Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1
https://doi.org/10.5194/hess-2022-99-RC1, 2022

Comment on hess-2022-99

Anonymous Referee #1

Referee comment on "Operationalizing equity in multipurpose water systems" by Guang Yang et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-99-RC1, 2022

This paper introduces equity metrics to design reservoir operations in multipurpose water resource problems. Equity metrics penalize variance across multiple metrics. The impact of introducing equity is evaluated through a set of four multi-objective formulations for the management of Lake Como, Italy. This is a pleasant read, with a clearly defined contribution that has the potential to be interesting. Yet, it is unclear from the paper what the introduction of an equity index can really bring to the resolution of a multipurpose reservoir operation problem. Authors need to address this in a revision to make this paper a significant contribution.

Authors note in the introduction that multi-objective optimization has gained traction in the field because it enables a posteriori decision-making (the decision is made with an understanding of the available alternatives, and the trade-offs involved) as opposed to a priori decision-making (where objectives are aggregated before alternatives are generated). An important remark in this context is that equity is by definition an a priori aggregation choice (as explored in 4.2). This means that this paper closes the circle by mixing a priori and a posteriori formulations. It is arguably the first to do it this way, but certainly not the first to explore this theme. Usually, these explorations are not groundbreaking, which is why water resource problem framings are either a priori or a posteriori, rather than a mix.

Then, what does adding equity really bring to the table? It seems this question is not asked beyond noting that it adds solutions, especially comparing P1 and P2. But the difference between P1 and P2 can hardly come as a surprise, as it is common for new solutions and trade-offs will emerge when a third objective is added to a two-objective problem.

This is a shame because the paper has all the ingredients to present a compelling exploratory framework how to account for several objectives (here recreation / environment) through a single added objective. This is important because many-objective

problems often stretch both the abilities of MOEAs and the available computational resources. Then, replacing several objectives with one could be extremely helpful. Here are the ingredients the paper has:

- The design P1 to P4 already enables to quantify the impact of (1) adding the objectives explicitly, (2) adding equity instead. Yet no metric is provided (hypervolume? Gain in selected objectives?) to provide this quantification.
- In Section 4.2, different ways to define equity are introduced. These should be presented in the experimental setup to explore (and quantify!) the impact of equity indicator choice.

Another important thing the revision could do is compare operations under different solutions (e.g., release and or lake levels as time series), to give a better sense of what solutions that are unique to one formulation bring to the set of alternatives that decision-makers could choose from.

Therefore, I would recommend for authors to demonstrate the interest of introducing equity indexes by enhancing their experimental design with (1) explicit consideration of different equity indexes at experimental stage, and (2) relevant metrics to quantify the differences between formulations. I would also encourage them to slightly revisit their introduction to note (i) that equity is an aggregation of several objectives, and (ii) that high numbers of objectives stretch our ability to solve multi-objective problems.

Miscellaneous minor remarks:

Referencing all over the manuscript: please add single spaces between references when you have several at the same time (e.g., lines 85-86)

Lines 42-44: Please add references on the efficiency / equity conflict in the water resource literature (a 1997 Loucks paper, and some of Ximing Cai's early paper, touch on that).

Line 105: "could not be equal" denotes an impossibility. Is that what authors want to convey? If not, please rephrase.

Equation (1): could authors please say a word on neglecting other terms (in particular

evaporation from the lake)?

Line 111: ":" missing at the end of the sentence; the reference should not come with extra "()"

Line 116: why is 4 an appropriate number of RBFs in this case?

Section 3.2: my advice would be to use subscripts rather than superscripts, in particular because equation (4) parameter n^F reads like an exponent (same for equation (6)).

Equation (7): please define all reliabilities in a consistent format. Besides, the introduction of an upper environmental flow limit, while great to see, requires a justification in a field where ecosystem requirements are classically represented with a minimum flow only.

Please choose between "formulation" and "problem" to describe the alternative framings throughout (with a personal preference for "formulation" with codes F1 to F4, but authors to decide).

Figure 2: please include the color code in the legend, and / or add P1 to P4 as labels on the left y-axis (instead of using floats: there is no problem 1.00 or 4.00, and this is all very confusing, as is the absence of correspondence on the figure between formulations and PX numbers). Finally, it is not clear the vertical scaling should be different in panel (a) compared with all other panels.

Section 4.2 Why not make that part of the experimental design in Section 3? This would make this section much simpler to follow.