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Comment on hess-2021-521

Anonymous Referee #1

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-RC1, 2021

This study addresses the phenomenon that the water, energy, and food crises that human society is facing are highly interconnected issues, and their evolutions would further stimulate human response actions, which would in turn (re)shape the evolution trajectories of the FEW systems. In doing so, the authors develop a holistic sociohydrologic model, which not only mimics the water, energy, and food systems but the related human components (e.g., population, GDP, industry, agriculture) are also incorporated endogenously. Overall, the work is interesting and represents a very important direction for extending the scope of sociohydrology, which has been discussed particularly by Di Baldassarre et, al, Sociohydrology: Scientific Challenges in Addressing the Sustainable Development Goals https://doi.org/10.1029/2018WR023901. In this sense, I think this manuscript is a valuable contribution to the scientific progress within the scope of sociohydrology. However, I do have some concerns and suggestions that need to be addressed, which are listed below.

- The text and grammar should be revised throughout. There are many places (too many to be listed) where the language is unclear and misleading.
- I suggest the authors give a more detailed description of figure 1. This figure is very important for understanding the overall feedback relationships between the model variables. Currently, I am not very clear about the feedback relationships.
- I have some concerns about equations (2)-(5). First, this seems not the Malthus growth model. In the Malthus growth model, the right side of equations 2-5 should be N, G, A, and WQ, respectively, instead of $N_{0,}$ etc. please check if it is a typo. Second, there is an exponential term which the authors call the technology effect, dampening the growth rate of the state variables. This is not very convincing. I believe that technology development would contribute to water conservation activities and thus reduce water

use quota, but I do not understand why it would have a negative effect on GDP, population and crop area, this is somewhat counter-intuitive. Third, equation (5). Why is there a negative sign in front of WQ? From table 2, r_{qwu} is already a negative value (i.e., -0.02). If you intend to indicate that the water use quota is decreasing over time, one negative sign needs to be removed. In addition, in this case, the exponential term would dampen the decreasing rate of water use quota. This might not be reasonable, because technology development is always supposed to accelerate the decreasing of water use quota instead of dampening it. Fourth, there is a term representing the effect of GDP on water use quota in equation (5). I assume the rationale is that GDP development would prompt the advancement of water-saving technology. But the effect of technology has already been considered by the exponential term. I think perhaps the equation (5) is over-complex. Fifth, line 155, the authors claim that this study considers municipal and rural water consumption, industrial water consumption and agricultural water consumption, so I think there should be a distinction of water use quota for each of these types of water use. However, there seems no distinction between the different types of water use in equation (5).

- The description of the water resources allocation in section 2.1.2 is too simple. I cannot understand the rationale behind equations 6 and 7. Especially, reservoir operation is an important focus of this study, I suggest the authors give some more detailed descriptions of the water resources allocation processes. Currently, it is difficult to see how the water shortage rate is calculated in equation 7.
- Equation 8 has the same problem as equation 5, please see comment (3).
- I am a bit confused about how energy consumption is defined in this study. In equation 9, energy consumption is calculated by multiplying water supply by energy use quota, so I assume that energy use quota is defined as the energy demand for supplying per unit of water. In this case, energy consumption in this study means the energy consumed by the water supply sectors only. However, in line 319, the authors introduce the energy consumption by the steel and petrochemical sectors. I think more clarifications are needed. In addition, would the situation of energy shortage have a negative effect on water supply? There is no energy considered in equations 2-7.
- Equation 11. Similar to comment (3), technology development is supposed to benefit crop yield, but the exponential term here is dampening the crop yield.
- Environmental awareness put forward by van Emmerik et al. is intended to capture human sensitivity to environmental deterioration. In this study, the authors quantify environmental awareness by water shortage, food shortage and energy shortage (i.e., equation 14). I feel food shortage and energy shortage are more like social problems rather than environmental problems. It might be better if the authors change a name for this variable.
- Equation 18, 19 and 20 should be piecewise equations. I.e., when E is smaller than Ecrit, f(E) should be zero.
- Equation 21-23. If GDP would have an effect on water, food and energy systems, I think it might be more reasonable to use the magnitude of GDP instead of its changing rate.
- Section 3. Human response to the issues of water, food and energy shortages is an important aspect of the model. I suggest the authors give some observable evidences to show human adaptive response towards the mismatch between demand for and availability of water resources. for example any policy?
- A more detailed description of figure 3 is needed.
- Table 2. These are parameters and they may need to be listed in table 3. In table 2, the authors may need to show the initial conditions of the state variables, i.e., population, GDP, crop area, etc.
- Table 2 and 3 are too simple. At least the authors need to give a brief description of these parameters, as it is in table 5.
- There are only ten years data (i.e., 2010-2019, in yearly time step), but there are 35 parameters that need to be calibrated, which means this is a very complicated overparameterized model. I guess most of the parameters are insensitive. Perhaps an

initial sensitivity analysis is needed to screen out those insensitive parameters before conducting calibration.

- Section 4.3. The authors explore the system sensitivity to seven parameters. I wonder why these seven parameters are chosen? Especially, all of them are threshold parameters. Are there any management implications obtained? I think it might be more informative if the sensitivities of the parameters related to human management actions are explored.
- Table 6. I am a bit confused about how the shortage rate is calculated. In some cases, the shortage rate is derived by dividing shortage by demand, and in some cases it is not. For example, in scenario I, the shortage of rural users is 0, why the shortage rate is 0.23%?

Additional minor comments:

- Line 63. The authors claim that system of systems model and agent-based model do not consider the feedbacks of integrated systems. I do not think this is true. A more appropriate literature review may be needed.
- In equation 4, crop area is denoted by A, but in equation 12, it is denoted by CA. please make it consistent.
- Line 251. The authors claim that environmental awareness proposed by van Emmerik et al. is more specific than community sensitivity. This is not the case. In fact, community sensitivity is proposed by Elshafei et al. through a more extensive literature review, and it is considered more sophisticated and is used more widely.
- Figure 4. Please try not to use abbreviations in the figure. It is very difficult to read.
- I notice that in some places, the authors use the word “resilience”. This is a complex concept, and as it is not the focus of this study, I suggest the authors use some simpler words.