GlobeDrought – Global assessment of drought risk for agricultural systems

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Background and Methodology

Results

Summary

Improved understanding of drought and proactive plans and policies to mitigate drought effects are priorities of many national and global institutions. Responding to their needs, we present for the first time, an integrated assessment of drought risk and impact for both irrigated and rainfed agricultural systems at the global scale.

We linked meteorological data, satellite-based vegetation, land cover and total water storage anomaly data with hydrological and crop water models and vulnerability indicators to assess drought risk.

Our findings can support the identification of tailored measures to reduce drought risk and increase the resilience of agricultural systems.

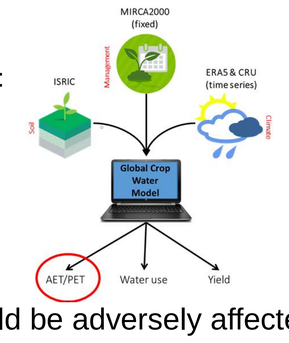
Data and methods

DROUGHT RISK INDEX = HAZARD×EXPOSURE×VULNERABILITY

HAZARD : a deviation of the situation in a specific year or month from long-term mean (1986–2016).

Two models simulated the terrestrial hydrology on daily steps:

- *WaterGAP with climate forcing WFDEI-GPCC (30 arcmin) .*
- *Global Crop Water Model (GCWM) with climate forcing CRU-TS 3.25 (5 arcmin)*



EXPOSURE : the elements located in areas that could be adversely affected by drought hazard.

- *Weighting grid-cell-specific hazards with the harvested area of irrigated and rainfed crops MIRCA2000, national scale*

VULNERABILITY : the predisposition to be adversely affected as a result of the sensitivity or susceptibility of a system and its elements to harm, coupled with a lack of coping and adaptive capacity.

- *Selection and classification of 46 vulnerability indicators by socioecological susceptibility (SOC_SUS,ENV_SUS), lack of coping capacity (COP) and lack of adaptive capacity (AC) following the risk framework of the IPCC*

Drought risk : multiplying hazard and exposure by vulnerability at pixel level

Conclusion and outlook

❖ Our findings affirm the disparity in drought effect through space and crop type.

❖ Aggregating drought effects on different crops misrepresent the drought impacts on specific crops, and notable information gets lost by aggregation.

❖ The spatial variability in drought risk on global and regional scales might help to identify leverage points for reducing impacts and properly anticipate, adapt and move towards resilient agricultural systems.

References

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- Eyshi Rezaei, E., S. Siebert: Global patterns of agronomic drought risk, The German Society of Agronomy Conference proceedings – From Big Data to Smart Farming, Göttingen, Germany, 2018.
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Drought risk

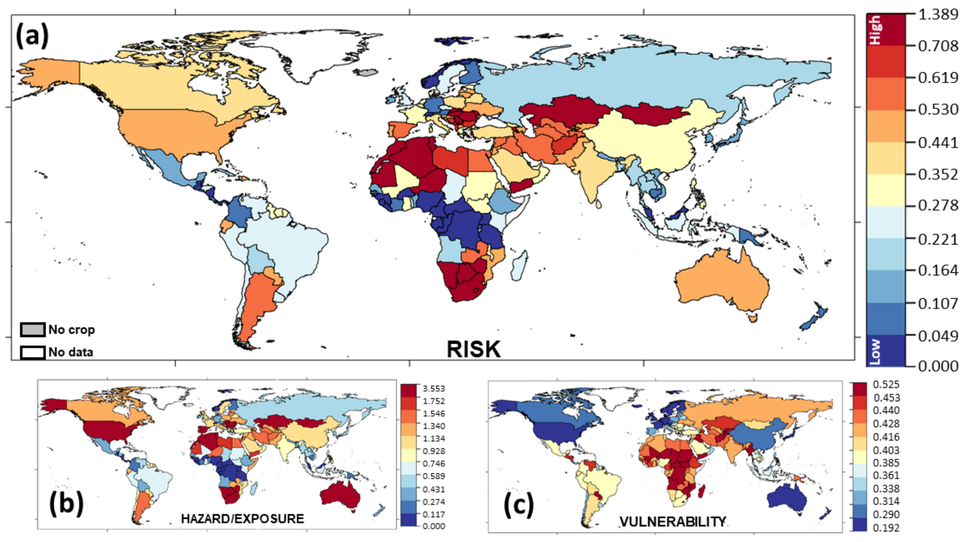


Figure 1. Drought risk(a), hazard and exposure(b), and vulnerability(c), from Meza et al (2020)
* The legends were defined by assigning the median of the value distribution to the yellow color in the center, the 90th percentile to the deepest red and the10th percentile to the deepest blue and by determining the class ranges of the other colors by linear interpolation.

- Heterogeneous pattern of drought risk at the global level, with higher risk for southeastern Europe as well as northern and southern Africa.
- The patterns of hazard and vulnerability often do not overlap.
- The highest drought risk appears in regions with elevated hazard and vulnerability.
- Since reducing hazard is difficult, drought risk management should mainly address vulnerability and exposure.

Crop-specific drought hazard for rainfed systems

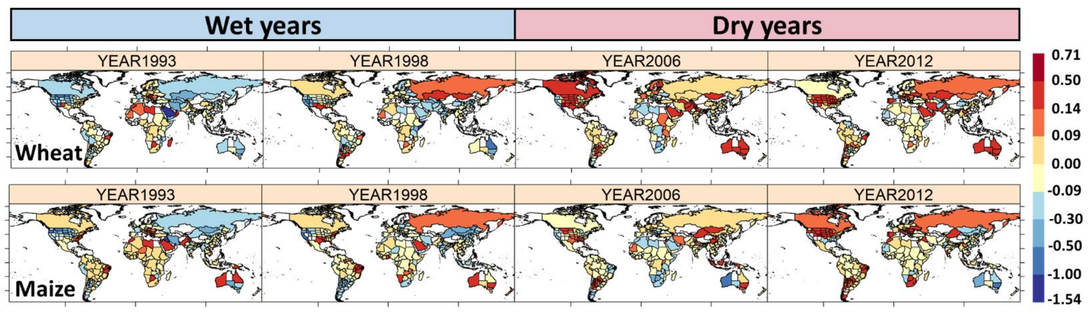
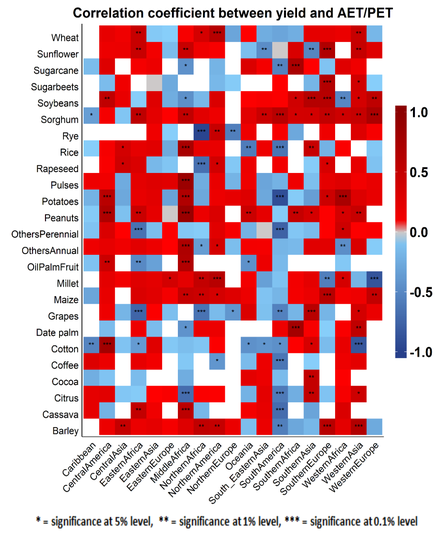


Figure 2. Crop-specific drought hazard – the case of wheat (a) in two wettest (1993, 1998) and driest years (2006, 2012), and for maize in these specific years (b), from Nouri et al. (in-preparation)
* The drought indicator varied from -1.54 (no drought, dark blue) to 0.71 (extreme drought, dark red); white shows the absence of crop

Substantial differences in the spatio-temporal variability of drought indicator for individual crops

- Severity of drought varied for different crops; the most severe drought for wheat happened in 2006 while for maize was in 2012.
- Wheat in the US and Australia was intensely affected in dry years and hardly affected in wet years which was not necessarily the case for maize (e.g. in Canada and parts of Australia in1993).
- Although 1993 was the wettest year for wheat, maize suffered from a mild drought in some parts of Africa, Australia, Canada, and South America.

Drought impact on the crop yield at regional and national scales



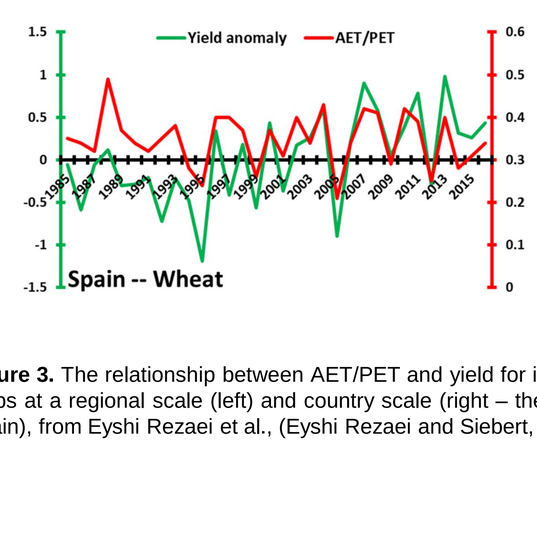


Figure 3. The relationship between AET/PET and yield for individual crops at a regional scale (left) and country scale (right – the case of Spain), from Eyshi Rezaei et al., (Eyshi Rezaei and Siebert, 2018)

- Drought impact on yield varied among crops over space.
- Western Asia and Western Africa experienced the largest impact of drought on most crops.
- Our approach was suitable on a country scale, as well. AET/PET and yield anomaly for wheat production in Spain followed similar trends.

Acknowledgements

SPONSORED BY THE
Federal Ministry of Education and Research
FONA Research for Sustainable Development
BMBF
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