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Earth System Dynamics
Discussions

# *Interactive comment on* "Climate impacts on human livelihoods: where uncertainty matters in projections of water availability" *by* T. K. Lissner et al.

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**Reply to Reviewer**

We wish to thank the reviewer for recognising the importance of our work and for several important suggestions, which will clarify and improve the manuscript. The following paragraphs respond to the general comments. In the table of changes they are listed again with the according adjustments in the manuscript. All other comments not mentioned here are addressed in the table of changes.

*1. This paper attempts to systematically asses climate impacts on livelihood via a method- ology called AHEAD, which combines the effect of a variety of climate impacts,*



*and the appropriate assessment of model uncertainties. The paper focuses on water avail- ability (as an example) using results from ISI-MIP, and ascertaining when model un- certainty is significant to livelihood predictions and when it is not. The overall goal of the methodology is to digest model results for policymakers, including ascertaining relevance of various uncertainties.*

*The authors approach in doing this is to begin with a long list of subjective elements (listed in Section 2.1), and attempt to quantify them through impact model output and what turns out to be a simple scheme based on fuzzification. However, this translation (from qualitative to quantitative) is necessarily arbitrary. This puts the whole endeavor on thin ice. Such a translation would seem to demand transparent methodology, thorough examination of assumptions, careful justification of every step, and precise language.*

We have carefully revised the manuscript on the basis of the reviewer comments, focussing on more precise language. We have also focussed on extending and clarifying the translation process from qualitative to quantitative and several points in the manuscript, especially in Section 2.1 and 2.2. An additional paragraph added to Section 2.1 elaborates on the differentiation between the identified elements of AHEAD and the representation with data (see comment #3). We will also add a table to the supplementary which outlines in more detail the process from the element definition to quantification.

In this paper we only briefly present the AHEAD approach, to clarify the basis for the consequent quantification. We are currently in the revision process of a manuscript containing further details on the conceptual background, which discusses the choice of elements in more detail. This paper should be available online soon.

*2. I feel that the overall goal of this paper, to meaningfully digest impact model results and uncertainties, is important. However, I feel that the methodology presented here is perhaps too qualitative, and the presentation too imprecise, to successfully advance*

*this goal.*

Our choice of fuzzy reasoning specifically focusses on representing imprecisions and vagueness which are associated with the translation from qualitative to quantitative in socio-ecological analyses. We have extended the discussion of the relationship of qualitative and quantitative aspects in several parts of the manuscript, specifically also with regard to the fuzzy logic method.

With regard to the potential impreciseness in the presentation of the results, we have carefully revised the manuscript on the basis of the suggestions of both reviewers for a more precise presentation.

*3. Furthermore, there seem to be some culturally-specific assumptions underlying this work (e.g. the necessary factors for adequate livelihood), which should perhaps be given explicit consideration.*

As the criticism of culturally-specific assumptions and the choice of indicators is recurrent, we would like to address the issue in detail at this point. The choice of the elements of AHEAD is based on literature, which was chosen according to the focus on generally valid determinants of human livelihood needs (please see also comment #1). According to the underlying concepts, the elements included in AHEAD are not culturally-specific, but generally valid and globally applicable (see e.g. Narayan et al., 2000; Sen, 1985; Alkire, 2002; Max-Neef, 1992). Following the idea put forward by Max-Neef (1992), generally valid needs can be met by different satisfiers, which can vary, for example according development status or culturally-specific preferences. While the identified elements of AHEAD (which are conceptually designed to correspond to needs according to Max-Neef) are non-culturally specific (according to the underlying approaches), the choice of indicators to represent their fulfilment (satisfiers) can vary. For the purpose of a global application, the availability of data sets of sufficient coverage is clearly a limitation. This may lead to some cultural bias, as available data are limited. Data sets are usually raised within a specific cultural frame, mostly by



institutions in developed nations, therefore available data on satisfiers is often culturally specific. We agree that this is an essential point, and we have given it much consideration during the development of the approach. The choice of indicators was discussed in an international team of researchers and the cultural bias of available data was an intense topic of debate and reduced where possible (e.g the representation of “social protection”). However, in most cases data coverage proved to be a strong limitation in the choice of indicators.

In the revised manuscript, we have added an additional paragraph in Section 2.1 addressing the issue, and address the topic explicitly in the discussion. To keep the presentation of results concise we have chosen not to discuss each indicator in detail in the text. Detailed accounts of the backgrounds of the used indicators are available in the indicated literature in Table 1. As indicated in comment # 1, we will also add a table to the Supplementary, which provides further details on the used data.

*4. I find the acronym "AHEAD" to be awkward.*

We decided to use an acronym because the terms well-being and livelihood have been used in different fields of research as related, but sometimes slightly conflicting concepts. The concepts are also used at different scales (i.e. individual vs. national/aggregate measures). Such conflicting views on a fundamental concept may lead to difficulties, as a keyword may raise expectations that then remain unmet. Therefore, we have chosen an acronym, to reflect the scale and scope of the approach. We are happy to take up alternative suggestions of terms or acronyms in this regard.

*5. “Based on a transdisciplinary sample of influential concepts” sounds vague./ The word "influential" here weakens the presentation. Similar persuasive rhetoric appears often in the paper, and is not helpful.*

Thank you for your comments in this regard. We have carefully screened the manuscript to reduce instances vague and persuasive language of the paper.

*6. 'However, the idea of adequacy is easily presented in linguistic categories, for example "sufficient water is available".' I find this sentence to be too simple, and also tautological (i.e. "sufficient" is a synonym for "adequate" here). Does "sufficient" mean "sufficient to drink"? Or "sufficient for subsistence agriculture"? Or "sufficient for non-native landscaping"? This sentence highlights the fundamental tension between the qualitative and the quantitative in this paper. A more sophisticated and precise treatment of this tension might be needed.*

We agree that this is a major challenge of our paper and hence follow your suggestions to address the tension more explicitly. As indicated in the previous comments, we have revised the manuscript in this regard at several points (specifically Section 2.1, discussion, Supplementary table) and hope that this makes the presentation precise. Please see also specific comment #4 for details on this paragraph.

For the purpose of this first global implementation, we refer to the cumulative water needs for all sectors, as proposed by Falkenmark (1997) and Falkenmark and Rockström (2004). The detailed representation of "sufficient water availability", is an important question and we have given this more detailed attention in a paper currently under review for HESS (doi:10.5194/hessd-11-4695-2014).

*7. Equations 1-4. I would be interested to see how results would change if every variable swapped shape of membership function. I'm not convinced that the level of precision implied by the use of two classes of shape is relevant to the results. / How much uncertainty is introduced by use of these idealized functions? / Gamma = 0.6 seems arbitrary.*

Every exact number used in the framework is associated with vagueness, which is the reason for using a fuzzy logic approach. The order of magnitude, and likely ranges, of the thresholds and gamma values are motivated by the properties of elements and literature; the specific choices of these values are arbitrary only within these ranges.

We have prepared several figures to illustrate the effects of changed membership func-



tions and gamma. With regard to using a gamma value, we have prepared comparison plots of gamma-values of 0.4 and 0.8 (see Fig. 1 and 2), compared to the original value of 0.6. While differences are visible, values within this range yield the same message as the standard choice.

Figures 3 through 6 show how different membership functions would affect the result. Fig. 3 and 4 show how fuzzified values of water and calorie availability vary with different membership functions, which illustrate the effect of such different assumptions. Fig. 5 and 6 show changes in AHEAD values, if only linear (Fig.5) and exponential (Fig.6) membership functions are used.

*8. What are "micro credits"?*

The additional table in the supplementary will give a brief description of each indicator. Micro credits refer to the access to low (or no) interest loans, available informally or through institutions (e.g. governments or NGOs). The indicator provided by the Institutional Profiles Database is an aggregate of informal and institutional access to micro-lending schemes, as well as the quality of the micro-lending guarantees (see de Crombrugghe et al. (2009)).

*9. I am not inclined to agree with the implication (by inclusion in the same dimension group) that cell phones and the internet are equivalent in importance to the other infrastructure factors such as shelter or health care. I think there is an underlying assumption in this work as to what is necessary for adequate livelihood, which is critically culture-dependent.*

Please see comment #3 with regard to the culture-dependence. With regard to assigning different weights, for the purpose of a global implementation of AHEAD we follow the reasoning of the underlying literature, according to which no hierarchies exist between elements, except for the Subsistence elements (see e.g. Max-Neef (1992)).

In terms of the specific indicators, the distinction between the element 'communication'

and the representation with data has to be noted (see comment #3). The relevance of access to communication for adequate livelihoods has been shown (see e.g. Horner et al., 2010; Figueroa et al., 2002; Urry, 2003) and at global scale we can measure this aspect with the two indicators.

*10. Why is it necessary to use a political grid in this study?*

The use of countries as the spatial scale of reference is motivated by the availability of data, as societal aspects are usually assessed at national resolution.

*11. Table 1. For the "communication" category, why are the lower and upper bounds 0% to 100% respectively?*

It was not possible to identify specific threshold values from the literature. As there is no information regarding the needed levels of access to communication, we have included the full range of values here.

*12. Table 1. I find the implicit claim that 0.5 cap$^{-1}$ motor vehicle density is necessary for "adequate livelihood" to be a conundrum in a paper about climate change, and another culturally-specific assumption.*

As indicated, a global analysis relying on available data faces some constraints and more detailed representation of many indicators would be preferable in many cases. This is indeed a very important point that has been insufficiently addressed throughout the manuscript so far. As indicated, we have added this aspect at several points of the paper and very specifically address it in the discussion.

In the case of representing mobility, data availability is limited at present. Many different ways of satisfying the need for mobility are possible, however, only data on motor vehicle density is currently available with a comprehensive global coverage. The methodological approach of calculating the adequacy of each element would allow to change this representation, if additional or more suitable indicators become available. With regard to the relation between motor vehicles and climate change it must be noted,



that the present analysis does not suggest mitigation or sustainability goals, but aims to depict the present situation of livelihood conditions with the currently available data.

Please see the attached table of changes for all other comments.

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Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/5/C272/2014/esdd-5-C272-2014-supplement.pdf

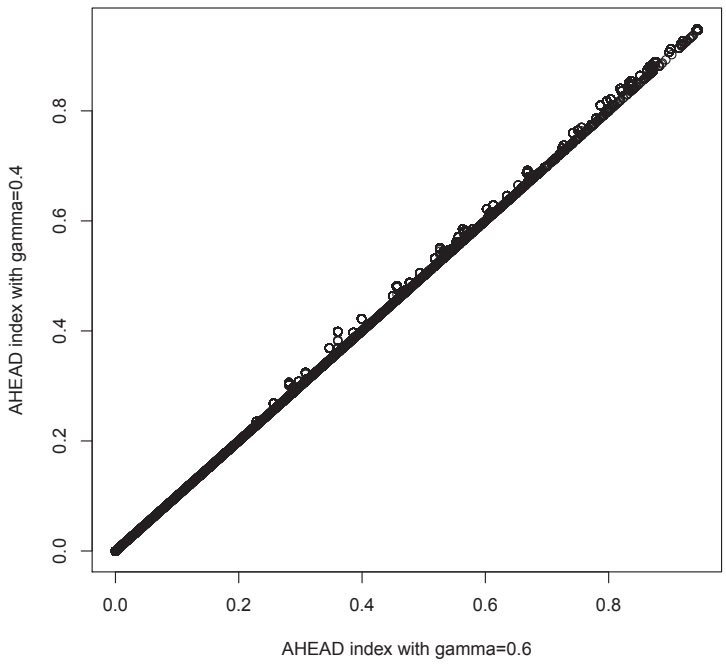


**Fig. 1.** Comparison of AHEAD results with gamma=0.6 (original value) vs. gamma=0.4 (water data: ensemble mean, baseline)

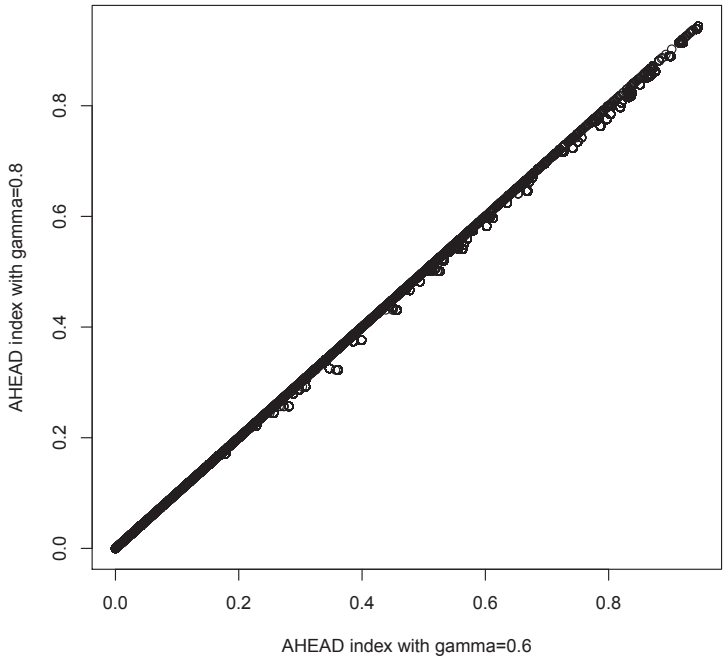


**Fig. 2.** Comparison of AHEAD results with gamma=0.6 (original value) vs. gamma=0.8 (water data: ensemble mean, baseline)



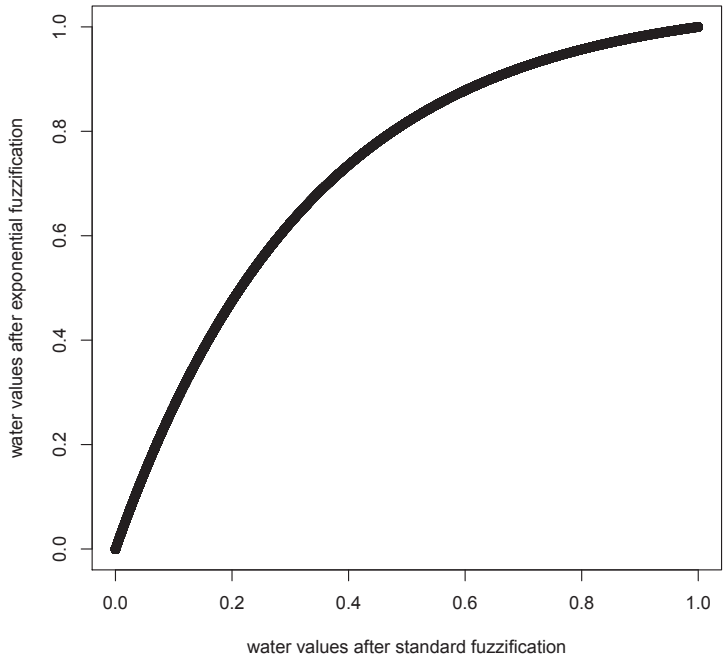


**Fig. 3.** Comparison of differences in fuzzified values of water availability between a linear (standard) and exponential membership function.

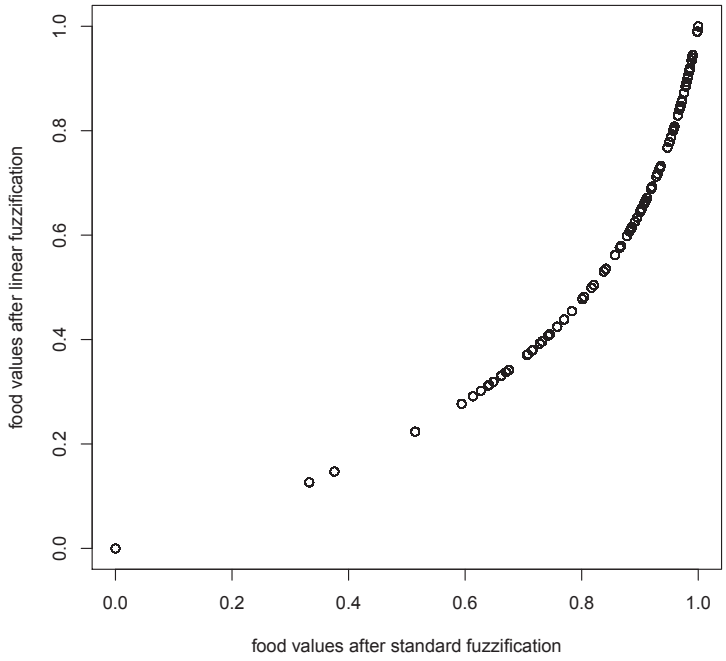


**Fig. 4.** Comparison of differences in fuzzified values of calorie availability between a linear and exponential (standard) membership function.



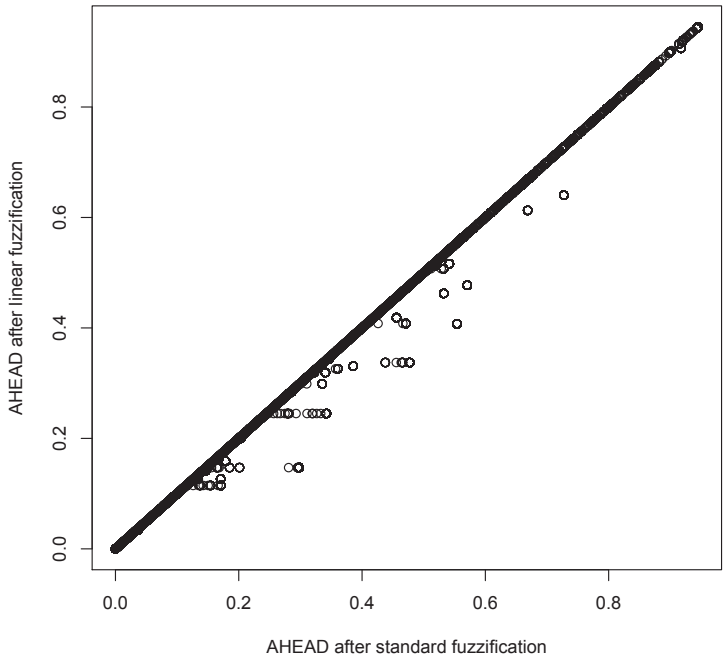


**Fig. 5.** Comparison of differences in AHEAD values between the standard fuzzification procedure and fuzzification using only linear functions.

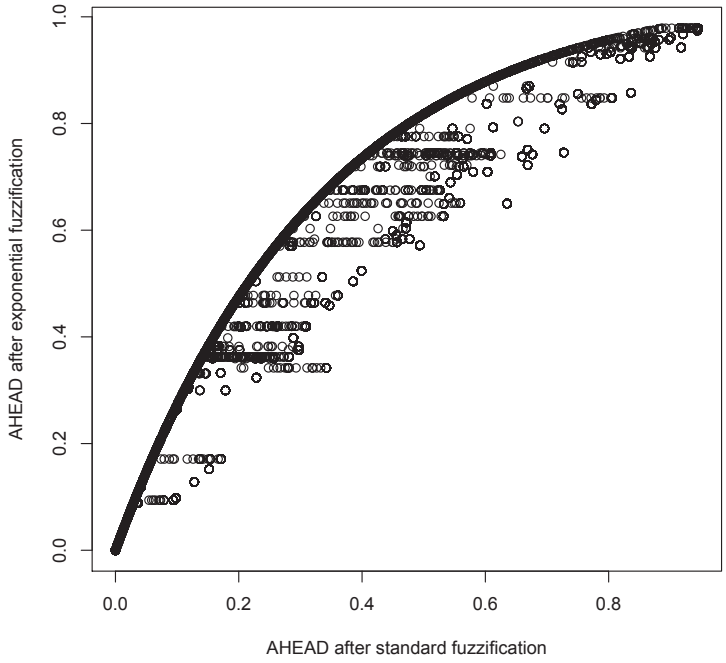


**Fig. 6.** Comparison of differences in AHEAD values between the standard fuzzification procedure and fuzzification using only exponential functions.