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Discussions

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Comment on hess-2021-521

Anonymous Referee #3

Referee comment on "A system dynamic model to quantify the impacts of water resources allocation on water-energy-food-society (WEFS) nexus" by Yujie Zeng et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-521-RC3, 2021

The authors create a multi-sector system dynamics model, including environmental awareness dynamics and coupled reservoir simulation. The model simulates, among other things, water demand, energy consumption, food production, environmental awareness, and population and GDP growth. The authors apply their model to the Hanjiang river basin and discuss the model simulation results at length. They identify stages of expansion, contraction, recession, and recovery for future water and energy dynamics as well as stages of expansion and stabilization for future food dynamics. The authors conduct a one-at-a-time parameter sensitivity analysis and also show that WEFS (water-energy-food-society) outcomes are strongly impacted by the presence or absence of reservoirs.

While this work aims to contribute in two primary areas – improved understanding of the impact of (1) environmental awareness feedbacks and (2) water supply reservoirs on WEF systems – I believe the work does not achieve these contributions, for the reasons described below:

- It is not clear what exactly about the approach is new. What separates the present study from those WEF studies cited in the introduction, other than the specific context and states modelled? It seems to me that the intended novelty might be coupling a WEF "system-dynamics" model with a detailed reservoir network simulation model, though this is not made clear in the paper. The discussions of model formulation and results do little to emphasize reservoir impacts, though the title suggests that reservoir impacts are central to the paper.
- Socioeconomic model (section 2.1.1, equations (2)-(5)):
  - The model formulation and justification overlooks well-established growth models subject to resource constraints. Why not use a logistic model for growth?
  - Each of these growth rates seem likely to be as or more effected by the *actual* resource limitations (i.e. shortages) than by the "environmental awareness" of those limitations. Yet, the physical limitations are not factored into these equations.

    - I believe rates of change should be proportional to the state at time t, not the initial condition.
    - The impact of technology development is either formulated unrealistically or discussed inaccurately – current formulation/discussion implies that technology suppresses growth.
    - The water quota dynamics are especially unjustified – an exponential growth/decay model seems ill-fit.
- Water shortage model (section 2.1.2, equations (6)-(7)):
    - The index for summation is not declared, making the equations difficult to interpret.
    - The variable definitions are inconsistent and contradictory. W_{dem} is said to be water demand in line 201, yet WD also appears in equation (7) and is defined as water demand. There is also a W_d variable which is never defined.
    - The temporal resolutions (time step and sub time step) are not explained and are therefore confusing.
    - The distinction between "natural" and "total" water inflow is unclear.
- Energy system and Food system modules (sections 2.3 and 2.3, equations (8)-(13));
    - These modules apply opposite approaches, without justification. The energy module simulates energy demand and takes energy production as an input ("planning energy production"). In contrast, the food module simulates food production and takes food demand as an input (misleadingly named "planning food production"). Why not simulated food demand or energy production?
    - No justification is provided for formulating energy demand as a function of water supply, as opposed to population or GDP for instance. Water supply seems like a more important factor for energy production, though energy production is not modelled.
    - I would think that the entire crop yield dynamics are due to technology changes (ignoring water shortage), yet technology change is offered as a single term in equation (11).
    - From the results (Section 4, see especially Tables 2 and 5), it seems that a constant energy production and constant food demand are used to drive the model simulation. This seems unrealistic.
- Model validation (Section 4.1):
    - The methods used to develop the observed time series are unclear. For instance, how exactly were the agricultural water demand exceedance frequencies used?
    - The observed data is not sufficient to validate the model. The observed data cover a short period during the beginning of the simulation during which all states increase approximately linearly. The effects of shortage and environmental awareness are minimal during this period (as stated by the authors in their interpretations); therefore, the observations offer no validation of the awareness dynamics or feedback. That the model matches observed dynamics under this narrow, early set of conditions does not mean that the model can reliably simulate dynamics under drastically different conditions. For instance, a model which predicts perpetual linear growth in all states would seem to match the observations equally well. Given that the data does not validate the model, the model results are only useful to the extent that the model formulation seems true-to-reality. However, little justification is given for the model formulation, and as described above, there are many problematic elements of the model formulation.
- Model results (Sections 4.2-4.3):
    - Most of the discussion of the results (co-evolution of WEF system) is a text description of what is seen in the figures. The discussion does little to draw out and emphasize insights.
    - The sensitivity discussion does little to add understanding. Most interpretations of sensitivity results are vague, such that the same observations could be stated just from the variable definition and model formulation. For example, in lines 551-553, the effect of lowering the food shortage sensitivity threshold level is obvious from its definition.

- Impacts of reservoir system (section 4.4):
  - The methodology applied here is unclear, what exactly does it mean that one scenario considers allocation and the other doesn't?
  - Nonetheless, it seems that scenario I is running the model with the real-world reservoir network and scenario II is running the model with all reservoirs removed (?). If so, scenario II does not seem like a useful comparison. Is the region considering removing any or all dams in the basin?
- There are language issues throughout the manuscript – most frequent were typos, poor sentence structure (lots of passive voice that creates confusion about who is the subject and what exactly they are doing), and inappropriate word choice. There are too many to list specifically.