Review for manuscript "Assessment of probability distributions and minimum storage draft-rate in the equatorial region"

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Summary

The study by Hasan et al. focuses on low flows, drought, and minimum storage draft-rates in seven catchments in the Selangor region in Malaysia. The study consists of four types of analyses: (1) a non-parametric trend analysis on annual mean, minimum, and maximum flows using the Mann-Kendall and Sen's slope tests; (2) a low flow frequency analysis on annual minimum flow using the Lognormal 2P distribution; (3) an analysis of drought characteristics determined using a fixed drought threshold at the 90th flow percentile; and (4) the determination of minimum storage draft rates necessary to ensure sufficient water supply during low flow periods.

General remarks

The study performs a variety of analyses related to low flows and drought and in my opinion has several deficiencies. (1) It does not seem to follow a clear aim and motivation and lacks the specification of a research question; (2) it has an unclear structure and shows elements belonging to Introduction, Methods, Results, Discussion, Conclusions all over the place (i.e. not all introductory material is in the introduction,…); (3) the method descriptions are confusing and it is hard to tell how the analysis was exactly done. I was only able to understand what was approximately done when I finished reading the conclusions; (4) the presentation of the results could be significantly improved; (5) a novel aspect is missing, which leads to insignificant conclusions. I do not think that this study is publishable in NHESS.

I still discuss some major points below which may help to improve the study design and presentation.

Major points

- **Title:** I would replace 'in the equatorial region' by 'in Malaysia'.
- **Abstract:** The abstract is missing a clear problem statement. The study region of interest should be mentioned. I would give it a clear structure by listing the four elements of the analysis: (1) trend analysis, (2) low flow frequency analysis, (3) drought analysis, and (4) storage draft rate analysis. The abstract should also include a short summary of the main findings and end with a concluding statement (this requires a clear problem statement at the beginning).
- **Introduction:** The introduction needs a clear research question and should introduce the problem and some background knowledge related to this research question (or questions). Currently, the introduction lists various statements related to low flows and droughts but does not tell a compelling story. The introduction would profit from a clear distinction between low flows, droughts, and water scarcity (for a discussion on these different concepts see e.g. [*Van Loon et al.*, 2016]). In addition, a short introduction to the concept of 'storage rate' should be provided (e.g. does storage refer to reservoir storage or another type of

storage?). I suggest to restructure the introduction as follows: (1) introduce why are droughts, low flows, and water scarcity important and what is the relationship between the three, (2) introduce factors influencing drought and water scarcity characteristics, (3) introduce the storage-draft rate concept and how this is related to drought, (4) provide a short introduction of study area and the problem you are trying to solve, (5) state research question, and (6) provide a short overview of methods used to answer this question.

- **Data:** The study lacks a proper introduction of the dataset used for the analysis. The following specifications are necessary: are you working with observed or simulated streamflow data? Are the streamflow time series natural or influenced by water abstraction and storage (at least some of them seem to be influenced)? Why are inconsistencies a problem? What types of streamflow regimes do the catchments represent (i.e. what is the seasonality of the Indian and Asian monsoons)?
- **Methodology:** In my understanding, the analysis consists of four main steps: (1) Trend analysis of annual mean, maximum, and minimum flows, (2) low flow frequency analysis based on annual minimum flows, (3) analysis of drought characteristics for individual events, and (4) storage draft analysis. Is this correct. If this is what was actually done, I would restructure the methods section accordingly. It is unclear which types of variables are used for which type of analysis. I only figured out e.g. which variables were of interest in the trend analysis when I started to look at the tables presented in the Results section. The methods descriptions are confusing and unclear and include a lot of unnecessary detail instead of providing essential information. I do for example not understand why a detailed description of Flow Duration Curves is necessary (these were just used to determine the drought threshold, right?). Or what does the description of plotting positions do in the methods section (I did not find any results relating to plotting positions)? In my opinion, the detailed description of the Mann-Kendall test can be removed and be replaced by an appropriate reference (l. 131-157). Instead, it should be specified (a) which distributions were used to fit the low flow datasets and why (i.e. which distributional properties are important here), (b) how low flow is defined (based on the results I believe as the minimum annual flow but this is not clear from the methods section), (c) for which variable/events return periods were determined, (d) whether the determination of return periods relies on empirical or theoretical distributions, (e) which drought characteristics were analyzed in the below threshold drought analysis, (f) whether a short pooling window of 7 days (l.220) actually guaranteed independence of events, (g) whether minor droughts were removed or not (methods section says yes, results section says no (l. 297)), (h) what the storage-draft rate method does and what kind of storage it refers to (an illustration of the concept would help).
- **Results:** The results section contains several paragraphs actually belonging to the methods and introduction sections (e.g. l. 246-250: and by the way I thought the trend analysis was performed using the non-parametric Mann-Kendall test and not linear regression). There is even a statement that belongs to the introduction describing the ‘primary purpose’ of this study (l. 260-261). I would restructure according to the restructuring also suggested for the Methods section: (1) Results of trend analysis, (2) results of low flow frequency analysis, (3) results of drought characteristics analysis, and (4) results of storage rate analysis. And also here, it always needs to be clear which variables the results refer to. I would in some instances replace results presented in tables by figures. This particularly concerns l.300 -351. I would try to visualize these results instead of presenting them as plain text. E.g. number of

events as barplots, durations, and deficits as boxplots for all stations. This would allow for a comparison across stations. In addition, you could also plot deficit time series per station to compare particular events.

- **Discussion:** The discussion presents a lot of material that in my opinion belongs to the introduction (l. 393-411). I would instead discuss the implications of your findings for water management in the region.
- **Conclusions:** Instead of providing a summary of the methods, focus on the insights we gain from this study. Currently this seems to be: 'Based on the analysis of the study, the estimated minimum storage-draft rates for each station cannot meet the water demand during low flow at specific return periods, which is 10-year recurrence interval for this research.' (l. 448-449). Formulating conclusions will be easier once you have identified a clear research question.
- **References:** Should be carefully checked. There is at least one duplicate (Sarailidis et al. 2019), and I would consistently use lower caps for nouns (e.g. Bakanogullari et al. 2014).
- **Language:** The article needs editing with respect to the use of tense and sentence structure. Some redundant information can be removed (e.g. l. 102 and l. 107).

Figures and Tables:

- **Figure 1:** I would indicate the locations of the dams mentioned in l.90-99 if they are important for the analysis. But I am still unsure whether the storage-rate refers to reservoir storage or something else. I would reduce the density of the stream network displayed in order to increase the distinctiveness of the colors.
- **Figure 2:** Is this figure really needed?
- **Figure 3:** Indicate that outliers are not displayed?
- **Figure 4:** Increase legend font, provide one legend for all subplots not per subplot. What does the dark grey bar mean? Increase size of axis labels.
- **Table 1:** Can in my opinion be removed as information is also contained in Figure 1.
- **Table 2:** Introduce in methods section, reference should be provided for each distribution.
- **Table 4:** It seems as if trends were not only determined over the whole period but also for very short time periods of 7 years. This sub period analysis does in my opinion not make sense. I think I would plot time series of mean, minimum, and maximum flow for each catchment to illustrate the trends and instead remove the sub period analysis.
- **Table 5:** I find it strange that no 3-parameter distributions were tested as extreme values are usually insufficiently represented by 2-parameter distributions.
- **Table 6:** The p-values should lie in the range of [0,1]. Were the column names mixed up? I would indicate for which distributions and catchments, H0 of 'the distribution of the sample corresponds to the theoretical distribution' was rejected.
- **Table 8:** can in my opinion be removed as you just focused on a threshold of Q90. By the way, I would talk about Q10, to consistently refer to non-exceedance probabilities throughout the paper.
- **Table 10:** Is this table related to Figure 4, and if so how or could it even be removed?

Minor points

Trend detection and attribution is a pretty active research area and I would not agree that we are 'beginning to pay more attention to trend analysis' (l. 118).

A goodness-of-fit test rejects or non-rejects a hypothesis but does not ‘accept a fit’ (l. 163).

The return period in a univariate setting is defined as T=1/(1-p), where p is the non-exceedance probability, i.e. T it is not the probability of occurrence itself (l. 188).

l.353-359: move material to introduction.

l. 363-367: move to methods section

No further editing suggestions are provided as the manuscript in my opinion needs to be completely revisited.

References used in this review

Van Loon, A. F. et al. (2016), Drought in a human-modified world: Reframing drought definitions, understanding, and analysis approaches, *Hydrol. Earth Syst. Sci.*, *20*(9), 3631–3650, doi:10.5194/hess-20-3631-2016.