

Response to Reviewer Comments

Dear editor,

We sincerely thank you and the reviewer for the careful, constructive, and highly valuable assessment of our manuscript. We greatly appreciate the time and effort devoted to evaluating the work and providing detailed comments. The reviewer's observations were particularly helpful in improving the clarity, precision, and overall presentation of the manuscript.

We have considered all comments carefully and have revised the manuscript accordingly. In preparing the revised version, we aimed to address each point thoroughly. We believe that the manuscript has benefited substantially from this review process. Below, we provide a point-by-point response to the reviewer's comments. For ease of assessment, each comment is reproduced, followed by our response. Where relevant, we also include the corresponding revised manuscript text in blue, together with line-number references to the clean revised manuscript, so that the changes can be located easily.

We are grateful for the opportunity to revise and resubmit our manuscript, and we hope that the revised version satisfactorily addresses the reviewer's concerns.

Sincerely,

Ahmed Kenawy

On behalf of all coauthors

Point-by-point response

- This paper uses a dataset of news articles about drought to compare drought indicators with reported hydrologic and agricultural drought impacts. For impact data, the authors use standardized monthly frequencies of news articles, by province. For climate data, they use 48 different lengths (1–48 months) of Standardized Precipitation-Evapotranspiration Index and Standardized Precipitation Index. Comparing differences in the relationships between SPI and impacts and SPEI and impacts, they assess the contributions to impacts of temperature-driven processes vs. precipitation-driven processes. They find stronger relationships over longer time periods, 3–12 months for agricultural impacts and 12–48 months for hydrologic impacts. Their findings are consistent with what one would expect, but/and provide a novel way to quantify the effects of SPI and SPEI, including which timescales are most relevant. Using a dataset of media articles with counts standardized by month and location is a novel and substantial methodological contribution. The authors find extensive spatial heterogeneity between provinces in the relationships between drought indicators and drought impacts. I believe this study provides a robust methodological approach that could be used to begin exploring the contributions of different social and environmental variables to local resilience.

We thank the reviewer for this positive and constructive overall assessment. We appreciate the recognition of the methodological contribution of the media-derived drought-impact dataset and the multiscalar analysis linking SPI/SPEI to reported hydrological and agricultural impacts. In revising the manuscript, we retained the main analytical framework while clarifying the methodological and interpretive issues raised in the specific comments below. We also made the interpretation of spatial heterogeneity more cautious by clarifying that socioeconomic, management, irrigation, reservoir-operation, and vulnerability variables were not directly included in the PCA.

Lines 415–419: “Because socioeconomic, agricultural-management, irrigation, reservoir-operation, and vulnerability variables were not included directly in the PCA, the resulting spatial components should be interpreted as empirical modes of reported drought-impact variability rather than as direct explanations of the socioeconomic causes of impact heterogeneity.”

- On line 90 it says news articles published from May 1976 to December 2023 were analyzed. That would be 572 months. But line 144 refers to 576 months. Please reconcile the difference.

We agree with the reviewer. The period from May 1976 to December 2023 corresponds to 572 monthly observations, not 576.

Lines 87–91: “All articles published from its foundation on 11 May 1976 to 31 December 2023 were analysed. Articles were initially pre-filtered for drought relevance using a supervised classifier based on a fine-tuned Longformer model within the SeqIA framework (López Otal et al., 2025). This binary classifier identified 15,102 drought-relevant news articles over the study period. ... In each sector-specific analysis, the input matrix consisted of monthly observations from 1976–2023 as rows ($n = 572$) and Spanish provinces as columns ($n = 48$).”

- Starting on line 94, drought impact extraction – are the bins of agricultural or hydrologic impact articles mutually exclusive, or how much overlap is there? I ask because Fig 1c illustrates a fairly tight relationship between agricultural and hydrologic impacts, or, as described on line 211, “coherent cross-sector drought propagation.” It makes sense that they would be occurring at the same time, but differences would be masked if a substantial portion is being reported in the same articles. News framing could be “drought is causing problems such as [ag impact], [hydro impact].”

We thank the reviewer for this important clarification. We revised the Methods section to state explicitly that impact extraction was multi-label rather than mutually exclusive. Thus, an individual article could contribute to more than one sectoral series when it reported multiple drought consequences. We also revised the interpretation of Fig. 1c so that the strong agricultural–hydrological relationship is described as cross-sector drought reporting and impact co-occurrence, rather than fully independent evidence of causal propagation between sectors.

Lines 108–115: “Monthly impact frequencies were quantified as the number of drought-related articles published for each province and impact category. The extraction was multi-label rather

than mutually exclusive. Therefore, a single article could contribute to more than one impact category when it reported multiple drought consequences, such as crop losses together with reservoir depletion or water-use restrictions. The agricultural and hydrological series should therefore be interpreted as sector-specific monthly reporting frequencies, not as disjoint sets of articles. To assess the possible influence of co-reporting, we quantified the article-level overlap between the two broad sectors and considered this overlap when interpreting the relationship between agricultural and hydrological impact series.”

Lines 209–215: “The strong relationship between agricultural and hydrological impacts ($r = 0.89$, Fig. 1c) should be interpreted with caution because the impact categories are not mutually exclusive at the article level. Some articles report multiple drought consequences simultaneously and therefore contribute to both sectoral series. Accordingly, Fig. 1c reflects both genuine temporal co-occurrence of sectoral impacts during major drought episodes and partial co-reporting within the same media articles. We therefore interpret this relationship as coherent cross-sector drought reporting and impact co-occurrence, rather than as fully independent evidence of causal propagation between sectors.”

- Line 148 refers to a covariance matrix, but I am not finding what variables are being analyzed. Please explicitly describe them. Is it the 48 timescales of SPI and SPEI, hydro vs ag, and province? I found myself looking for socio-economic variables, particularly in light of the references to non-linear responses and spatial heterogeneity.

We agree that the original wording was ambiguous. We revised Section 2.4 to specify that the covariance matrix was calculated from standardized monthly media-reported impact time series across provinces. PCA was performed separately for hydrological and agricultural impacts. Rows represent months and columns represent provinces. SPI/SPEI timescales, drought-index values, both impact sectors jointly, and socioeconomic variables were not included in the PCA. To avoid overinterpretation, we also added a Discussion statement clarifying that PCA components should be interpreted as empirical modes of reported impact variability, not as direct explanations of socioeconomic causes.

Lines 145–153: “To reduce dimensionality and identify dominant spatial-temporal patterns in drought-related impact reporting, we applied Principal Component Analysis (PCA) to the standardized monthly drought-impact time series. PCA was conducted separately for hydrological and agricultural impacts. In each sector-specific analysis, the input matrix consisted of monthly observations from 1976–2023 as rows ($n = 572$) and Spanish provinces as columns ($n = 48$). Therefore, the covariance matrix represented covariation among provincial impact-reporting time series within a given sector. SPI and SPEI were analysed subsequently in the drought–impact correlation and sensitivity analyses. The PCA was used only to identify the dominant spatial modes of reported impact variability and the provinces contributing most strongly to those modes.”

Lines 415–419: “Because socioeconomic, agricultural-management, irrigation, reservoir-operation, and vulnerability variables were not included directly in the PCA, the resulting spatial components should be interpreted as empirical modes of reported drought-impact variability rather than as direct explanations of the socioeconomic causes of impact heterogeneity.”

- Fig. 3: It would be helpful to have a little more contrast between the two colors.

We thank the reviewer for this helpful suggestion. We revised Fig. 3 by increasing the visual contrast between the sectoral series, using more distinguishable colors for hydrological and agricultural impacts while retaining line style differences to distinguish SPI and SPEI.

- Line 441: The discussion of using media coverage as data beginning on line 61 is good and nuanced. It stands in contrast with the sentence beginning on line 441.

We agree with the reviewer. We revised the Discussion to make it consistent with the nuanced framing of media coverage in the Introduction. The revised Discussion now describes media-reported data as complementary to climate-based drought indicators and clarifies that news articles provide a credible but not exhaustive record of drought effects at specific places and times. This avoids implying that media reports are superior to climate-based indicators and instead emphasizes their value as a best-available proxy for observed societal consequences.

Lines 60–68: “Media coverage plays an important role in shaping the societal interpretation of drought impacts. Newspaper articles provide information on the timing, location, and sectoral manifestation of drought impacts (Bachmair et al., 2016; Murphy et al., 2017; Wang et al., 2020; O’Connor et al., 2023; Jobbová et al., 2024), which allows us to understand physical conditions and social responses. They are often used for reconstruction of past droughts and interpretation of human behaviour in relation to climate change (Brazil et al., 2018; Nash et al., 2019).”

Lines 440–450: “Although news articles are written for purposes other than systematically documenting drought impacts, they provide a credible, though not exhaustive, record of drought’s effects at specific places and times (Dow, 2010). In contrast to SPI and SPEI, which quantify meteorological moisture deficits and atmospheric evaporative demand, media-reported impact data document how drought was observed, narrated, and experienced through effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems. In this study, these records are therefore treated not as direct physical measurements of drought damage or as a comprehensive inventory of all impacts, but as a best-available proxy for the societal visibility, timing, location, and sectoral framing of drought events. Because news coverage is shaped by editorial priorities, institutional context, public attention, event novelty, perceived severity, and uneven spatial coverage, low reporting frequencies should not necessarily be interpreted as the absence of drought impacts. Rather, media-derived impact data identify when and where drought became socially salient, problematic, or publicly visible, making them useful for relating climate-based drought indicators to observed societal consequences.”

- Line 442: What does “also” refer to? If you are comparing drought impacts reported by media to drought impacts that are physical effects derived from climatological indicators, please define your terms in much greater detail. Same comment re/ “another” on line 443.

We removed the ambiguous comparison implied by “also” and “another” and replaced it with an explicit distinction between climate-based drought indicators and media-reported impact data. The revised text now defines SPI/SPEI as indicators of meteorological moisture deficits and atmospheric evaporative demand, while media-reported impact data are defined as records of how drought was observed, narrated, and experienced through societal and sectoral effects.

Lines 441–445: “In contrast to SPI and SPEI, which quantify meteorological moisture deficits and atmospheric evaporative demand, media-reported impact data document how drought was observed, narrated, and experienced through effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems. In this study, these records are therefore treated not as direct physical measurements of drought damage or as a comprehensive inventory of all impacts, but as a best-available proxy for the societal visibility, timing, location, and sectoral framing of drought events.”

- Lines 443 & 446: You mention media bias without going into any depth about what you mean or what it may mean for your analysis. I urge researchers using news as data to avoid routinely mentioning bias without explaining what they are referring to. News media are indeed constrained and shaped by cultural and institutional norms and are sometimes designed to express explicit viewpoints. (Science is also constrained and shaped by cultural and institutional norms, including the methods, preferences and interests of various disciplines.) But more germane than “bias” is the reality that news is not intended to be a comprehensive record of drought impacts. It is broader-brush, focusing societal attention where it’s needed, on what’s novel or problematic, serving an issue-identification function (Dow 2007). Using news as drought impact data is valuable in that it helps us understand drought’s effects at specific places and times. But in calibrating drought indices, news-derived impacts can be thought of as “best-available” data or “reasonably proxy” data, rather than the data that would exist if researchers or policymakers had the resources to collect data that was tailored for purpose. To call that “bias” seems a bit off-point.

We thank the reviewer for this insightful comment. We revised the text to avoid using “bias” as a vague or routine qualifier. The revised version now explains the specific issue more clearly:

news articles are not designed as a comprehensive drought-impact inventory, but they provide a credible, historically grounded, best-available proxy for when and where drought became visible, problematic, or socially salient. We also added Dow (2010) and specified the mechanisms shaping coverage, including editorial priorities, institutional context, public attention, novelty, perceived severity, and uneven spatial coverage. We therefore no longer present the limitation as generic “bias,” but as the non-comprehensive and socially mediated nature of news-derived impact records.

Lines 440–452: “Although news articles are written for purposes other than systematically documenting drought impacts, they provide a credible, though not exhaustive, record of drought’s effects at specific places and times (Dow, 2010). In contrast to SPI and SPEI, which quantify meteorological moisture deficits and atmospheric evaporative demand, media-reported impact data document how drought was observed, narrated, and experienced through effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems. In this study, these records are therefore treated not as direct physical measurements of drought damage or as a comprehensive inventory of all impacts, but as a best-available proxy for the societal visibility, timing, location, and sectoral framing of drought events. Because news coverage is shaped by editorial priorities, institutional context, public attention, event novelty, perceived severity, and uneven spatial coverage, low reporting frequencies should not necessarily be interpreted as the absence of drought impacts. Rather, media-derived impact data identify when and where drought became socially salient, problematic, or publicly visible, making them useful for relating climate-based drought indicators to observed societal consequences. Recent research has demonstrated that media-based data sets can record drought effects at relatively high spatiotemporal resolution (Madruga de Brito et al., 2020; Wang et al., 2025), although they entail reporting biases and changes in media practices (Stahl et al., 2015; Serrano-Acebedo et al., 2026; Pita Costa et al., 2024).”

- Line 443: “... and subject to varied media coverage” ... the sequence of clauses in this sentence leaves the object of this thought in question.

We revised the sentence to remove the unclear clause structure. The revised paragraph now explicitly states what is shaped by coverage processes and what this means analytically. Specifically, news coverage is identified as the object shaped by editorial priorities, institutional context, public attention, novelty, perceived severity, and uneven spatial coverage, and we clarify that low reporting frequency should not automatically be interpreted as absence of impacts.

Lines 445–449: “Because news coverage is shaped by editorial priorities, institutional context, public attention, event novelty, perceived severity, and uneven spatial coverage, low reporting frequencies should not necessarily be interpreted as the absence of drought impacts. Rather, media-derived impact data identify when and where drought became socially salient, problematic, or publicly visible, making them useful for relating climate-based drought indicators to observed societal consequences.”

- On line 444, instead of “consumed,” do you mean “experienced” or “framed” or “interpreted”? People are said to consume news but are not said to consume drought.

We agree with the reviewer. We removed the word “consumed” and replaced it with more precise wording. The revised text now states that media-reported data document how drought was “observed, narrated, and experienced,” which more accurately describes the role of news articles in recording societal and sectoral consequences of drought.

Lines 441–444: “In contrast to SPI and SPEI, which quantify meteorological moisture deficits and atmospheric evaporative demand, media-reported impact data document how drought was observed, narrated, and experienced through effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems.”

- A possible rewrite of this important sentence: Although news articles are written for purposes other than systematically documenting drought impacts, they provide a credible representative record of drought’s effects at specific places and times. News articles go beyond the physical

effects of drought, providing historic documentation of how drought affected people, livelihoods, ecosystems and socio-economic systems.

We thank the reviewer for the suggested wording. We incorporated the core idea into the Discussion while slightly modifying the phrasing to avoid overstating representativeness. Specifically, we used “credible, though not exhaustive, record” and added Dow (2010). We also retained the reviewer’s point that news articles go beyond physical drought indicators by documenting effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems.

Lines 440–444: “Although news articles are written for purposes other than systematically documenting drought impacts, they provide a credible, though not exhaustive, record of drought’s effects at specific places and times (Dow, 2010). In contrast to SPI and SPEI, which quantify meteorological moisture deficits and atmospheric evaporative demand, media-reported impact data document how drought was observed, narrated, and experienced through effects on people, livelihoods, ecosystems, water resources, agriculture, and socio-economic systems.”

We again thank the editor and reviewer for their constructive comments, which substantially improved the clarity, precision, and interpretive balance of the manuscript.