

The manuscript titled “Socio-hydrological modeling of the tradeoff between flood control and hydropower provided by the Columbia River Treaty” by Shrestha et al. understand the cooperation dynamics in Columbia River Basin through investigating how and what factors drives the two countries into a successful cooperative regime in the past, and what would the balance shift in face of the social, institutional and environmental changes. The paper is generally well written and structured. The concept of the paper is interesting, and crucial one for understanding the underlying mechanism of a successful cooperation dynamic and transboundary co-evolutionary dynamics in general. On top of that, this study provides valuable insights and reference for the negotiations of the treaty within and beyond Columbia River. I recommend this paper being accepted with some minor revisions.

General Comments:

- The manuscript can generally be improved with a more solid literature review in the introduction. More specifically the authors are encouraged to review on the existing studies in understanding transboundary rivers management from different disciplines, and through the lens of conflict and cooperation dynamics. The selection of variables that influence on the choice of cooperation, i.e. institutional capacity, social and behavioral preferences could be articulated.

Authors’ response: Thank you for your kind evaluation and helpful comment. We will articulate the cooperation and conflict dynamics in other transboundary river basins based on the existing literatures from the perspective of institutional capacity and social preferences.

Detailed comments:

- Line 49: “actors’ decisions are guided by their or social preferences”, delete “or”;

Authors’ response: Thank you for pointing this out. We will improve this in our revised manuscript.

- In the introduction line 50-52, the authors stated that “actors exhibit social preferences if the actor not only cares about their own material benefit but also cares about the material benefits of other actors”, this is not clear, please re-structure this sentence.

Authors’ response: Thank you for this comment. The sentence is conveying that, as suggested by Fehr and Fischbacher (2002), and Kertzer and Rathbun (2015) the decision makers have social preferences and that their decision is motivated by social preferences, which is the behavioral characteristics that such actors care about gain (here, material payoff) not just for themselves but also for others. We will certainly revise this.

- Line 64: update the number of global transboundary river basin with 310 rivers, see McCracken & Wolf 2019 for the most updated info on this: “Updating the Register of International River Basins of the world” by McCracken & Wolf 2019, <https://doi.org/10.1080/07900627.2019.1572497>

Authors’ response: We appreciate updating us about this recent information. We will revise this.

- Line 70, what is “social comparison”?

Authors’ response: Social comparison refers to the social behavior that actor compares their position, benefit, or risks with other actors. For example, according to some previous research in behavioral economics, it was empirically revealed in a field experiment that people tend to be more cooperative if they know many others are contributing (Frey and Meier, 2004). We will elaborate this by explaining it alongside the social preferences.

- Paragraph 89 – 100 introduced the challenges of cooperation in transboundary river basins through listing the possible impacting factors, i.e. political/economic power, geographic locations, followed by the four types of benefits, which were a bit of a sudden jump, please consider re-structure this paragraph.

Authors’ response: Yes, we agree. We will revise these two arguments with better transition.

- Line 121- 135, descriptions on social preferences, there are four types of social preferences stated, what are the differences between the social preferences and social motives? There are also four types of social motives: individualism, competition, cooperation and altruism, how is the social preference differentiate with the social motives and why social preferences is selected here?

Authors’ response: Thank you for this important question. Considering the equal benefits and risks sharing provision between two actors in CRT, each actor has their individual decision roles which determine the benefit or risk they receive. The successful continuation of CRT is indeed the result of mutual decision making and agreement, rather than competition. And as the agreement was founded on the equal benefit sharing, the two actors and their decisions are best described by inequality aversion.

- Line 150, this research builds upon the work of Lu et al. (2021), could the author explicitly explain the novelty developed for the model used in this paper, what are the advancement?

Authors’ response: The application of socio-hydrological model in the transboundary river basin to study the dynamics of cooperation between actors as an evolutionary process is relatively new in science of socio-hydrology, which is discussed by Lu et al. (2021) too, and we use the similar concept in the Columbia River Basin to study the dynamics in cooperation as the function of reservoir operation, equitable benefit sharing and feedback of this benefit sharing. Particularly in our study we used the concept of behavioral economics with social preferences between actors and convert overall benefits of water resource management to the utility of cooperation or no-cooperation. This allow us to quantify the cooperation for each actor as an individual decision maker. It is also to be noted that the power dynamics between actors is very different in Columbia River Basin than in Lancang-Mekong River Basin. We also simplified the structure of model such that these individual actors’ cooperation directly affects lumped reservoir operations

using continuous input of the streamflow (i.e., inflow) as the independent variable and other key variables such as outflow and benefits as the response variables. This approach of integrating concept of behavioral science such as social preferences is suitable particularly (and extendable) to cases when the reciprocity between actors is the main driver for cooperation, where system operates to share benefits equitably while ensuring the resources are sustainable.

- Figure 2, some variables illustrated in the figure are not explained, i.e. “utility for cooperation”, “Utility for no cooperation”, etc., also, the feedback loop illustrated could be improved by differentiating variables by different types, i.e. economic variable, hydrological variables, social variables, etc., to reflect the infrastructural, hydrological, economic, social, and environmental aspects being considered in this model.

Authors’ response: Thank you for this suggestion. We will revise figure 2.

References

- Fehr, E. and Fischbacher, U.: Why social preferences matter - The impact of non-selfish motives on competition, cooperation and incentives, *Econ. J.*, 112(478), 1–33, doi:10.1111/1468-0297.00027, 2002.
- Frey, B. S. and Meier, S.: Pro-social behavior in a natural setting, *J. Econ. Behav. Organ.*, 54(1), 65–88, doi:10.1016/j.jebo.2003.10.001, 2004.
- Kertzer, J. D. and Rathbun, B. C.: Fair is Fair: Social Preferences and reciprocity in international Politics, *World Polit.*, 67(4), 613–655, doi:10.1017/S0043887115000180, 2015.
- Lu, Y., Tian, F., Guo, L., Borzì, I., Patil, R., Wei, J., Liu, D., Wei, Y., Yu, D. J. and Sivapalan, M.: Socio-hydrologic modeling of the dynamics of cooperation in the transboundary Lancang-Mekong River, *Hydrol. Earth Syst. Sci.*, 25(4), 1883–1903, doi:10.5194/hess-25-1883-2021, 2021.