

## RESPONSE TO REVIEWERS

### **Reviewer #1 Yongping Wei**

#### **1) Reviewer Comment:**

I enjoy reading this manuscript. A landscape at water catchment is a holistic system in which nature and culture co-evolve. This begs the question: to what degree did the cultural construct influence the water catchment hydrology, and vice versa? However, the cultural construct (societal values) has not been adequately studied in existing hydrological models, except those studies mentioned in the manuscript. Therefore, this review is important by bringing this knowledge gap to the hydrology community (HESS). I would like to recommend this manuscript to be accepted, subject to responses to the comments as follows:

**Authors response:** We thank Yongping Wei for her positive review. We firmly agree that the degree to which cultural constructs influence catchment hydrology and vice versa remains to be explored in depth.

#### **2) Reviewer Comment:**

Culture is a notoriously slippery concept, has no agreed-upon definition across social science fields. There are more 170 definitions of 'culture' in the literature. Culture is often perceived to be opposed to nature, becomes synonymous with civilization. Culture is defined operationally as a set of common values, norms and attitudes shared by the majority of a region population, which is arguably the most important mediating mechanism that links us not only with other human beings, but also with the rest of nature of which we are part and within which we live (Keesing 1974). To talk about cultural change is one thing. To measure them precisely is quite another. The study of cultural evolution has traditionally been the purview of anthropology and sociology.

Past attempts to explain cultural evolution used the 'thick description' rather than explanatory approach which would not distinguish between explanandum and explanans. It is known that they have poor predictability. This is why culture (societal value) has not been nicely integrated in the hydrological models. However, these disciplinary studies provide the fundamental basis for any attempts of quantifying the societal value. So, I would like to this manuscript to include a more thorough review of measurement and explanation of societal value in these disciplines.

**Authors response:** We agree that culture has been a nebulous concept and that there are numerous definitions. There are challenges in incorporating culture into socio-hydrological modeling. This is why we selected the VBN framework, which allows us to identify culture as a property that emerges from the feedbacks between values, norms, and the hydrological system. This is one of the first steps to integrate social science theories linked with values and norms in context of socio-hydrology. Please note that this is an opinion piece on values and norms in socio-hydrological models, which we agree should build upon strong knowledge of the subject matter. For this reason we have provided a review of VBN theory, which we believe is very well aligned with the current state of the art in socio-hydrological modeling. With further progress in socio-hydrology, we should be able to define the components of culture (i.e., value, beliefs, norms) related to water management and seek the data sources to be exploited. Nonetheless, in the

revised paper, we will provide an additional review on the measurement and explanation of different values of society in Section 4.1 while keeping to the scope of the paper.

**3) Reviewer Comment:** VBN is one of many theoretical frameworks in sociology which explains the impact of the value-belief-norm on individual or societal decision-making and practice. However, I do not think it is practical in the context of socio-hydrology, in particular when we aim to simulate and reconstruct the historical societal value. Given the limited documents (data) sources, how can you obtain data on value, belief and norms?

**Authors Response:** Please see our response to the first comment. The VBN framework provides us a fundamental basis not only to quantify values but also to quantify the interlinkages between values and norms via beliefs, norms and human actions via behavior and human actions and norms via beliefs. Indeed we agree that the complexity of system concepts needs to be sacrificed in favor of simpler ones (while maintaining theoretical integrity), such as only piggybacking on feedbacks between values, behavior and hydrological response, according to data availability on values, beliefs and norms (see e.g. Roobavannan et al, 2017). The data challenges are discussed in Sections 4.1 and 4.2.

**4) Reviewer Comment:** You make detailed difference between value, belief and norms in Figure 2, but you did not make clear difference between these three concepts in text. So I suggest to combine 3.1 and 3.2 and use a general concept to explain the feedbacks between value and behaviour.

**Authors Response:** We intend to provide more detailed discussions of these concepts, provide more detailed definitions and adapt our text to highlight this point of the referee further.

Please also see our response to the previous comment. We agree that there is a greater emphasis on values and behavior than beliefs and norms but this emphasis is no greater than the overall case for VBN theory. Section 3.1, however defines all the terms and even illustrates the role of beliefs and norms in how values influences behavior. Further, we also emphasize the role of beliefs in changing norms and hence water use behavior, when beliefs update as a result of environmental degradation from past water use behavior.

We respect the desire of the referee to use a general concept of the feedbacks between value and behavior and given the paucity of data, VBN theory provides us with a fundamental framework to do that exactly. Section 3.1 explains the VBN theory and defines its components, while Section 3.2 deals with data paucity and to what extent such a theory has been (or can be) implemented in socio-hydrological models. We will revise the relevant section to add more detailed discussion.

**5) Reviewer Comment:** You did not give a full explanation of Figure 2, and you did not use main info in Figure 2 in your manuscript either, so I would suggest you delete it.

**Authors Response:** Please see our response to the previous comment. The illustration of a Murrumbidgee farmer is in context of Figure 2 while Section 3.2 confronts data availability with socio-hydrological models that embed the concepts from VBN theory. So we would like to keep Figure 2, if this is acceptable to the reviewer and editor.

**6) Reviewer Comment:** There is a bit repetition between Section 1, Section 2 and Section 4. Besides our findings in Australia (Wei et al., 2017) which you cited and used the data from, we had published similar findings in China (Xiong et al., 2016). I list it here for your information. Yonglan Xiong, Zhiqiang Zhang, and Yongping Wei. 2016. Evolution of China's water issue framed in Chinese mainstream media. AMBIO 45 (2): 241- 251 DOI: 10.1007/s13280-015-0716-y.

**Authors response:** We will minimize the repetition, especially in terms of socio-hydro modeling studies cited. For completeness we will also cite the work in China by Xiong et al. (2016). Thank you for bringing this to our notice.