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Interactive comment on "Socio-hydrologic modeling to understand and mediate the competition for water between agriculture development and environmental health: Murrumbidgee River Basin, Australia" *by* T. H. M. van Emmerik et al.

Anonymous Referee #2

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This paper conceptualizes a complex water management problem in the context of socio-hydrology. The authors formulate the problem into an analytical model including some essential interrelationships between hydrology, agricultural development and ecosystem, and show insights on the co-evolution of coupled natural and processes and human activities through a numerical model applied to Murrumbidgee River Basin, Australia. More specifically five system states (irrigation area per capita, a; population, N; water storage in the settlement, S; wetland storage, W; environmental awareness, E.) are simulated by five types of ordinary differential equations (ODEs). These states and endogenous processes are driven by exogenous factors like climate and food prices. The whole watershed is divided into three sub-systems (i.e., upstream, middle stream and downstream), which represent the one-way hydrologic connection and two-way population migration. I have the following comments which hopefully help the author refine the manuscript.

1. Some discussion on the analytical model including eleven ODEs can be interesting. It will be difficult to interpret the nonlinear dynamics of a system with such many nonlinear ODEs. The well-known Lorenz system, which is represented by only 3 nonlinear ODEs, shows chaotic behaviors. This then brings up some concerns about the stability of the solution of such complex systems that are characterized by nonlinear dynamics and feedback loops. Further studies that are to be based to the complex system theory can end with insights about the complex problems.

2. The parameters of the numerical model were obtained by calibration. However, more interesting results can be found from sensitivity analysis to those parameters. Which parameters are the system states most sensitive to? Which parameters can be major controlling ones? Which parameters can cause the instability of the sub-systems and the entire system? A related question is about the impact of the initial condition. The solution of a nonlinear system often depends on the initial state.

3. The results are interesting in terms of the sub-system coupling. Since this paper attempts to promote socio-hydrology, what are the insights, implications (based on the results) and suggestions for future efforts to the hydrology side (processes and/or systems)? In other words, what is the take-home message derived from this study to current generation of hydrologists?

4. Page 3393, lines 9-10, some explanation on the "generic model framework" will be helpful, i.e., on the conceptualization, model formulation, and/or model solution?

5. Page 3396, lines 20-25, Equation 1. In the economic literature, agricultural land change is driven by land value (USDA provides the estimate of land value by regions over years). Moreover, some justification/rationale on the impact of environment awareness on irrigated area based on literature will be helpful. For example, authors may look at the irrigated area change over years in the Republican River Basin, where irrigation development after 1990 has been indeed related to groundwater over withdrawal and stream flow depletion issues.

6. The population dynamic equations need some justifications in terms of 1) the form of general demography models; 2) irrigation potential and environmental awareness as driving forces; 3) immigration limited within the boundary of a basin (three parts). Is there any history of population change with irrigation development, especially within the study basin?

7. The storage equation. It seems that only surface water (from the river) is used for irrigation; while groundwater is the major source in many basins, where surface and ground water are often connected; deep groundwater is used in many cases (e.g., Northern China and Great Plain of the U.S.); inter-basin water transfer is another source. A bit more complex hydrologic relationships might make the analysis more realistic.

8. Equation 6. Should “min” be “max”? Why only Q1 and why not Q2?

9. Equation 7, should the epsilon function be an “S” function with a negative value when n is below a threshold and a positive value with diminishing marginal value when n is above a threshold? Can this function be related to environmental regulations over time, which however might cause step change of some of the sub-systems?

10. Equation 8, crop yield changes by region (i) given different natural (e.g., soil and landscape) and technology conditions in different regions.

11. Fig. 6 and Fig. 7 show interesting correlations among multiple sub-systems. Can

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these be related to policy/regulation change over the historical time?

12. The time period includes near future time (2014-2020). So the segments during the future period predict the plausible near future states. This should be interested to basin managers and stakeholders. Additional discussion will be interesting.

Providing the comments/questions above, I do not mean to request the author to address all of them in this paper. Some of those might be with future studies.

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