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Reply on RC2

Ibolya Török et al.

Author comment on "A new approach to assess the impact of extreme temperature conditions on social vulnerability" by Ibolya Török et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-45-AC2, 2021

Dear Reviewer,

I would like to thank you for the relevant remarks you have made after reviewing the manuscript. These comments are all valuable and helpful for revising and improving the paper. The main corrections and the responses are as follows.

Point 1. Although the introduction is perfectly organized and well document the progress and directions of social vulnerability, it fails to include key concepts on (socio) vulnerability and extremes temperatures.

Response 1. We have embedded the relevant findings from the papers you suggested into the main text:

In the last decades the effects of global climate change could be observed in relation to the frequency of extreme heat events, with more severe heat related health effects especially in urban areas (Meehl and Tebaldi, 2004; Gershunov and Douville, 2008; Golden et al. 2008). There has also been significant progress in understanding the relationship between extreme heat and human health, but also in identifying population characteristics associated with these effects (Anderson et al. 2013; Gronlund, 2014). Besides the social and economic disparities, living conditions, language and occupational barriers, Hansen et al. (2013) has revealed that ethnicity also represents a risk factor for heat-related mortality.

Point 2. The study area is described very vaguely, and any mention is given to the vulnerability of extreme temperatures. Is the area frequently exposed to extreme temperatures? What are the consequences detected in the last decades (considering the economy, the health, etc.)? There is a need for a substantial justification behind the selection of such a small scale of analysis. The methodology is not at all new; thus, a small spatial scale is not enough. Why don't you run the analysis considering Romania as a whole?

Response 2. This is a constructive remark, thank you too. Therefore we have included the effects of extreme temperatures on the economy and health into the analysis.

According to the International Disaster Database, the most severe cold waves and winter conditions in the last two decades occurred in the years 2000, 2002, 2005, 2008, and

2009, when outside temperatures fell below -34°C, resulting in the death of 146 people. In contrast, in the eastern part of the analyzed region where agriculture represents the dominant economic activity, the duration and frequency of heat wave events, usually associated with persistent draught or convective storm, make people and places more vulnerable. If we consider the same database, the most severe weather conditions in the analyzed county have been recorded in 2004 when outside temperatures reached 38 °C leading to 27 deaths as well as in 2017 when a convective storm has led to 9 deaths and a total damage of 7 300 000 $ (CRED, 2020). In the two years mentioned we could witness a 21.4%, respectively 11.9% decrease in the crop production (NIS, 2019). Moreover in these 2 years, 53.9% of the registered illnesses in the analyzed county have been strongly related to cardiovascular diseases, with a direct contribution from the effects of extreme temperatures. For example, in Cluj-Napoca an approximately 14% increase in general mortality was registered during heat waves. Such events tend to become a threat since they have constantly increased in frequency, duration, and intensity over the last decades in Romania (Croitoru et al., 2018).

The main reasons for choosing a smaller territorial unit for the analysis were as follows:

In the last years resesearching social vulnerability has represented an important concern for several authors in Romania, although none of them has included the impact of climate conditions in their work. As a result, we first wanted to test if these indicators could be included into a SOVI model, thus selecting a smaller territorial unit.

Another reason for choosing Cluj county was related to the availability of a climate related dataset at admini9strative territorial units level. Of course, becoming acquainted with these deficiencies, in the near future we can address each meteorological station in Romania for providing us with the available data.

The third reason for selecting this county from Romania was strongly related to the variety of physical-geographical characteristics: with an altitude variation from lower than 300 m to more than 1800 m, including plateaus and mountains.

Point 3. Another important point is the choice of the variables. It seems that a standard set of variables has been included, and some of them have not direct relation with extreme temperatures vulnerability. By exploring the literature, variables, in this case, are concrete and need to be justified and contextualized. Otherwise, "the peculiar socio-cultural characteristics of the study area" are not met in the analysis.

Response 3. We have carefully revised all the introduced variables, and we have left out those, which have shown a redundancy, running the PCA analysis from the beginning.

Point 4. In the "methodology" chapter, many references are missing regarding the database consulted. I expect to find the link in the reference list. Also, which year or years have been considered for data collection? It is not mentioned anywhere.

Response 4. Thank you for this observation. We have filled in the missing reference list and the years considered for data collection, as follows:

The first data source (demographic, social and economic indicators), including the 2011 Population and Dwelling Census was obtained from the National Institute of Statistics, the Tempo online web database as well as the Territorial Observatory (NIS, 2021). The datasets contain data from 1990 onwards, both at regional as well as local levels (NIS, 2021). In order to have an integrated and comparable database for all variables, we have considered the values for 2018, as part of the data was not available for more recent

years.

The second data source which included public revenues and public expenses by category was provided by the Ministry of Regional Development and Public Administration (MRDPA, 2021). Climate indicators, representing the third data source, were derived from daily extreme (maximum and minimum) temperature gridded data for the entire county at a spatial resolution of 0.1° (on latitude and longitude). The gridded data over a 53-yr period (1961-2013) were made available by the Romanian National Meteorological Administration through the ROCADA database (Dumitrescu and Birsan, 2015). It covers the entire territory of Romania and was developed based on the highest spatial density of quality controlled weather station measurement data in Romania. Datasets are freely available on the World Data Center PANGAEA portal as well. ROCADA derived data have the best spatial resolution and accuracy when compared to other available gridded databases at present, such as E-OBS or CarpatClim (Sfica et al., 2017). From a total number of 35 extreme temperature and precipitation indices calculated from the entire county (World Bank, 2020), we have chosen for this study only those one which showed a statistically significant change over the considered period.

Point 5. I don't understand the connection with precipitation and the inclusion of even precipitation graphs within the manuscript. I recommend deleting those unless adequately justified.

Response 5. We have deleted the precipitation graphs as – you are right – for precipitation, no significant changes have been identified during the last five decades.

Point 6. Any information is mentioned regarding the indices. Can you introduce the paragraph with a general statement by giving the researchers' proper credits for who first developed them?

Response 6. For assessing the general vulnerability and calculating the Climate related Social Vulnerability Index (CleSoVI) we have followed the hazard-of-place model (Cutter, 1996) by performing a dimension reduction method, named a Principal Component Analysis (PCA). The PCA is a statistical process which helps reduce large sets of-/several independent variables into factors which still contain most of the information from the original data set. In order to ensure that all the variables are adequate for the analysis, we have run a collinearity diagnostic and two statistical tests: the Kaiser-Meyer-Olkin (KMO) and Bartletts's test of sphericity. In all cases, the value of KMO was above 0.7 while the Bartlett's test was also significant (< 0.000). The communalities (proportion of each variable's variance that can be explained by the factors) go beyond 0.500, further confirming the adequacy of the selected variables. The detailed CleSoVI construction procedure is presented as a flowchart in Fig. 3.

Unlike in the original SoVI model (Cutter, 1996), in this study we applied a weighting method developed by Török (2018) based on the percentage variance of each principal component, in order to ensure that components with a higher variance have a higher influence on the overall vulnerability (Eq.1). In the model, we have further integrated the climate related variables in order to capture both the physical and social components of vulnerability, which enabled us to have a broader insight to the vulnerability of people and places.

I also feel some confusion when explaining the database used (e.g. (i) when creating the DEVI, the authors amended one database with another one; or (ii) when included in the SEVI index another index -the Local Human Development Index). How is it possible to have an index into another index? This also reveals another critical flaw in the methodology. Do the authors perform a multicollinearity analysis? I guess that some of the variables may be explained

by some others, double-counting them into the equation. I am quite sure that within the 13 weather-related variables, some of them present some collinearity. Likewise income and social welfare, or the Local development index with some others.

As we have mentioned earlier, we have carefully revised all the introduced variables, and we have eliminated those, which have shown a redundancy, running the PCA analysis once again. Thus, we have eliminated the two composite indices (LHDI and social welfare) and – after running a multicollineraity analysis – we have included only those variables where the variance inflation factor (VIF) was below 5. Thus, we have kept 7 exposure indicators, 15 sensitivity indicators, and 14 indicators for adaptive capacity.

Point 7. Chapter 3 and 4 are divided into many subchapters that sometimes account for just a single paragraph. This makes them very difficult to read.

Response 7. Thank you. We have eliminated those subchapters and we kept only 3 relevant paragraphs:

- Methodology

3.1. Indices calculation

3.2. General vulnerability assessment

3.3. Spatial patterns of social vulnerability

- Results

4.1. Measuring climate related social vulnerability components

4.2. Assessing highly vulnerable areas

4.3. Identifying spatial patterns of climate related social vulnerability index

Point 8. "4.4 Analysis of BEVI": the authors state: "On the one hand, limited access to basic services like access to piped water and sewage network, the share of wooden houses make people more vulnerable, especially those from rural areas and highly isolated mountainous regions (southwestern and northeastern parts of the county)". How can the lack of basic sanitation influence the vulnerability of people to extreme temperatures? These very vague sentences make me feel that the variables' choice has been made without a proper understanding of the hazard selected. Running a social vulnerability analysis is not just a PCA; it is how the chosen variables interact in the current socio-cultural and economic environment.

How can the lack of basic sanitation influence the vulnerability of people to extreme temperatures?

Response 8. This is a characteristic specific to this specific county, since most of the rural households have their own wells, which are most affected in case of drought. It must be mentioned that the eastern part of the analyzed county has a geological structure mostly characterized by salty soil with much clay, which does not favor neither the good quality of drinking water, nor agricultural farming.

And more, are urban agglomerates more fragile to extremes temperatures because of lesser evapotranspiration rather than rural and mountainous areas?

Yes, the question is good, because high population and housing density contributes to anthropogenic excess heat, and the modified urban climate can have a further impact on the health of people by producing heat islands.

Point 9. What is the demographic dependency ratio and rate of natural increase? What is the social welfare ratio?

Response 9. The dependency ratio relates the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old). Dependency ratios indicate the potential effects of changes in population age structures for social and economic development, pointing out broad trends in social support needs. A high dependency ratio indicates that the economically active population and the overall economy face a greater burden to support and provide the social services needed by children and by older persons who are often economically dependent. A high youth dependency ratio, for instance, implies that higher investments need to be made in schooling and child-care.

The rate of natural increase (RNI) is a statistic calculated by subtracting the crude death rate from the crude birth rate of a given region. This rate gives demographers an idea of how a certain country's population is growing.

Social welfare rate is a composite indices means financial abundance, material goods and wealth in services available only for money. This index was left from the analysis.

Point 10. The discussion is somehow discussing the whole of Romania. Thus I would change the study area and make it wider.

Response 10. We have carefully revised the discussion section, focusing only on the analysed region. We have also performed a spatial analysis with the help of the ESDA technique (as one of the reviewers has recommended), and we have amended the discussion section with the main findings. As we already mentioned, a lot of data is either missing at country level, or it is not freely available for the wider public. We know that this is one of the limitations of the study and we are working on receiving a larger database in a near future.

One of the fundamental questions of spatial analyses is whether any regularity can be detected in the spatial distribution of the studied phenomenon, or the spatial distribution of the data is random. In order to detect spatial clustering in the resulted CleSoVI index, we have used the ESDA techniques, focusing both on the Global-, as well as the Local Moran's I statistics. The latter allows us to identify clusters of spatial outliers, i.e. statistical hotspots and cold spots, which in turn allow us to delimit areas characterized by the highest and lowest levels of vulnerability. The high value of Moran's I ($r = 0.360$) suggests a positive spatial autocorrelation at a significance level of $0.05 > p > 0.01$, reflecting a strong clustering process. Thus we could identify four main groups (Fig.6): communes with the lowest level of vulnerability (L-L cluster) can be found in the immediate vicinity of the largest urban centers (Cluj-Napoca), being surrounded by areas with a relatively high level of vulnerability as compared to the central regions (H-L cluster). Settlements with the highest level of social vulnerability (H-H cluster) can be found in the northern, eastern and southern parts of the county, where the occurrence of extreme temperatures regularly has a negative effect on agricultural production, thus influencing the overall socio-economic development of these settlements as well. The fourth cluster (L-H) includes both urban and a rural settlements of a smaller size, indicating a lower level of social vulnerability, as compared to the surrounding areas.

Figure 6: Cartogram of clusters representing the CleSoVI for measuring the general vulnerability

Point 11. In the conclusion, the authors mention that: "[...] the results of this research were obtained based on a significant selection of socio-economic and climate-related variables, an improved methodological assessment, and a GIS-based approach". Any GIS approach has been performed in the current manuscript. The display of the vulnerability into a map is not a GIS approach, nor it is new.

Response 11. We have eliminated this sentence and we have made some changes in the conclusions section by adapting the results of the spatial autocorrelation analysis.

The present paper aims to develop an in-depth analysis based on socio-economic variables to understand what makes a community more vulnerable compared to another. To better assess the social vulnerability of the analyzed region, the results of this research were obtained by combining physical, social and demographic aspects. This study represents a first attempt for understanding the spatial relationship between social vulnerability and climate change, offering the possibility to be tested in other regions as well. As the analysis revealed, the most vulnerable communities could be found in the northern and south-eastern peripheral rural areas, which are further affected by climate-induced negative impacts. Usually, these settlements are characterized by multiple social and economic disadvantages, which make it difficult to cope with the impact of any natural hazards. The present analysis represents an important step towards developing more adequate response strategies and towards helping local decision makers plan better to adapt and cope with the impact of climate change, taking advantage of the opportunities and support attributed to the European Green Deal (European Commission, 2020).

The study presents some limitations. Even though the analysis can offer a holistic approach by combining various social, economic, demographic, and climate-related/e indicators, some of them are not up to date as it could be found only in the 2011 Census. This makes it difficult to give a precise situation picture about/of the analyzed territories. The second limitation is strongly related to the static character of the analysis. By comparing different periods, it could further help to identify the changes of people's vulnerability, their coping, and adaptive capacity.

The third limitation is the small territorial unit of analysis. As we have already mentioned there are a lot of missing data for the whole country or are not freely available for the large public.

Overall, our paper has a large applicability, which can be applied for any local community, with some adjustments to capture the local specificity of the considered focus area.

Point 11. The legends of the figures are missing the unit of measurement

Response 11. We have included the unit of measurement in the figures.

We have changed the title of the manuscript to "Assessing the impact of extreme temperature conditions on social vulnerability". We consider, that the discussion part together with the limitations subsection capture the applicability of the used method well

enough.

Once again, thank you for your valuable comments and suggestions. I appreciate the hard work and sincerity, and hope that the corrections will be met with approval.