

Author Comments for: HESS Opinions: Operationalizing sociohydrology from systems thinking to systems doing for sustainable and resilient water management

Author comment in response to Alberto Montanari

Manuscript changes described below are proposed for the next revision. Referee comments are reproduced in italics; author responses appear in regular text. Line numbers refer to the discussion manuscript.

General Comment: Operationalising socio-hydrology is a timely and fascinating theme! Socio-hydrology has the potential to play a fundamental role in overcoming the lack of public—and local administrations—consensus on solutions aimed at improving sustainability and mitigating environmental and climate-related risks. To translate the concepts and methods of socio-hydrology into operational advice is indeed a challenge, also for the complications posed by so-called “institutional barriers”, that more and more represent the real obstacle to change adaptation rather than purely technical barriers (see, for instance, Oberlack, 2017).

The contribution herein presented is timely and highly significant. I enjoyed reading it as it has the potential to clarify the technical advance proposed by socio-hydrology. I believe this piece may be interesting not only to scientists working in the specific field, but also to the general public. To maximise the potential of reaching a large audience I am providing here below some minor suggestions in order to make the contributions more widely accessible. Quotes from the manuscript are copied in italic font.

This is a significant and timely contribution that has the potential to make an excellent opinion piece.

Response: We thank you for your generous assessment and constructive suggestions for making the paper accessible to a wider audience. We have simplified the abstract, clarified canonical feedback structures and case-derived critical pathways, qualified the levee and reservoir examples, illustrated a leverage point, and strengthened the discussion of participation and implementation capacity. Our point-by-point responses are below.

1. Line 20: *“(i) canonical feedback structures that make cases comparable without erasing context....”.* *The sentence is clear to me, but I suggest in the abstract to use a less technical language.*

Response: Thank you for this suggestion. We have replaced “complementary abstractions” with “complementary approaches” and “without erasing context” with “while accounting for important local differences.” We retain “canonical forms” and “critical pathways” as the central concepts, with brief explanations: the former describe the main components of human–water systems and how they interact, while the latter trace how management actions propagate through these components to produce outcomes, including unintended consequences.

2. Line 34: *I think clarity would benefit by explaining why so far (apparently) case representation has implied erasing the local context. An example would be highly beneficial, as the authors apparently recognise such “erase” as a limitation of socio-hydrological studies so far.*

Response: Thank you for this suggestion. We have clarified in Section 1 that our concern is the risk of oversimplification when shared component labels or aggregated variables conceal important local

differences. For example, a single urban “water demand” variable can obscure discretionary consumption by affluent households alongside unmet basic needs among poorer households. We cite Savelli et al. (2023) as a positive illustration of how distinguishing consumption patterns and inequalities in water access improves understanding of scarcity and informs interventions. The revised wording is “while accounting for important local differences.”

3. Section 2: I am missing a definition of what is meant by “canonical forms”. I think details should be given, for the sake of more clarity with respect to non-specialist readers.

Response: Thank you for this suggestion. We have added a concise definition at the beginning of Section 2: “We use canonical feedback structure, or canonical form, for this simplified representation of system anatomy, which makes cases comparable while retaining local differences.” The preceding sentence identifies six interacting components and calls for mapping their key feedbacks (Fig. 1; Tian et al., 2026). Thus, “canonical form” is shorthand for “canonical feedback structure”, referring to the system anatomy and its interactions. We use these terms consistently throughout the manuscript.

4. Section 2: the examples of the levee effect and reservoir effect are meaningful. I suggest to organise the text by taking into account the emerging criticism that levee-effect narratives can sometimes be mobilized as critiques of engineering-dominant paradigms. The criticism is based on the claim that several studies do not sufficiently distinguish between structural-only approaches and hybrid resilience strategies. I think an excellent reference is the recent paper by Catalano and Hall (2026).

Response: Thank you for this clarification and for recommending Catalano and Hall (2026). We have revised Section 2 to distinguish reliance on structural protection alone from hybrid strategies combining infrastructure with land-use planning, risk communication, preparedness, and adaptive management. Canonical feedback structures represent the system anatomy and its interactions, while case-derived critical pathways trace how interventions propagate to unintended consequences. These pathways help examine where complementary measures could interrupt adverse feedbacks while retaining infrastructure benefits. We similarly discuss reservoir storage together with demand management, allocation rules, and drought preparedness. We also distinguish storage-induced demand growth from the greater vulnerability associated with reservoir dependence (Lucero, 2002; Di Baldassarre et al., 2018).

5. Line 73: I suggest including a definition of leverage point. It would also be useful to provide an example of what can be considered a leverage point and how the underlying dynamics can be modelled and parametrised. Moving from identifying leverage points to the formalisation of how interventions propagate through feedback, delays, and adaptive responses is the critical step for ensuring that leverage points become efficient as predictive tools.

Response: Thank you for this suggestion. We have defined leverage points in Section 2 as places in a system where a small change can substantially alter its behaviour. The example concerns water-use restrictions: falling storage triggers restrictions, demand adjusts, and reduced withdrawals affect storage. A coupled reservoir-demand model can formalise this feedback (Garcia et al., 2020), with thresholds specified by operating policies and response rates and delays estimated from records or tested over plausible ranges. We clarify that predictive use requires testing these dynamics and evaluating uncertainty; identifying a leverage point alone is insufficient.

6. Line 104: I agree that participation is essential for moving from concepts to operational practice. However, very often participation paradoxically emerge as a barrier to action when it produces delay, tokenism, conflict escalation, participation fatigue, or procedural overload. See, for instance, Bruley et al. (2026) and Wamsler et al. (2020). Revisiting the strategy and organisation of participation is a key subject in the scientific debate.

Response: Thank you for highlighting this qualification and the relevant references. We have expanded Section 4, with a cross-reference from Section 3, to acknowledge that poorly supported participation can generate delays, tokenism, conflict escalation, fatigue, and procedural overload (Wamsler et al., 2020; Bruley et al., 2026). We specify the time, funding, facilitation skills, sustained engagement, and institutional capacity needed to connect participation with decisions and implementation. The discussion also addresses power imbalances, clear responsibilities, realistic timelines, feedback to participants, and continuing evaluation of their burdens and influence. This coordinated revision also addresses Ursula McKnight's Comment 5.

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