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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Socio-hydrologic drivers of the Pendulum Swing between agriculture development and environmental health: a case study from Murrumbidgee River Basin, Australia" *by* J. Kandasamy et al.

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Reviewers Summary: Of all major challenges humans are facing in the modern era, resource constraints and environmental impacts are of serious concern. Urban areas, agriculture, industrial and energy development face water constraints alike. Scarcity of water for irrigation is a leading concern of farmers. Mighty rivers, are significantly depleted and highly polluted in their course over years. Environment and ecology is now seriously threatened given this situation. Inefficient irrigation practices are lead-

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ing to aquifer depletions and this situation is now endemic. In this context, the current manuscript clearly describes, using a detailed case study from Murrumbidgee River Basin, the challenges and drivers. Although, the authors are driving the point that there needs to be a paradigm shift in viewing and understanding the problems from a social perspective, I see it as a changing perspective in the hydrologic community toward engineering. The issues raised here are not unique to the location and mankind is always exposed to changing conditions. How they deal with the issues entirely depends on the cultural and political situation in that region. It is a highly challenging task if not impossible to model evolving human values/behavior and a claim that social interactions based water allocation model that is dynamic is optimistic. However, the manuscript clearly points out the necessity for better management and the significance of demand fluctuations aligned to social conditions in water resource modeling. The paper has good discussion points and with minor revisions, will become a good case study presentation paper that drives the key points. It does not have any significant methodological contributions, but this manuscript should be viewed as a discussion paper that addresses or presents the current water management issues in a clear fashion.

Authors Response: Water resource management decisions produce positive or negative impacts that in many cases become evident after a long time (see figure 6 regarding response times). Therefore given the growing demand for water resources to satisfy increasing human populations, water resources management decisions needs to be based on predictions over long (decadal to century) time scales. However, in order to make predictions of future water resources we need reasonable models of how future human societies will demand, use and supply water. Hydrologic predictions over long timescales cannot escape from the twin problem of predicting how human societies themselves will evolve with respect to water in its many manifestations. This paper illustrates the challenge this poses for prediction by way of the Murrumbidgee case study, where the hydrology is governed by the physical (natural and human-induced), socio-economic and institutional structures but these are in turn shaped by changing

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values and norms of the population regarding water and the environment. Sivapalan et al. (2012) have proposed a socio-hydrologic framework that permits the study of coupled human-water system dynamics, including inherent bi-directional feedbacks between the two sub-systems. This paper argues that, to avoid these costly pendulum swings as described in the Murrumbidgee case study, management needs to be underpinned by long-term coupled socio-hydrologic system models that explicitly include the two-way coupling between human and hydrological systems, including evolution of human values/norms relating to water and the environment. Properly developed coupled socio-hydrologic model that includes the bi-directional feedbacks between human and water systems can track the co-evolution of the physical (hydrological), human (social systems, infrastructure, agricultural), and environmental (biogeochemical, ecological) subsystems in response to external drivers (i.e., climate variables, market conditions, food prices), and the demand for water and food (i.e., governed by human population). Further such coupled human-water system models can provide insights into dominant controls of the trajectory of their co-evolution in a given system, and can also be used to interpret patterns of co-evolution of such coupled systems in different places across gradients of climatic, socio-economic and socio-cultural conditions, and in this way to help develop generalizable understanding. The integrated water resource management (IWRM) approach, has as its focus optimising water systems to reach desired outcomes for society and the environment. The Murrumbidgee case study has clearly demonstrated the weakness of the IWRM approach for sustainable water resource management over decadal to century time scales, due to the fact that it cannot account for the bi-directional feedbacks between hydrological and human systems that have been responsible for much of the complex, emergent dynamics witnessed in the Murrumbidgee. Therefore there is a need to go beyond optimising of a water resources system.

Reviewer Questions 1) Abstract: Paragraph line 15; The statement is over optimistic. Modeling the evolution of human values is a challenging to impossible task. A better term may be human demands. What people value at any given time is impossible to

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quantify.

In this paper, we sought to describe the evolution of human values in terms of the issues that contribute towards it and to what ultimately drives decisions on allocation of water resources. In this respect we did not seek to limit the issues that influence and used a broad expression of this. The term "human values" is used within this context. However we recognise this term is ambiguous and will take up the reveiwer's suggestions and replace it with human demands.

2) Introduction: Paragraph line 5; Contrary to the statement here, humans do behave rationally to maximize their benefits. This will lead to a collective benefit if there is a mutual benefit in all the transactions. Please also state clearly, if the water supply problems here are related purely to climate shocks or due to lack of proper storage facilities to act as buffer.

Despite the optimistic nature of the reviewers comment, there are numerous examples to the contrary. The Murrumbidgee is one example. Often issues that are excluded from consideration, or minimised in some way, emerge some time later in detrimental ways requiring some response. This paper advocates, over a long time frame, the holistic appraisals of all issues and how each influences, and subsequently modifies under the influence, of the others (feedback loops). See also the authors' response above. In this respect the water recourses management issues are not specifically related to climate shocks or adequate storage facilities but a failure to consider their impacts in a holistic manner over a long term with proper accounting of feedbacks. The authors in this paper sought to generalise the problem encountered in the allocation of water recourses by way of case study.

It is worthwhile mentioning that storage facilities have control and management systems in place and have been used to cater for a range of issues including environmental water shortage. In the Murrumbidgee, storage dam levels have been low, but never actually run out, highlighting water use restriction policies that trigger when dam

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levels fall below thresholds. In the past these policies have changed over the course of time in response to changing emphasis or management criteria. These changes have been costly to the community as alluded to in our paper. This highlights the place of socio-hydrological analysis, and why problems should be managed holistically, and not just through engineering optimisation.

3) Introduction: Paragraph line 15; "hydrologic predictions": have to clearly state upfront what is being predicted here.

Hydrological predictions are specific to the problem encountered. In our paper we discussed the problems encountered in the Murrumbidgee catchment and sought to generalise the issues for broader application. In that sense we prefer not to be specific, suffice to say we include the typical hydrological parameters.

4) Page 7200 Line 20: Can the authors clarify here on what ecological costs are, how they are being measured, and how can one come up with a trade-off measure between ecological costs and value of water?

Ecological costs refers relates of the deterioration of the environment. In our paper, we refer to the deterioration of the Murrumbidgee wetlands and riverine ecology and the related flora and fauna. In various previous studies referenced in our paper, this was measured by number of fish species, proportion of each species, wetland area, bird count, etc.

The trade-off relations the reviewer refers to are, in the authors' opinion, an outcome of holistic consideration of issues related to allocation of water resources advocated in this paper. In developing these it is important to include in their development the appraisals of all issues and how each influences, and subsequently modifies under the influence, of the others (feedback loops). See also the response to item 2.

5) Page 7200 Line 5: Reference required for IMRW limitations. Sivapalan et al 2012 is a similar opinion paper on the need for hydrologists to looks at real demands also.

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However, it did not have any modeling demonstration. Can the authors clarify this?

Reference (Sivapalan et al 2012) will be added to the revised manuscript.

The actual modelling of the discussion in this paper is beyond the scope of this paper. In this paper the authors sought to provide the base information and the related data. It is intended that this paper and the data it provides will give the basis for modelling that the reviewer ask for. These efforts are in fact currently being done and have been developed into a paper. “Conceptual Socio-hydrologic Model of the Pendulum Swing Between Agriculture Development and Environmental Health in Murrumbidgee River Basin, Australia” by Zhang, Sivapalan, et al.

6) Page 7203, Line 5: “Development of perceptual model”.. in this context the authors should at least cite some references on papers that addressed these issues before. For example please refer to A modeling framework for sustainable water resources management, Authors Ximing Cai, Daene C McKinney and reference there in.

References will be added to the revised manuscript. Please also refer to the response of item 5. These models are currently being developed.

Table 1: Mention in the caption that the change of decline in bird population is also provided in parenthesis. The revised paper will be amended accordingly.

Figure 1: Please be more descriptive for the figure. Example: What are the dots (stations), triangles (weirs) etc. . . this will help readers who are not familiar with these notations.

The figure in the revised paper will be amended accordingly.

Figure 2: Other important and competing water sectors can be mentioned here.

Figure 2 is drawn in relation to the important issues faced in the Murrumbidgee as described in the paper. The figure and the issues are generalised in Figure 6 and 7. This generalisation and evolution will be made clearer in the revised paper.

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Figure 3: Please have actual time line here on the time axis.

The time axis is demarcated into the four Eras which are marked on the figure. The times of the fours eras are shown in the captions.

Figure 4: Make the fonts bigger. Also, please improve the resolution of the figure.

The resolution of Figure 4 and its fonts will be made bigger in the revised paper.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 7197, 2013.