

## ***Interactive comment on “Evolving water science in the Anthropocene” by H. H. G. Savenije et al.***

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Referee Comment

Evolving water science in the Anthropocene H. H. G. Savenije, A. Y. Hoekstra, and P. van der Zaag

General comments [Refer to page numbers where listed.]

The authors take an expansive, if still somewhat selective, view of the relationship between humans and water. This is very much in line with the objectives of the HESS special issue.

Scale interdependencies are crucial to understanding socio-hydrological processes and modifications. Beyond brief mention in the abstract and discussion, scale and

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interdependencies (not simply that processes, both human and natural, occur at different scales) get rather short shrift. The governance discussion in Section 4.2 does a good job of exploring interlinking scales and how actions/processes at one scale can have unintended consequences at another. For this paper to have greater impact, it would be helpful to strengthen scale interdependencies in at least two other sections: 2.3 “Nature talks back” and 4.1 “Emerging new concepts”.

Specifically for 2.3, are there early localized signs of ecosystem stress or adaptation to human impacts on water systems? Can these be better understood and translated to broader scale challenges (likely not always, but principles may emerge)? For 4.1 the pile-up of concepts from virtual water, water value flows, footprints, precipsheds, and remote sensing with info tech, could be reworked to more clearly identify which scale-related challenges present which analytical opportunities, and which scale-interdependent processes (human, natural, and at their intersection) require new analytical concepts and tools. At present, section 4.1 reads as tools looking for problems.

In general in this paper, groundwater use is mentioned but does not get the attention it deserves as a human intervention with global-scale implications for hydrological processes and human development.

The p. 7623 paragraphs on ancient civilizations and water suggest that the start of the Industrial Revolution is an arbitrary zero-milestone for the Anthropocene. I return to my comment on scale; clearly, at catchment scale, humans have had unalterable hydrological impacts since much earlier than Europe began to industrialize. And at the global scale, it is arguable whether human impacts began as early as the 1700s; indeed, the now well-known atmospheric CO<sub>2</sub> “hockey-stick” diagram puts the take-off point in the mid-20th Century. I am not advocating for another (equally arbitrary) starting point, simply observing that this too is scale related.

2.3 “Nature talks back” is particularly well done, and could use further strengthening in

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the mutually interactive dynamics between humans and water systems. Along these lines, IWRM appears to more of the command-and-control feed-forward version of human intervention in water systems, while adaptive water management (AWM) that has been posed – meaningfully, in my view – as a rejoinder to IWRM, is more responsive and feedback-oriented.

3.1-3.3 - I presume the intent of these sections is to demonstrate global-scale initiatives and consensus (or at least attempts to attain consensus) on water management. If so, why just these initiatives and not, for example, the World Water Forums, World Water Council, etc.?

7630 – virtual water can be shown as positive (lead to water savings) at the global scale – although the full life-cycle accounting of energy and infrastructure for transportation must also be considered (I'm not aware if some of your work undertakes this, Arjen?) – even if at the local scale it can have a pernicious effects, e.g., Mexico is a net VW importer even though some of its aquifers are in depletion resulting from VW exports [doi:10.1088/1748-9326/8/3/035005]

7638 – Along with production of agricultural commodities, I don't think it's electricity generation per se that is symptomatic of the Industrial Revolution, but energy development (starting with coal, later (hydro-) electricity, oil and gas including the current fracking boom, and nuclear; and later, potentially solar and wind) that has transformed the earth system and along with it water management. In other words, developed energy resources are both tools for intervention available to planners and engineers and they result in irreversible landscape modification – mining, hydrodam inundation, fracking, nuclear-waste repositories, etc. I say this even though electrical power has some very unique properties and direct impacts on the water cycle, e.g., see work on energy-water nexus, institutions and policy, etc. [doi:10.1016/j.enpol.2011.08.013]

7639 – the paper ends with prescriptions that are rather general; most of these I agree with, however, it would be much more helpful to draw out specific new research ques-

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tions for evolving water science that are posed as a result of your assessment in the paper, both of the state of science today and in light of the considerable challenges presented for humans and water in the Anthropocene.

Below, see further comments on some of these general observations.

Specific comments [Refer to page/line numbers where listed.]

I understand the authors' intent with the usage "man" and "mankind" but you may wish to rephrase this in the more inclusive form as "human" and "humankind".

7634/26 – 7635/13 – In my view these paragraphs are ill-matched to the governance discussion of section 4.2. Indeed, the preceding PES paragraph on 7634 might better be combined with discussions elsewhere in the text on ecosystem services, or related to the disciplinary evolution of hydrology to eco-hydrology to socio-hydrology.

7637 – the section title is not indicative of the content of these paragraphs; I suggest thinking of a clear title

7638/21 – "water knowledge \*and interventions have\* played a key role"

Technical corrections

None – this is written very clearly.

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