

Review: Characterising the Potential for Drought Action from Combined Hydrological and Societal Perspectives, Towler et al.

Reviewed February 2019

Summary:

Linking groundwater to drought response actions to develop a new indicator, the Potential Drought Action Indicator (PDAI). The PDAI is applied in south-central Oklahoma where there are disputes around the use and management of groundwater in the Arbuckle-Simpson Aquifer (ASA). The indicator aims to understand what actions people may take in response to drought and when they may take them. The PDAI is built around water users perceptions on the importance of water for specific uses. This is a novel approach, but perhaps difficult to see how this could be rolled out more widely – particularly in an operational setting.

Recommendation:

I enjoyed the paper in its attempts to incorporate management actions with physical indicators of drought, better understanding the link between indicators and impacts, but also management actions is crucial to improve monitoring and early warning of droughts in human modified systems. However I feel the paper needs major revisions before it can be accepted. Please see below.

Overarching Comments:

The aims of the paper should include a view on how this will be useful for operational monitoring systems and the additional information it will provide on top of what is already available e.g. through the National Drought Mitigation Centre Drought Monitor etc.

There is no validation of the new indicator – this is crucial in order to see whether the indicator works --- could it be validated against Drought Impact Reporter response data? If not, include in the discussion why it's not possible to use DIR data.

How can this approach be applied in other locations? Would the same interviews need to be repeated? I gather the link to the world views is an attempt to see how it could be transferred elsewhere, but unless these world view responses are also available then can it be transferred? The groundwater level thresholds used here were clearly related to management actions or changes in system behaviour – it would be useful to address how you would obtain these data elsewhere. This should also be considered in a discussion on the transferability of this research.

The fact interviews were undertaken during a drought may have skewed the responses from stakeholders – there is often a loss of memory about droughts after an event has ended, if the questionnaire was repeated, would the same levels of importance be assigned to the water uses? Although it may not be possible to repeat the surveys, this question of bias should be addressed in the discussion.

L207-212: There is not enough information provided on how you derived the drought indicators (PDSI, PDHI and SPI) and what data were used. You should include brief descriptions of the methods (e.g. including what distribution was used to derive the SPI, what years were data available etc.) and crucially the references for each and which variables from the data you cite were used for each. This should be introduced before the cross-correlations with decadal groundwater likelihoods. There is a general imbalance throughout between the discussion and description of hydrology compared to the social sciences.

The conclusion introduces new material – it should cover the content of the paper in a standalone manner. I suggest you create a new section 4.5 on future enhancements and the drought feedback loop described in Fig 9 – i.e. Lines 500-562. It may also be helpful to consider a section to discuss how you see the PDAI working alongside existing monitoring tools and the Drought Impact Reporter to manage and monitor droughts in near-real-time – this may then feed into your section on future enhancements.

Individual Comments:

It would be helpful to include a map of the area as figure 1, to include the ASA, Oklahoma City and the locations where you undertook interviews

L58: add Bachmair et al. 2016 (<https://onlinelibrary.wiley.com/doi/full/10.1002/wat2.1154>) reference here which assessed global MEW providers and found a lacking in impacts (on society and the environment) in the monitoring systems

L67: do you mean more systematic monitoring of impacts or indicators? Make this clear, I think it means impacts(?)

L91: add Tjardeman et al 2018 (<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2017WR022412>) to the Pulwarty reference here

130: what is Climate Division 8? Please provide context for the international audience who may not be familiar with this

L157: “an anthropological lens through which to examine how stakeholders perceive” grammar could be improved here

L223: the grammar of this key question could be improved

L241-243: the grammar improving, as it is this paragraph doesn't read as a complete sentence. What other functions would you apply and for what purposes – perhaps provide an example here

L245-248: Am I correct in thinking therefore that a PDAI is computed for each of the 6 water uses described L229-231? Make this clear in Section 3.3

Add into Section 3.3 that lower PDAI equates to less potential for action and higher PDAI indicates greater likelihood of action for clarity.

Section 3.4: it would be interesting to see the questions and statements used to establish the world views, these be included in the supplementary information

Figure 1 is not mentioned in the text, introduce this in Section 3.3

Figure 2 & Figure S1: As figure 2 is the same as the 10 year panel of Figure S1, I suggest that Figure S1 is removed from SI and replaces Figure 2. As it is, it represents unnecessary duplication and due to the different plotting style (including different y-axes) and different captions, provides potential for confusion.

L300: ‘that have high variability and likelihood swings (e.g. 5-year windows) and longer time...’ not needed

L301: ‘gets washed out’ colloquial – replace with ‘is smoothed out’ or ‘is removed’ or similar.

L305 (and throughout): are these correlations significant? Please include p-value/indication of significance

L306: 'and select~~ed~~ drought indices' select should read 'selected'

L306: 'hydrologic threshold exceedance' – this refers to the groundwater exceedance, it should say groundwater, not hydrologic for consistency (especially as hydrological drought indicators are used elsewhere to discuss the PDHI)

L307-308: when the established drought indicators were introduced, these drought type categories (meteorological, hydrological, agricultural) were not given – include these in the methods section, and you could include the indicators following the appropriate drought type in brackets

Table 1: what is the significance of these correlations?

L310-311: It would be nice to include a plot of the rainfall, river flow and groundwater levels for the area together to show the variability of these variables over the time period (and/or the indicators themselves). It would then be possible to see the relationship between the flows and ASA levels

L313-315: when discussing other aquifers and the potential impact of greater human influences on levels, the properties of the aquifer will also play an important role in the relationship with the PDHI/SPI/PDSI etc. as for example, a more slowly responding aquifer may have a poor relationship with the hydrology due to increased propagation times.

L316 & Table 2: how did you select these decades? This selection should be introduced in the methods.

L320-328: "Given the close association of drought (Table 1) this suggests ..." Is there a word missing here? Do you mean the strong correlations between the groundwater levels and the other drought indicators? However, I don't think that you can say that because these indicators are correlated that stakeholders experienced dry/average/wet decades. Is the reference to Table 1 a mistake? This paragraph should be made much clearer – this paragraph underlines the suggestion to include time series plots of the variables/indicators as then readers could visualise the dry/wet/average years you discuss here (which could be labelled/marked on these plots too).

L344: full stop after '(Interview 1)' should be a comma. And comma after perspective should be a full stop.

Section 4.3: is it possible to include the results for all the water use categories in your description of the results – it is a shame not to include them as you show the data in Fig S2.

Figure 5 and Figure S2 for recreation are different – in Fig S2 the lines for driest and dry/rec are the same but in Fig 5 they are different. The equivalent figures for drinking water are identical between Fig 5 and S2 – is this intentional or is there a mistake here? If the data in Fig 5 and S2 are meant to be the same, and given the previous comment, you could just replace Fig 5 with Fig S2

L360: 'of data that are equal ~~to~~ or less than that value.' 'to' missing from sentence

L375: 'from wetter to drier' is this referring to the difference between moving between the eCDFs for the wetter/drier decades? If so, make this clear by adding 'from wetter to drier ~~decades~~'.

Figure 7 would be more interesting if you include the other water uses, especially as you mention PDAI for spirituality on L402

Table 3: these correlations (although some are significant) are very low – I’m not sure it’s really possible to really draw any conclusions from these results.

L427-429: you use the term variance here but I’m not sure this is correct as this is the difference between the correlations for individualism and egalitarianism squared. You should change the word variance here to ‘difference’.

L455: I think that your ‘finding **shows** that this disagreement is not solely due to threats...’ (rather than mean)

L467: ‘...and these corresponded **to** drought conditions.’ Missing ‘to’ from this sentence

L46 9: this should be made clear that you mean exceeding the groundwater threshold. The conclusion should succinctly summarise the paper, which includes mentioning the groundwater exceedance and other drought indicators calculated.

L506: point 1 – groundwater levels in the ASA closely resemble the climate rainfall signal – you talk about other aquifers having different human activities, but what about where the aquifer properties mean it also naturally behaves differently and levels may not closely resemble the rainfall.

L547: point 5 – you should reference Tjardeman et al 2018 (<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2017WR022412>) here which looks at the linkages between meteorological and hydrological drought indices for near-natural and influenced catchments in the US. It also looks at the relationship between the indicators and impact data from the DIR.

Figure 2: What period is used to create the ‘smoother’ average? The should be given in the caption

Figure 4: could be improved if the y-axis was labelled with more/less important in addition to the numbers 1-5

Figure 7: in the caption the abbreviation Rec is used for recreation, but elsewhere in the paper rec has been used for ‘recent’ – avoid this multiple uses of the same abbreviation for clarity.