

## REVIEWER 2

---

### Comment 1

Firstly, the introduction focuses on drought and drought impact assessments. While I do believe a framework for drought impact assessment would be valuable, it seems that the framework and manuscript here are **not really focused on drought**. The framework and descriptions in the manuscript are quite general and would apply to any water issue not only to drought. There are no specific aspects that only relate to drought.

### Response 1

We agree that some specific parts of the framework might appear not drought-specific. The identified key dimensions do include some general aspects of transdisciplinary approaches, which can be relevant and applicable beyond drought impact applications since they were built on existing literature on transdisciplinarity. In fact, the purpose of our framework is to adapt generic transdisciplinary frameworks to the complex subject of drought impact assessment, which requires specific processes to be carefully addressed. As a consequence, some dimensions embrace those key features of any robust transdisciplinary process, including, for example, stakeholder engagement, while others are more drought-specific dimensions, for example, "building a shared knowledge on drought", which reflects the complex and context-specific nature of drought compared to other natural hazards.

However, we do believe that an effort to adapt an even more generic dimension to the specific subject of drought can indeed strengthen the relevance of our framework and increase its usefulness. For this reason, we will **revise the description of the different dimensions, highlighting the specific features connected to drought research**. We will also rename some of the dimensions to explicitly include drought-related features. For example, "Mapping and engaging stakeholders" (Section 3.1) will be renamed as "Set up a collaborative space for drought knowledge co-creation." , "Framing the scope of the co-creation process" (Section 3.2) will become "Framing the drought co-creation process", while "Conceptualising and implementing the model" (Section 3.4) will be renamed as "Co-selecting and co-developing models to understand drought impacts".

Sections 3.1 and 3.2 address two dimensions that encompass key features of transdisciplinary processes. These sections would benefit most from revision to emphasize the specific aspects related to drought research. In Section 3.1 we will add the following text to better reframe this dimension from the perspective of drought impact assessment:

*"In addressing water resource challenges, particularly drought, the failure to include*

*marginalized groups—especially indigenous populations and low-income communities—can significantly hinder effective decision-making. Drought conditions often exacerbate existing inequalities, making it even more crucial to incorporate diverse perspectives and traditional knowledge into resource management strategies. Despite claims of inclusive frameworks, available methods frequently fall short of genuinely integrating stakeholder input, leading to decisions that overlook local conditions and perpetuate power imbalances. A systematic approach to engaging all water stakeholders, including those with Indigenous knowledge, is essential for developing more equitable and effective responses to drought and ensuring that resource management is truly reflective of community needs and experiences (Hargrove and Heyman, 2020)."*

Moreover, we will start Section 3.2 providing more context about the importance of aligning the research questions with societal knowledge demands when addressing drought:

*"Co-creation processes envision that not only methods, research itself, and interpretation of results, but also research questions are developed in partnership. From a transdisciplinary perspective, a crucial aspect of this step is aligning the research questions with societal knowledge demands (Sarewitz and Pielke, 2007). Thus, framing the scope of the co-modelling process is crucial, as societal problems often lack clear boundaries, involve multiple stakeholders, and are deeply interconnected with other challenges, especially when dealing with complex and multifaceted phenomena, such as droughts. To ensure alignment between research questions and societal knowledge demands, it's crucial to have a representative group of engaged stakeholders (see Sect 3.1). Framing the problem and setting the research agenda to encompass diverse understandings and perspectives may require expanding the team to include additional disciplines or engaging with other stakeholders to find the right mix. From a practical perspective, this would lead to an iterative initial phase in which a first set of stakeholders is identified, the scope of the process is framed, and then potential additional stakeholders can be added, requiring further refinement of the scope."*

#### References:

Hargrove WL, Heyman JM. A Comprehensive Process for Stakeholder Identification and Engagement in Addressing Wicked Water Resources Problems. *Land*. 2020; 9(4):119.

<https://doi.org/10.3390/land9040119>

Sarewitz, D., & Pielke, R. A. (2007). The neglected heart of science policy: Reconciling supply of and demand for science. *Environmental Science & Policy*, 10(1), 5–16.

<https://doi.org/10.1016/j.envsci.2006.10.001>

#### **Comment 2**

In addition, the framework seems to be focused on modelling. Drought impact assessment can take many forms, but the framework describes procedures for a co-modelling approach. This is related to my second point. The introduction describes the differences between co-creation, co-production and co-modelling in detail and

in a way that makes it seem important to consider the whole co-creation process and not only the co-modelling part. However, the description of the framework focuses mostly on co-modelling. It would be nice to see perhaps some other co-development methods aside from co-modelling. Could the co-creation process include a step where the appropriate methods are decided? Rather than focusing on modelling from the start? Alternatively, the paper could be rewritten so that from the start the focus is more on co-modelling, but doing this may be a missed opportunity for introducing hydrologists to transdisciplinary methods that go beyond co-modelling.

## Response 2

We use co-modeling in a very broad way to accommodate different kinds of modeling approaches. Here, a model is any simplified representation of reality, including mathematical or computer models, but also conceptual models related to hydrological or socio-hydrological aspects. We acknowledge that this definition was not explicit in our submitted version of the manuscript. **We will reshape the dimension "Conceptualising and implementing the model" to include a deeper review of modeling approaches** for drought impact assessment.

## Comment 3

The description of the framework seems to be more about describing the problems of not taking a transdisciplinary approach and making the case for doing so, rather than describing the actual steps that should be taken to overcome these hurdles and to implement a transdisciplinary approach. An example is section 3.5: lines 240-262 describe how there may be power imbalances between stakeholders and that this can influence model construction and output and only in the last two sentences, in lines 262-266, there is some mention of what steps would be needed for a transdisciplinary approach. This also applies to the other sections describing the framework. Overall, this means that section 3 reads more like an introduction to the difficulties that come with doing transdisciplinary research rather than a description of a framework and concrete steps and examples for overcoming these difficulties. Section 4 introduces some steps for each part of the framework, but it would be nice to see these steps described in more detail, including some examples of how this could be done. These examples are being hinted at in section 4.2: "To propose suitable solutions to these and many other problems, a promising opportunity consists of learning from available case studies that might successfully cover some aspects of our framework when assessing drought impacts." It would be nice to include a review of these examples and include the learning from that in the framework. Including this would make the framework more useful in the sense that it would provide hydrologists with guidance on which transdisciplinary methodologies to implement and how. In its current form, the framework does not really go beyond a description of the problem.

### Response 3

We really thank the reviewer for suggesting a constructive improvement of Section 4. **We will draw from existing cases in the literature to review and exemplify more concretely the recommendations** and potential problems of knowledge co-creation for drought research. We will start by drawing from the article suggested by the reviewer in their last comment and expand on similar ones. We believe that this would make our dimension much more understandable and practically useful.

### Comment 4

One part of the framework is about setting a clear scope. However, I would argue setting a clear scope is part of any modelling study and isn't necessary transdisciplinary. The way one does it could be transdisciplinary, but I feel the description is very broad and not focused on the transdisciplinary aspects of setting the scope. In fact, the examples of time periods that are given here are very hydrological (a drought event, for example) and wouldn't allow for, for example, including policy processes that usually take longer than one drought event, but from a transdisciplinary perspective may be very important to include in the analysis.

### Response 4

We will add a paragraph at the beginning of section 3.2 "Framing the scope of the co-creation process", to better clarify the transdisciplinary aspects related to the phase of scope setting. Here is a proposal for the text we will add:

*"Co-creation processes envision that not only methods, research itself, and interpretation of results, but also research questions are developed in partnership. From a transdisciplinary perspective, a crucial aspect of this step is aligning the research questions with societal knowledge demands (Sarewitz and Pielke, 2007). Thus, framing the scope of the co-modelling process is crucial, as societal problems often lack clear boundaries, involve multiple stakeholders, and are deeply interconnected with other challenges, especially when dealing with complex and multifaceted phenomena, such as droughts. To ensure alignment between research questions and societal knowledge demands, it's crucial to have a representative group of engaged stakeholders (see Sect 3.1). Framing the problem and setting the research agenda to encompass diverse understandings and perspectives may require expanding the team to include additional disciplines or engaging with other stakeholders to find the right mix. From a practical perspective, this would lead to an iterative initial phase in which a first set of stakeholders is identified, the scope of the process is framed, and then potential additional stakeholders can be added, requiring further refinement of the scope."*

#### Reference:

Sarewitz, D., & Pielke, R. A. (2007). The neglected heart of science policy: Reconciling supply of and demand for science. *Environmental Science & Policy*, 10(1), 5–16.  
<https://doi.org/10.1016/j.envsci.2006.10.001>

Regarding the specific aspect of the time, we agree that indeed **two different time dimensions might be considered**, one is the time horizon of the modeling, and the other one is the time horizon of the transdisciplinary process. **We will rephrase the text to take into account this further aspect.**

## Comment 5

Finally, section 2 is very short and does not contribute that much to the manuscript. I wonder why only the state in the art for socio-hydrology is described? Why not include sections on the state of the art in transdisciplinary research in sustainability science, integrated water resources management, socio-hydrology, science and technology studies, and political ecology? In addition, I feel section 2 is missing some socio-hydrological studies on participatory approaches. They may not be on drought, but there are several studies on co-creation or at least co-modelling within the socio-hydrological literature. Some of them may be limited in how much they include stakeholders, but I think they should be included in the discussion of the state of the art in socio-hydrology. Some examples include:

<https://doi.org/10.1016/j.jhydrol.2024.131522>

<https://doi.org/10.1016/j.envsci.2023.03.012>

<https://doi.org/10.1016/j.jhydrol.2024.131248>

<https://doi.org/10.3390/hydrology9030049>

<https://doi.org/10.5194/hess-26-5103-2022>

<https://doi.org/10.1016/j.apgeog.2015.05.008>

<https://doi.org/10.1016/j.envsci.2015.09.009>

## Response 5

We thank the reviewer for suggesting additional literature. We will carefully review it and include it in the manuscript.

First of all, we would like to clarify that the reason for having a specific state-of-the-art session only for socio-hydrology, lies in the fact that **this paper approaches drought from a socio-hydrological perspective**, offering a framework tailored for transdisciplinary studies and projects that view drought as a result of feedback between water systems and human activities. As a natural consequence, **socio-hydrology is one of the seven bodies of literature we are investigating, and it has been the first from which we began our methodological exploration.** Transdisciplinary approaches in socio-hydrology mainly address flood hazard. Nevertheless, as we intended to do with all the other bodies of literature, we tried to understand if some key features might be transferred to drought.

Clarified that, according to the comments received also by the other reviewer, we have decided to remove Section 2 and move its content into the Introduction, to further contextualize the research gap within the target research field of socio-hydrology.