

**Response to reviewer number 1 – NHESS SPECIAL ISSUE Drought, society, and ecosystems
(NHESS/BG/GC/HESS inter-journal SI)**

Dear Anastasya Shyrokaya,

Thank you for your thoughtful and constructive comments on our manuscript, for your time reviewing it and for your prompt review. Your feedback has contributed to improving the clarity and depth of our work. I apologize for the delay in my response, as I needed some time away from research before my PhD defense. As the first author, I am now able to fully address your comments. Please, see them attached.

Kind Regards,

Louise Cavalcante on behalf of all co-authors.

Comment	Response
<p>Line 53-65: This paragraph introduces different types of droughts. I wonder why environmental/ecosystem type of drought is not included among meteorological, agricultural and hydrological types, which is still a physical manifestation of impact before introducing the socio-economic drought? (pls refer to AghaKouchak et al. 2021). If the reason for this is the limited number of impact reports for environmental drought (as shown in Wildfires category in S1 Table 3), leading to its merging with socio-ecological-economic impact category, I would suggest first introducing the environmental drought and its physical impacts, and then explaining why they were merged.</p>	<p>We appreciate this suggestion and have revised the introduction to include a discussion of environmental/ecological drought. We also referred to AghaKouchak et al. 2021.</p> <p>We now introduce environmental drought and its physical impacts before discussing socio-economic drought. This revision aligns with a similar request made by another reviewer, further reinforcing its importance.</p> <p>“Another category, often considered by ecologists, is environmental or ecosystem drought, which refers to a temporary shortfall in water availability that pushes ecosystems beyond their vulnerability limits, disrupts ecosystem services, and triggers feedback loops within both natural and human systems (Crausbay et al., 2017).”</p> <p>We have reviewed the paragraphs on drought definitions, and they now read as follows:</p> <p>“Due to the complexity of drought, scholars are continuously engage with and stay informed about the latest discussions and advancements in the subject because there is no there is no universal definition of drought. This ongoing engagement highlights the multidisciplinary interest in the subject (Mishra & Singh, 2010; Lloyd-Hughes, 2014; Wilhite & Glantz, 1985). In the context of climate change, defining drought becomes even more challenging, as it is difficult to establish climatological norms for the various components of the local water balance. As human activities increasingly impact the environment,</p>

there is a growing need for an integrated approach that considers both natural and human factors. Recent research suggests that drought should be viewed and understood as a process, not merely a product. It involves complex interactions between natural and human-induced changes, such as climate change, land and water management, and human decision-making (AghaKouchak et al., 2021).

Different categories of drought are understood based on the specific context and disciplinary perspectives through which they are examined. For example, meteorologists might define drought in terms of precipitation deficits, focusing on meteorological drought—characterized by prolonged periods of insufficient precipitation, often coupled with increased evapotranspiration, affecting large geographic areas (Wilhite et al., 1985). Agricultural scientists, on the other hand, might emphasize soil moisture levels and the impact on crops, leading to a focus on agricultural drought, which occurs when a lack of soil moisture prevents plants from growing, often due to precipitation shortages and/or high evapotranspiration rates (Wilhite et al., 1985). Hydrologists typically concentrate on the availability of surface and groundwater resources, categorizing drought from a hydrological perspective, which includes negative anomalies in surface and groundwater, such as below-normal groundwater levels, reduced water levels in lakes, shrinking wetlands, and diminished river discharge (Van Loon, 2015). Another category, often considered by ecologists, is environmental or ecosystem drought, which refers to a temporary shortfall in water availability that pushes ecosystems beyond their vulnerability limits, disrupts ecosystem services, and triggers feedback loops within both natural and human systems (Crausbay et al., 2017).

When attempting to describe the social components intertwined with complex interactions, such as those found in socioeconomic drought, important questions arise

	<p>about where the physical aspects of drought end and the human impacts begin. Socioeconomic drought has traditionally been linked to the imbalance between water supply and societal water demands (Wilhite & Glantz, 1985). However, this type of drought is not merely about the physical scarcity of water but rather the broader societal and economic consequences that arise from it. While recent reflections have expanded the concept of socioeconomic drought to include indirect impacts beyond just the lack of water (Kchouk et al., 2023), many still rely on indices based on physical data to assess these droughts. For instance, indices like the Water Resources System Resilience Index (WRSRI) are used to more accurately identify the onset and duration of socioeconomic drought events (SEDEs) (Wang et al., 2023b). The transition from meteorological and hydrological drought to socioeconomic drought has been analyzed using linear methods (Wang et al., 2023a). However, a significant limitation of these approaches is the absence of direct social data, such as the impacts on populations, economic activities, social vulnerability, or public response to drought conditions.”</p>
<p>Line 114-116: I assume you focused on smallholders, because “they are one of the most vulnerable group to climate extreme impacts” and they are also called “family agriculture”? I would slightly rephrase these 2 sentences to make this clear. Also would replace “group” with “groups”.</p>	<p>We have also incorporated comments from the other reviewer into this paragraph, which now read as follows:</p> <p>In this study, we leverage data from traditionally low-data environments, recognizing the significance of these often-overlooked sources as a valuable epistemic contribution to the study of droughts. We integrate and validate these datasets to demonstrate their critical role in enhancing our understanding of drought dynamics, particularly in regions that are among the most vulnerable to drought, yet lack robust on the ground information. Our focus is specifically on the impacts on smallholders, commonly referred to as family agriculture in Brazil, as they represent one of the most vulnerable groups to the effects of climate extremes.</p>
<p>Point 2.1: A map could help a reader to locate Ceara state and visually compare it to other states.</p>	<p>We included the map and some text related to it. Please, see the map on the bottom of the page.</p>

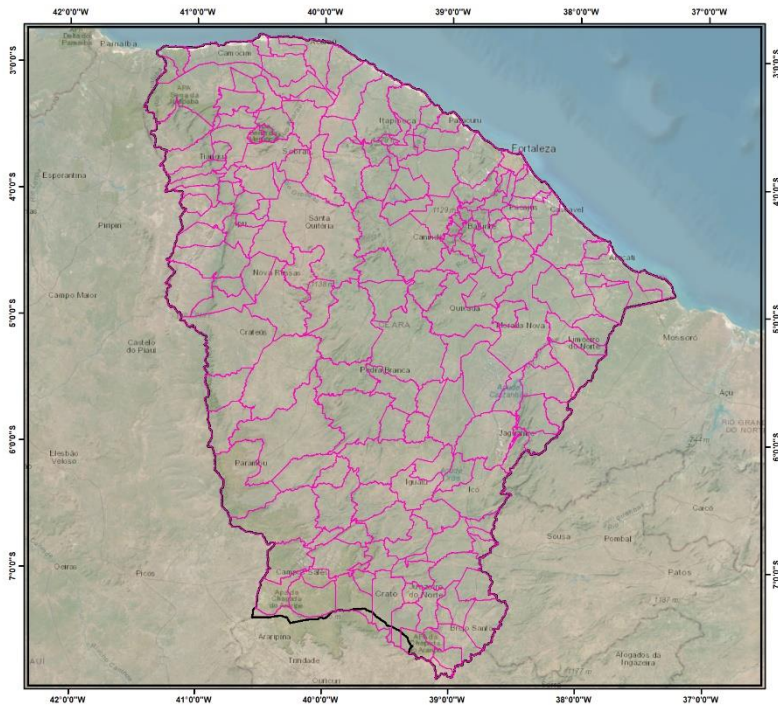
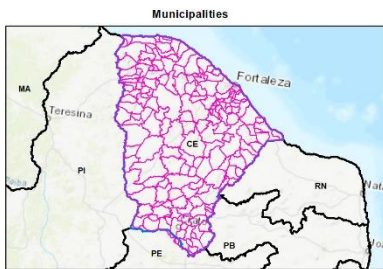
	<p>“The map illustrates the geographic layout of Ceará State, located in Northeast Brazil, which covers a total area of approximately 148,920 square kilometers. The state is divided into 184 municipalities, as outlined by the purple boundaries on the map. These municipalities are home to around 9 million people. In addition to the municipal boundaries, the map highlights the semiarid region of Ceará with a light orange shading. This semiarid delimitation is significant as it encompasses areas that are particularly susceptible to droughts and related environmental challenges. The semiarid region covers a substantial portion of the state, influencing both the climate and the socio-economic conditions of the municipalities within this area”</p>
<p>125 – 126 - The state has various economic activities, mainly the industrial, textile and automotive sectors, and tourism related to its tropical beaches and wind sports". Aren't textile and automobile industries part of the industrial sectors?</p>	<p>Thanks for noticing, it is rewritten as:</p> <p>The state has various economic activities, with key sectors including industry, particularly textiles and automotive manufacturing, as well as tourism driven by its tropical beaches and wind sports.</p>
<p>Table 1: I would leave a space before "July 2019, November and December 2021 and April 2022" to make it more clear that it indicates the period of Field work data.</p>	<p>Done! This was also asked by the other reviewer.</p>
<p>Line 192-193: "Policy documents were collected to understand the objectives and strategies of relevant policies and programs in the study area". I would advise specifying more what is meant by "relevant". E.g. policies related to supporting farmers and their families etc.</p>	<p>Done!</p> <p>Policy documents specifically related to supporting farmers, their families, and rural communities were collected to gain a complete understanding of the objectives, strategies, and implementation frameworks of these relevant policies and programs within the study area.</p>
<p>"<i>These impacts include: (8), high production costs (9), and socioeconomic impacts* (11)</i>". Is there an impact type missing in front of (8)? Should be "Wildfires" based on Fig.2?</p>	<p>I had forgotten to write this, or it might have been accidentally deleted. Thank you for noticing.</p> <p>"These impacts include: wildfires (8), high production costs (9), and socioeconomic impacts* (11). "</p>
<p>Figure 2: I would add "impacts" to socio-env-eco and start with the capital letter "Socio-env-eco". Could potentially move these titles to the</p>	<p>Done!</p>

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<p>top within each box and place them horizontally.</p>	
<p>Figure 3: It's a bit difficult to read the sentence "Socio-environmental-economical impacts of drought" within the last box, would recommend making the contrast more visible. Same for Figure 6 as Figure 3 is part of it.</p>	<p>Done!</p>
<p>Same for Figure 6 as Figure 3 is part of it.</p>	<p>Done!</p>
<p>Figure 3: "illustration illustrating" in the Figure's caption.</p>	<p>Done, now reads as: Schematic illustration depicting various directions for the cascading of drought impacts.</p>
<p>Line 308-310: "<i>The data analysis indicates that socio-environmental-economic impacts have the lowest frequency of reporting, suggesting that public policies have been effective in alleviating the cascade of impacts</i>". I would not generalize this conclusion for environmental impacts – the farmers/observers might not report on the state of ecosystems incl forest, freshwater ecosystem, water quality in lakes/rivers etc. Also, there were no policies mentioned that were alleviating specifically environmental impacts.</p>	<p>We have revised this section to avoid generalization. Now read as: The data analysis indicates that socio-environmental-economic impacts have the lowest frequency of reporting, suggesting that public policies may have been effective in alleviating some of the cascade of impacts. However, this should not be generalized to environmental impacts, as farmers and observers might not have reported on the state of ecosystems, including forests, freshwater systems, and water quality in lakes and rivers. Additionally, no specific policies targeting the alleviation of environmental impacts were not found.</p>
<p>Line 413: "<i>On drought related policies, they remain reactive, such as the crop insurance implement after drought impacts are experienced</i>". This presents an opportunity to mention an example of moving from reactive to proactive policies by e.g. using cash transfers based on forecasted impacts rather than responding to those that have already occurred, highlighting the importance of forecasting and associated proactive drought management.</p>	<p>We have incorporated this suggestion into the discussion, highlighting the importance of proactive policies and the potential benefits of using forecasted impacts to inform drought management strategies. Thanks for your thoughts on it. " In response to Michel Jarraud's claim, our investigation revealed that policy responses have been somewhat effective in alleviating the socioeconomic impacts due to the development policies in place. However, drought-related policies still tend to be reactive, such as implementing crop insurance only after drought impacts have occurred. This reactive approach</p>

	<p>presents an opportunity for improvement. For instance, moving towards proactive policies, such as utilizing cash transfers based on forecasted impacts rather than responding to those that have already happened, could enhance the effectiveness of drought management. This shift emphasizes the importance of forecasting and associated proactive measures.</p> <p>After several years of research and discussion on drought, we advocate that drought should be managed as a cross-cutting issue that impacts multiple sectors simultaneously, necessitating a comprehensive and interconnected approach. Drought’s far-reaching impacts go beyond water scarcity, influencing agricultural production, socio-economics, and increasing the risk of fires. Therefore, we highlight the significant role that public policies can play in mitigating the cascading effects of drought, particularly those impacts not directly related to increasing water availability”.</p>
<p>S1. Table 2: A little unclear with the headings: I'm guessing that "Survey Questions", "Alleviating Factor" shouldn't have a circle in front since they're the same level as the rest of the headings?</p>	<p>Addressed, thanks for noticing.</p>
<p>S1.3 Policy documents data "<i>The selected documents were about the public policies reported by both farmers and observers in the interviews</i>": have you considered checking other relevant documents that were not mentioned by farmers/observers, just generally from legislative repositories? In case there are some policy documents that potentially help alleviate prevailing hydrological impacts, but are not used by farmers for some reason?</p>	<p>Thank you for your suggestion regarding the consideration of additional policy documents from legislative repositories. I would like to assure you that throughout the five years of my PhD research, I conducted a thorough review of all relevant policy documents, including those not specifically mentioned by farmers or observers.</p> <p>This extensive search included a comprehensive examination of legislative repositories to ensure that no significant policies were overlooked. The documents selected for the study represent the most pertinent policies related to drought mitigation and hydrological impacts in the region.</p> <p>These were carefully chosen based on their relevance and practical application in the study area.</p>

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Fonte - Base Cartográfica Contínua do IBGE, 2024.

Legend	
	Ceará Municipalities
	Semiarid Delimitation

Projection UTM - Zone 24 M
Datum Horizontal - SIRGAS 2000