Reviewer 4

This study modeled the WEF nexus by incorporating community sensitivity and reservoirs operation, where the co-evolution behaviors of the nexus across the water, energy, food, and society (WEFS) were simulated by the system dynamic model. The proposed approach was applied to the mid-lower reaches of the Hanjiang river basin in China, and the results indicated that water resources allocation could ensure water supply through reservoirs operation and greatly decrease the water shortage rate. This study is an interesting and crucial one for improving resources management. While modeling the WEF nexus in a large watershed is a very challenging problem and difficult to validate its suitability and applicability, especially when there are only limited datasets. This study made a great effort in this direction and proposed a sophisticated methodology with some preliminary analyzed results, which is a valuable contribution to the scientific community. However, I have some concerns and suggestions, which need to be better addressed, listed as follows.

Thank you very much for your positive remarks on our paper. We will thoroughly revise the paper based on your comments. We believe the current comment can greatly help improve the quality of the paper. Here are the responses to your comments:

1. The initial conditions of external variables for the integrated system shown in Table 2 and the calibrated parameters presented in Table 3 should be explained in more details. I am curious why many parameters have the same calibrated value. How to set these values?

1 Response

Thanks for your supportive suggestion. We will add the notations, descriptions, units and values of variables and parameters in Table 2 and 3. And we will give more details for model calibration in Section 4.1. Initial parameter sensitivity analysis is adopted to screen out the insensitive parameter, indicating that there are 13 insensitive parameters and 21 sensitive parameters, respectively. The setting of the insensitive parameter is on basis of expert knowledge and the work of Feng et al. (2019) (the insensitive parameters are thereby set to 0.0856), which has been proved with good performance and suitability. The sensitive parameters in model are then calibrated by fitting the observed data.

2. How many datasets are used for model calibration? The number of calibrated parameters used for model calibration should be discussed. How to justify the suitability and applicability of the calibrated model should be given.

2 Response

Thanks for your supportive suggestion. The observed data of annual water demand, energy consumption, food production, population, GDP and crop area from 2010 to 2019 are used to calibrate the model. We will add the details for model calibration, as is discussed in "1 Response". 21 sensitive parameters are screened out and calibrated by fitting observed data, the calibration values of which will be listed in Table 3.

We will also give more details for the suitability and applicability of the calibrated model in Section 4.1. The Nash-Sutcliffe Efficiency (NSE) coefficient and percentage bias (PBIAS) are used to calibrate the model. With the NSE more than 0.7 and the absolute value of PBIAS less than 15%, the modelling performance is considered reliable. The NSEs are always more than 0.7 and the corresponding PBIASs are within -15% to 15%, suggesting that the established model is capable to simulate co-evolution of the WEFS nexus.

3. The "Respond links" among the different variables in the WEFS nexus should be explained in much more detail. The terms of feedback functions based on previous work should further explain their suitability.

3 Response

Thanks for your supportive suggestion. The details of respond links will be added in Section 2. Description for connection between water system and energy system as well as food system will be improved as follow: The water demands and available water resources are further inputted into water resources allocation model to determine water supply and water shortage for every water use sector in each operational zone. The water supply for socioeconomic water use sectors outputted from water system module is taken as the input of energy system module to determine energy consumption. And the agriculture water shortage rates is taken as the input of food system module to estimate the food production. And description for feedback driven by environment awareness will be improved as follow: As environmental awareness accumulates over its critical value, negative feedback on socioeconomic sectors (i.e., population, GDP and crop area) will be triggered to constrain the increases of water demand and further energy consumption and food production to sustain the WEFS nexus.

The description for the suitability of the feedback function will be added in Section 2.5. The terms of feedback functions are based on the work of Feng et al. (2019) and Van Emmerik et al. (2014), which has been proved with good performance and suitability, as it has been successfully applied to simulate the human response to environment degradation in Murrumbidgee river basin (Australia) Hehuang region (China).

4. Figure 4 shows the trajectories of population, GDP, crop area, water demand, energy consumption, food production, shortage rates for water, energy, and food, awareness for water shortage, energy shortage, and food shortage as well as environmental awareness during 2010-2070. The trajectories are the basis of the following analyses. How to get these trajectories should be given in more detail, and their suitability should be discussed?

4 Response

Thanks for your supportive suggestion. The co-evolution of WEFS nexus is conducted based on system dynamics modelling (SDM), which conducts according to the nonlinear ordinary differential equations and dynamic feedback loops as is demonstrated in Section 2.

More details about the application of the established WEFS nexus in the study area will be given in Section 4. The SDM is applied to model the WEFS nexus in the mid-lower reaches of Hanjiang river basin. The established WEFS nexus runs on a yearly loop. Specifically, as water resources allocation model in water system module takes a monthly time step in the study, the annual water supply and water shortage are firstly determined before outputted to energy system module and food system module, respectively. The annual shortage rates of water, energy and food are then used to determine environmental awareness and further the feedback.

5. How to divide the evolution of water demand and energy consumption into four phases should be given?

5 Response

Thanks for your supportive suggestion. The co-evolution processes of water demand and energy consumption can be divided into four phases (i.e., expansion, contraction, recession and recovery) based on the trajectory of environmental awareness.

We will emphasize the phase dividing rules in Section 4.2. With environmental awareness below its critical value, the negative feedback on socioeconomic sectors isn't triggered and water demand as well as energy consumption increases rapidly in the beginning of co-evolution, which is defined as expansion phase. As environmental awareness exceeds its critical value, negative feedback on socioeconomic sectors is triggered and the increases of water demand and energy consumption are constrained, which is defined as contraction phase. The environmental awareness accumulates to the maximum value and water demand as well as energy consumption goes to depress significantly, which is defined as recession phase. As environmental awareness gradually decreases below its critical value, water demand and energy consumption decrease slightly and then tend to stabilization, which is defined as recovery phase.

6. The seven controllable parameters adopted for sensitivity analysis should be discussed in more detail.

6 Response:

Thanks for your supportive suggestion. As the critical values and boundary conditions of WEFS nexus are considered as vital factors for policy-makers and managers to control the integrated system so as to achieve the concordant development goals, seven parameters are selected for sensitivity analysis. We will update the figures for sensitivity analysis by replacing the black lines with colored lines and color bars so as to give a more informative sensitivity analysis for identifying the explicit variations of state variables with varying parameters. Sensitive analysis on water demand is taken as an example in Figure 6 here.

We find that the co-evolution mode of WEFS nexus functioning strongly depends on the selection of certain parameter values. Rational parameter setting of boundary conditions and critical values is of great significance for managers to keep the socioeconomic sectors from violent expansion and deterioration, especially in contraction and recession phases.

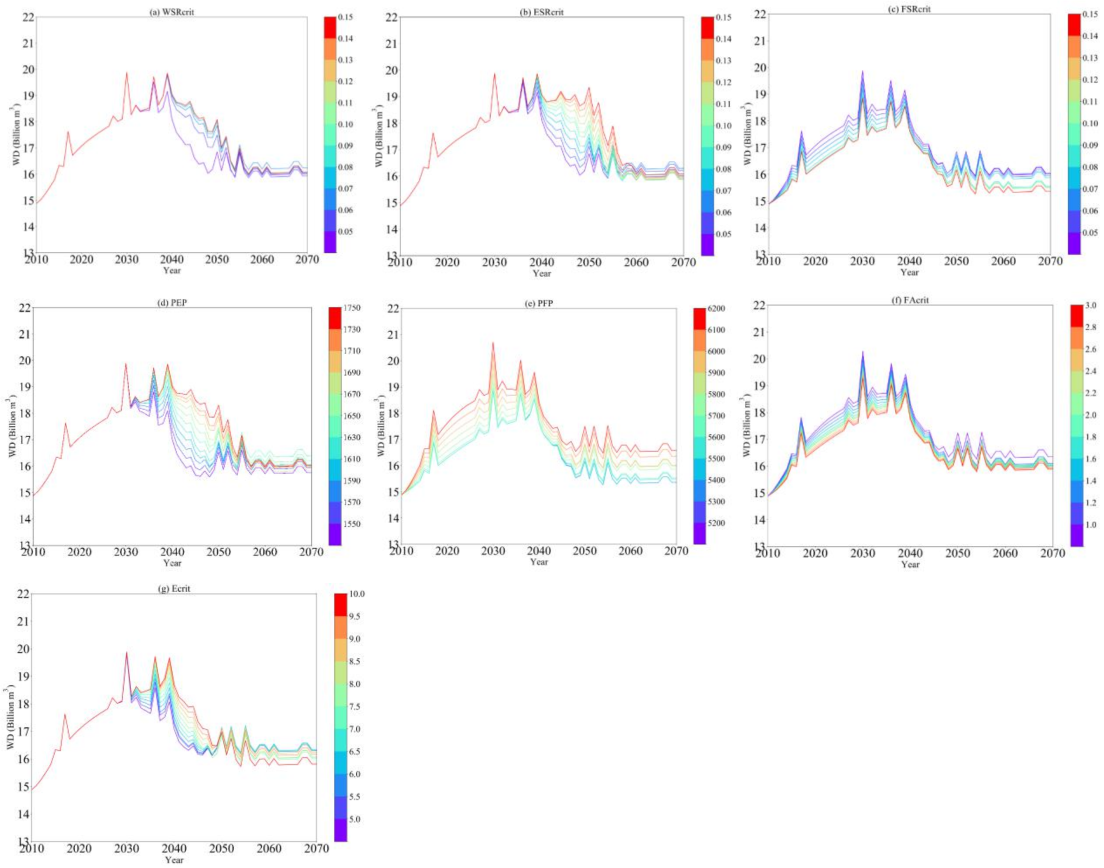

Figure 6. Trajectories of water demand with varied parameters. (Figure 7, 8 and 9 for trajectories of energy consumption, food production and environmental awareness will also be updated)

7. The conclusion seems like a long summary of the current study. The main contribution with brief (solid) scientific findings extracted from this study might be more interesting to read and easy to learn.

7 Response:

Thanks for your supportive suggestion. We will carefully improve the conclusion part to make it conciser as follow.

The proposed approach provides a valid analytical tool for exploring the long-term co-evolution of the nexus across water, energy, food and society systems. Environmental awareness in society system can effectively capture the human sensitivity to shortages from water, energy and food systems. The feedback driven by environmental awareness can regulate the socioeconomic expansion to keep the integrated system from constant resources shortage, which contributes to the sustainability of WEFS nexus co-evolution. The co-evolution of water demand, energy consumption and food production can be divided into expansion (accelerating and natural expansions for food production), contraction, recession and recovery phases based on environmental awareness. The co-evolution mode of WEFS nexus functioning strongly depends on the selection of certain parameter values. Rational parameter setting of boundary conditions and critical values is important for managers to keep the socioeconomic sectors from violent expansion and deterioration, especially in contraction and recession phases. Water shortage can be effectively relieved by the increased water supply through reservoirs operation. The high-level environmental awareness lead by water shortage is thus remarkably alleviated. As the negative feedback driven by environmental awareness is weakened, socioeconomic sectors develop rapidly. Water is thus no long the vital factor constraining the concordant development of WEFS nexus in expansion phase. Therefore, water resources allocation is of great significance for the sustainable development of WEFS nexus.

References

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