Interactive comment on "Human response to severe drought in Early Modern Catalonia. The case of Barcelona, Western Mediterranean (1620–1650)" *by* Santiago Gorostiza et al.

REVIEWER 2. GENERAL COMMENTS

The topic falls within the scope of the journal. It is an interesting paper about institutional responses to drought in the early modern period in a region (Catalonia, NE Spain) with still scarce research on the human history of climate (i.e., past adaptations, vulnerabilities, conflicts). Moreover, in line with previous research in the field of historical climatology re-assessing traditional documentary sources or presenting innovative ones (e.g., Adamson 2015, Veale et al. 2017), this research shows the potential of urban water supply manuals as a (rare, but unique) source to be taken into account to critically interpret the nature and range of institutional responses to droughts and water scarcity. Indeed, the authors have made their analysis by conducting the first complete transcription of the main primary source presented and interpreted (the Book of Fountains, 1650). Finally, I particularly appreciate the combination of a robust drought reconstruction with a complex environmental history narrative addressing questions of power and knowledge.

The manuscript is well-written and easy to read. The structure of the article is clear, although it could be further improved by reducing some redundancies (see below). In my opinion, the manuscript should be published in Climate of the Past, after addressing some minor issues mentioned and developed in the next section.

SPECIFIC COMMENTS

Reviewer 2: Why the article approaches (and is titled as) "human responses" and not directly institutional responses? To my view human responses would also include strategies of citizens/households, such as water thefts or changing water consumption patterns. However, the manuscript mainly addresses the actions of the Barelona City Council (Consell de Cent) and not the responses of other stakeholders.

Authors: Many thanks for this suggestion. Our article certainly focuses on the role of the city government, the Consell de Cent, and the post of the city water officer was part of it. The perception of drought we recount via *pro pluvia* rogations comes from an institutional source. The different strategies we examine – water transfers, water supply system expansion and maintenance, transformation of city mills, elaboration of the Book of Fountains – are led by the city government. Hence, in the new version of the manuscript we will change the title to "Institutional responses to severe drought in Early Modern Catalonia". This also helps delineating in a clearer way our contribution.

Just for the record, we initially titled the paper "human responses" because certain initiatives are also personal. The Book of Fountains in itself, while emerging from a petition from an institution (Consell de Cent), is the result of the personal effort and knowledge of the water city officer. The motivations of Francesc Socies to write the book were complex and may have involved his prestige (impact of the 1634 excommunication

in civil life), economic situation (need for a pension) and family situation (lack of sons or relatives to whom pass on his knowledge and job post).

Nonetheless, this is not the focus of our article, so we believe that referring to "institutional responses" in the title summarises our article better and clarifies our contribution. Thanks once again for pointing this out.

Reviewer 2: Why do you interpret the writing of the book as an appropriation of knowledge and not making (private or family) knowledge public?

Authors: We interpret the Book of Fountains as an "appropriation of knowledge" because the Consell de Cent demands the knowledge acquired by one of its employees (the city water officer) to be recorded in a book that will be kept in the premises of the city government building.

The very Book of Fountains, as established by the requirement made to Francesc Socies, cannot leave the grounds of the city government building. Only future city water officers and those authorised by the Consell de Cent will be allowed to consult the book. What the city government is interested in is the transfer of knowledge from the city water officer to the city government institution, which means an appropriation and a control of the very post of city water officer.

In other words, the knowledge recorded in the Book of Fountains is not meant to be made "public" in the modern sense. Water knowledge cannot be publicly disseminated for the sake of the institutions' own interests and for security reasons. The process of knowledge transmission reveals critical details about the location of water infrastructure, potentially subject to attack or disruption. Secrecy around infrastructure is strategic for the survival of the city, both for external and internal circumstances. External circumstances during the 1630s and 1640s are marked by war and the threat of siege by foreign armies. Internal circumstances involve competence of the city government with other urban institutions, such as the Cathedral's Chapter, as proved by the 1634 conflict and the long quarrel about the right to distribute food, discussed in our article.

Your suggestion of the work of Leonti (2011) and the concept of oblique transmission of knowledge is useful to clarify this point. During the 17th century, water knowledge transmission in Barcelona mainly took place *vertically*, between members of the family that hold the post of city water officer. Sometimes, however, it also took place *obliquely*, between members of one generation towards members of different families and generations, when families holding the post of city water officer changed. There are no long dynasties of city water officers during these decades, so it is probable that documents compiling water knowledge existed before the Book of Fountains, out of the reach of the Consell de Cent. By appropriating knowledge and codifying it in the Book of Fountains, the Consell de Cent aims at interceding in the circuit of knowledge transmission. It aims at transforming oblique knowledge transmission into the institution's property (see also other replies below).

In fact, following your suggestion to modify the title, we could say that by codifying water knowledge into a book, the Consell de Cent aimed at *institutionalising* it. Which

does not necessarily mean that the Consell de Cent wished to make this knowledge open to the public.

Finally, your comment made us realise that this is probably not clear enough in the current form of the manuscript. The revised version will highlight the secrecy around the Book of Fountains and why the city government considered that water knowledge could not be disseminated. It will also refer to the work of Leonti (2011). However, an analysis of urban water knowledge transmission would deserve an article on its own right.

Reviewer 2: Also regarding this topic, you could further develop your argument on knowledge storage and transmission as adaptation, with references such as Leonti (2011).

Thanks for suggesting the work of Leonti, which will help us to revise the part of the manuscript that deals with the Book of Fountains as knowledge transmission. We will incorporate in the revised version of the manuscript a reference to Leonti, M. 2011. "The future is written: Impact of scripts on the cognition, selection, knowledge and transmission of medicinal plant use and its implications for ethnobotany and ethnopharmacology". *Journal of Ethnopharmacology*, 134(3), 542-555.

In essence, we interpret the Book of Fountains as a mechanism to transmit and preserve knowledge which constitutes an example of adaptation in front of environmental stress. It is an adaptation so as to preserve knowledge, clarify property rights and control the work of the water city officer. We should interpret the Book of Fountains as a complex form of adaptation; the result of coevolution between nature and culture (increasing drought and the urban structures of the ancient regime) which pushes to change the forms of transmitting and keeping knowledge. In this regard, we can interpret the Book of Fountains in a similar way to how Leonti et al have interpreted the transmission of environmental knowledge in contexts such as ethnopharmacology (Leonti, Marco, and Laura Casu. "Traditional medicines and globalization: current and future perspectives in ethnopharmacology." *Frontiers in pharmacology* vol. 4 92. 25 Jul. 2013, doi:10.3389/fphar.2013.00092).

As suggested in the previous reply, expanding our interpretation of the Book of Fountains followin Leonti's work stimulates us to develop the article towards the urban history and history of knowledge transmission. This would also allow us to incorporate some of the suggestions of reviewer 1. However, this topic deserves a different article on its own right.

Reviewer 2: While the manuscript explains in great detail the array of responses to drought, sheds light on the complexity of drought and the interlinkages with other problems (e.g., water scarcity, food supply or politics), and effectively re-interprets the Book of fountains as an effort to codify and appropriate urban water knowledge in a certain climatic context; it remains under developed how your contribution relates to previous literature. Below, I point specific sections where this review would be useful to strengthen your article.

Introduction (Section 1):

1. In the introduction, you present the state of the art of historical climatology research in Catalonia, but a general view of the field and your specific contribution is lacking. It would be useful to provide a (short) review of the last research on human responses to climate anomalies (and particularly past droughts), the main gaps and debates, and your contribution. This could also be added in the abstract reducing contextual information and summarizing the novelties of this research.

Authors: Thanks for pointing this out. Even if successful at reducing contextual information, we have limited space to do this, but in the revised version of the manuscript we plan to address this comment in the following manner.

First, we will relate our work about past climate adaptations to the pioneering work on social dimensions of past climate change, ongoing during the last decades (for instance Pfister, C., Brázdil, R., Glaser, R. (Eds.), 1999, *Climatic Variability in Sixteenth-Century Europe and Its Social Dimension*, Springer Science & Business Media). Here we will refer to recent environmental history works that have successfully engaged with historical climatology and human impacts of climate stress (see the work of Sam White and Dagomar Degroot).

Second, we will situate our work on institutional adaptation in connection to research on multilevel adaptation to drought (Grau-Satorras, M. et al. (2018) 'Prudent peasantries: Multilevel adaptation to drought in early modern Spain (1600-1715)', *Environment and History*). In the current version of the manuscript this article is mentioned in the state of the art about Catalonia, but due to its analysis of adaptation as a multilevel process (including institutional responses), we will situate our research in explicit connection to it.

Third, we will relate our analysis of a knowledge manual (the Book of Fountains) to wider works that have reviewed the diversity of sources to study the climate of the past, in particular private diaries (Adamson, G. C. D., 2015, 'Private diaries as information sources in climate research', *WIREs Climate Change*, 6(December), pp. 599–611. doi: 10.1002/wcc.365; also Veale, L. et al. (2017) 'Dealing with the deluge of historical weather data: the example of the TEMPEST database', *Geo: Geography and Environment*, 4(2). doi: 10.1002/geo2.39.).

2. [In the introduction] You mention that you only found another book that shares some of the features with the Barcelona Book of Fountains (lines 98-101). Which are the similarities and differences between them? If relevant, please include a short explanation on that.

Authors: Your suggestion is something we would like to do in our future work. We would like to explore a comparative research once our work on the Barcelona case has been published. We would like to carry out comparative work about manuals of urban water knowledge, to ascertain if climate stress contributed to the codification of water knowledge.

However, the existing work on the *Livre des Fontaines de Rouen* (1524-1525) has been written exclusively from the standpoint of urban history (Sowina 2001, 2016). There is not, to our knowledge, a contextualisation within the historical climatology of the period.

We regard our contextualisation of Barcelona's *Llibre de les Fonts* in the climate of the 17th century as one of the main contributions of our article. We believe that any further reference to the writing of Jacques Le Lieur's *Livre des Fontaines de Rouen* would be relevant for the journal *Climate of the Past* only if referring to possible similarities in the climatological context between our Barcelona case and Rouen's. Considering that this research has not been carried out, we prefer to refrain from providing more details from the perspective of urban history or history of knowledge. In fact, in view of this, we even considered not to include any reference at all to Rouen's book.

For the record, however, Rouen's *Livre des Fontaines* was written by a member of the city council, not by the city water officer. It includes detailed urban maps and coloured illustrations and seems to be a more ambitious publication than the one of Barcelona. Rouen's book seems to have been actively used by local water officers until the 19th century and has been known and studied during the 20th century (a facsimile publication is available).

3. [In the introduction] To my view, there are some redundancies explaining the objectives and structure of article (e.g., lines 78-89, lines 125-148, lines 220-226). I would suggest simplifying them.

Authors: Thank you for spotting this. In the new version of the manuscript we will simplify this and therefore reduce the wordcount, making space for other changes.

4. Some parts of the text are too detailed and local that the reader may get lost. I would suggest reviewing the introduction, reduce details or too specific terms (that will be later addressed in detail in the next sections) and make the section more fluent and easy to understand.

Authors: Thanks. We agree. The revised introduction will be more concise.

Reviewer 2. Climatic context (Section 2):

5. I wonder whether this section is part of your results or just to provide a context. If you are presenting the climate reconstruction as a result, I think the methodology to characterize the climate should be better explained (either in footnotes or in a methods section), addressing questions such as how the drought frequency weighted index was constructed or what the different levels of "pro pluvia" rogations mean.

Authors: Many thanks for pointing this out. After your comments and those of reviewer 1, we realised that it was not clear that this section also included novel results about climate reconstruction. While the function of this section is to set the scene for the analysis of the institutional response to drought in the rest of the article, it also provides

new data and results which we were not emphasising enough (see the following reply). The revised version of the manuscript will devote more space to the section of the article dealing with climate reconstruction, providing references about the methodology followed, explaining better the data presented and emphasising its novelty.

6. While in Fig. 1 and Fig. 4 the data used is clear, the data sources in Fig. 2 and Fig. 3 appear to me unclear. Please, could you clarify it?

Authors: In order to clarify this, we would like to discuss the novelty of the data presented in the first paper, figure by figure.

> **"Figure 1. Drought Frequency Weighted Index. Standardised values. 11 years moving averages from 4 locations: Girona, Barcelona, Tarragona and Tortosa. Data adapted from Oliva et al., 2018."**
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> Annual data in this figure is not new. It is the general context of drought in the Catalan coast between 1501 and 1861. This information has been published and a bibliographic reference is provided.

> **"Figure 2. Drought Frequency Weighted Index. Standardised values. City of Barcelona (1521-1825)."**
>
> Figure 2 comes originally from the sources collected for the PhD thesis of Mariano Barriendos and published in Martin-Vide & Barriendos (1995). However, these sources have been subsequently updated and improved by adding new documentary materials to the database and applying statistical standardization processes. As stated by Mariano Barriendos, Figure 2 has been elaborated with new data.
>
> In the revised version we will clarify this and add to the figure's caption "Data improved from Martín-Vide and Barriendos, 1995."

> **"Figure 3. Drought Duration Index. Standardised values. City of Barcelona (1521-1825)."**
>
> Figure 3 comes from information compiled by Mariano Barriendos and so far unpublished. Drought duration of level 2 had not been studied in our geographical context. Data analysis and the preparation of this figure have been elaborated exclusively for this manuscript.
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> In the revised version of the manuscript we will highlight that this information on drought duration reconstruction is new.

"Figure 4: Monthly drought rogations levels in Barcelona, 1601-1650. Data improved from Martín-Vide and Barriendos, 1995."

Figure 4 comes from information compiled by Mariano Barriendos and so far unpublished. It is the first time that information of drought in our geographical context is analysed at daily resolution. Data analysis and the preparation of this figure have been elaborated exclusively for this manuscript.

In the revised version of the manuscript we will delete from the figure's caption "Data improved from Martín-Vide and Barriendos, 1995". Instead, we will highlight that this information on monthly drought rogations levels in Barcelona is new and had not been published before. We will also explain better the importance of this figure, to which we refer to several times throughout the rest of the paper.

Finally, while the Book of Fountains is a manual of urban water supply, it does provide information useful for the reconstruction of the climate of the past. When writing the book in 1650, during a severe drought episode, Socies pointed out that it was the first time in his life that he saw some of the water mines dry, and wrote that as years passed by, the flow of water in the city had been decreasing. In fact, he specifically pointed out to the years 1626-1627 as the moment when the "lack of waters" had started, and underlined the importance of the Sant Gervasi *qanat*, whose construction he had led in the late 1620s, to keep Barcelona supplied in these dry years (AS1, chapter 65). One of the achievements of our join work in this article is precisely to find out how Socies' assessment of drought in 1650 and in 1626-27 fits perfectly with the picture that emerges from the data analysis of *pro pluvia* rogations. This cross-check reinforces the validity of both sources.

In other words, the background of the institutional response portrayed in the article are several decades of drought, which we document with a multiproxy description (*pro pluvia* rogations at daily/monthly resolution and the written testimony of the city water officer, who was in charge of urban water supply and maintenance during the worst decades of drought).

In conclusion, the revised version of the manuscript will devote more space to section 2 ("Climatic context"), explaining better the data presented and emphasising its novelty.

Reviewer 2. Struggling for water supply (Section 3):

7. The tradition to kept and transmit knowledge from father-to-son was probably recurrent not only within water officers' families (lines 457-462). Could you explain more generally this system of knowledge transmission adding, for instance, a couple of references on that?

Authors: Knowledge transmission father-to-son was common within guilds' structures, where family and the family house were units of production. Within this context, knowledge about professions was transmitted to direct family and to apprentices. Therefore, knowledge transmission combines a type of oblique transmission (teacher to

pupil) with a vertical type (father to son, uncle to nephew) (Cavalli-Sforza, L.L., Feldman, M.W., 1981. *Cultural transmission and evolution: A Quantitative Approach. Monographs in Population Biology* 16. Princeton University Press, New Jersey, pp. 54–59; Leonti, 2011, cited by Leonti, M. (2011). "The future is written: Impact of scripts on the cognition, selection, knowledge and transmission of medicinal plant use and its implications for ethnobotany and ethnopharmacology". *Journal of Ethnopharmacology*, 134(3), 542-555).

Here we provide some references about knowledge transmission within the same family and different Barcelona guilds, which we will add to the revised version of the manuscript:

> Montaner i Martorell, Josep Maria (1990). *La modernització de l'utillatge mental de l'arquitectura a Catalunya (1714-1859)* (Vol. 96). Barcelona, Institut d'Estudis Catalans.
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> Creixell Cabeza, Rosa Maria (2008). "L'ofici de fuster a la Barcelona del set-cents. Noves aportacions documentals, noves mirades". *Locus amoenus*, *9*(1), 229-247
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> Solà, Àngels (2007). "Impressores i llibreteres a la Barcelona dels segles XVIII i XIX". *Recerques: història, economia, cultura* (56), 91-129.

Knowledge transmission could sometimes involve the creation of dynasties of the same families in the same job post. Apart from the case of the city water officer (Perelló Ferrer, 1996, already cited in the manuscript), there are several other cases. For the Barcelona case, the post of city building officer ("mestre d'obres municipal") stayed between 1690 to 1766 in the Juli dynasty; and the post master of Royal works of civil architecture ("Mestre Major de les Obres Reials d'Arquitectura Civil de Barcelona") in the Martí dynasty (1716 to 1762) (Montaner i Martorell, Josep Maria (1990), p. 177).

In the revised version of the manuscript we will expand this explanation by adding some of these references to knowledge transmission between different crafts and trades.

Reviewer 2. Codifying knowledge about water supply (Section 4):

8. Could you please develop a bit more the introduction to section 4.1 (lines 429-431)?

Authors: In the revised version of the manuscript we will rewrite this introduction to highlight the importance of the knowledge acquired by the city water officer, instead of simply describing the 1640s water thefts.

9. The article nicely explains how the water officer "inscribes water urban geography into the pages of the Book of Fountains" (lines 519-527). It would be useful to illustrate this finding with a figure showing these symbols. For instance, an image of the manual's margins or a picture of the crosses in the stone walls.

Authors: In the revised version of the manuscript we will add an image of the manual's margins showing a cross.

10. Would it be possible to shortly state whether the book was in practice used by next generations of water officers or the city council itself?

Authors: Unfortunately, it is difficult to say without further research. So far, we have found no primary archival sources to document how the book was used. Therefore, we can only offer conjectures. For this reason, we prefer not to develop this point in the manuscript.

For the record, nowadays the book is kept in good shape, something that might suggest that it was not used regularly outside the Consell de Cent premises (unlike Rouen's *Livre des Fontaines*). In addition, we find no annotations on the margin of the pages, which suggests that it was not used in the way Francesc Socies suggested to do it.

However, the Book of Fountains may have been used as a key reference in relation to water property, water concessions and locations of urban water infrastructure. Similarly, it could have been a reference book for the city water officers, who at the same time may have had their own practical manuals or notes. Multiple copies of the Book of Fountains may have been available. We hope to develop this research in the future.

Reviewer 2. Conclusion (Section 5):

11. As in the introduction, you should further develop the contribution of your case study to the international debates (e.g., what specific novelties it provides to the scientific literature on past historical adaptations to climate anomalies?) (lines 687-690).

Authors: Thanks for underlining this. In the revised version of the manuscript we will make our best to highlight the contribution of our paper to the scientific literature on past historical adaptations and reconnect to the introduction. We will emphasise the focus on institutional responses to drought and the potential of knowledge manuals as sources for the study of adaptation (via transmission of knowledge) as well as for climate reconstruction.

Reviewer 2. Please also note the supplement materials to this comment

Authors: Thanks for these brief comments as well. We will act upon them in the revised version of the manuscript.