. Assumptions underlie the definitions of each specific values within the framework, including the thresholds to define membership, fuzzy operators, the values of gamma or the chosen input data. The choice of these values is clearly important, as they determine the final result.

One of the main advantages of fuzzy logic is the possibility to account for vagueness, which is associated with the system of analysis, while nonetheless allowing for a quantification. We choose to assess range of adequacy, which allow to account for a gradual assessment of conditions, allowing for vagueness and uncertainties associated with strict thresholds. Every exact number used in the framework is therefore uncertain. However, the order of magnitude and direction of each value is motivated through the context and properties of the variables. A full sensitivity analysis for the whole assessment framework is beyond what can be done within this publication, since a large number of factors will have to be checked for sensitivity and presenting the resulting complex information is rather topic of an entire publication. However, we tested the impact of our assumptions on the final result. The attached figure (Fig.1) exemplifies for the municipal sector, how results change with a variation of gamma at +/- 0.2.

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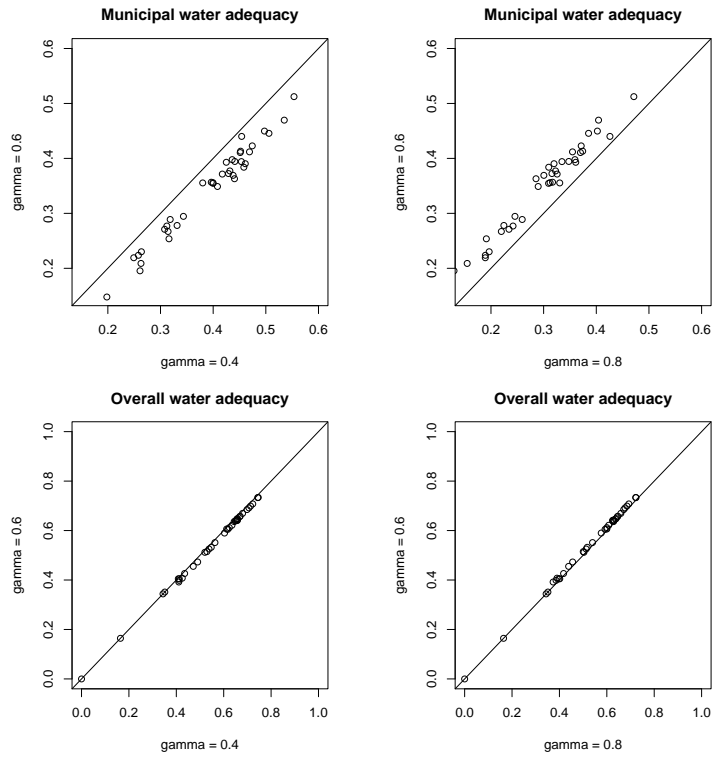


Fig. 1. Comparison of results of municipal water adequacy (upper panels) and overall water adequacy (lower panels) with variations of ± 0.2 of gamma-values for the aggregation of municipal water adequacy.