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Reporting Summary

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Statistical parameters

When statistical analyses are reported, confirm that the following items are present in the relevant location (e.g. figure legend, table legend, main text, or Methods section).

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐	An indication of whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistics including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated
☐	☒	Clearly defined error bars *State explicitly what error bars represent (e.g. SD, SE, CI)*

Our web collection on statistics for biologists may be useful.

Software and code

Policy information about availability of computer code

Data collection	No software were used to collect data in this study.
Data analysis	DSSAT version 4.6; Standard GTAP Model, Version 7

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors/reviewers upon request. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

The historical weather data (1981-2010) that support the simulations with Earth System Models (ESMs) in this study are publicly available online at https://data.giss.nasa.gov/impacts/agmipcf/; the future climate scenario data (2010-2099) that support the simulations with ESMs in this study are publicly available online at https://pcmdi.llnl.gov/?cmip5 and https://esgf-node.llnl.gov/projects/esgf-llnl/.

The spatial data of harvest area, yield, crop calendar, irrigation portion and chemical N input for barley that support the simulation with crop model (DSSAT) in this study are publicly available at (SPAM) http://mapspam.info/ and (SAGE) HYPERLINK "http://www.sage.wisc.edu/" http://www.sage.wisc.edu; the soil data that support the simulation with crop model (DSSAT) in this study are publicly available at WISE database (https://www.isric.online/index.php/), digital Soil Map of the World (DSMW) (http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1026564/).
The data and parameters that support the economic model in this study are available from GTAP 9 database (https://www.gtap.agecon.purdue.edu/databases/v9/default.asp), which were used under license for the current study. Data are however available with permission of GTAP center. The other data that support splitting barley and beer from the original database GTAP 9 are publicly available at FAOSTAT (http://www.fao.org/faostat/en/#data) and UN Comtrade Database (https://comtrade.un.org/data). All other relevant data are available from the corresponding authors.

Field-specific reporting

Please select the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/authors/policies/ReportingSummary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Beer is the most popular alcoholic beverage in the world by volume consumed, and yields of its main ingredient, barley, decline sharply in periods of extreme drought and heat. Yet, although the frequency and severity of drought and heat extremes increase substantially in range of future climate scenarios by 5 Earth System models, the vulnerability of beer supply to such extremes has never been assessed. Here, we couple a process-based crop model (DSSAT) and a global economic model (GTAP) to evaluate the effects of concurrent drought and heat extremes projected under a range of future climate scenarios.
Research sample	The historical (1981-2010) daily weather data was selected due to its suitability for agricultural modeling, featuring consistent, daily time series data. The dataset also substantially improves the representation of daily precipitation distributions of extreme events. The climate scenario data for the future years (2010-2099) was used based on the standard practice in the field of climate change studies such as IPCC. The economic data from GTAP was selected as this is the most commonly used and widely recognized global database for CGE simulation.
Sampling strategy	We do not use any sampling procedure to conduct our study.
Data collection	W. Xiong and J.P. extracted the following data from respective sources: AgMERRA dataset and the future climate scenario data (2010-2099) that support the simulations with ESMsw were extracted https://data.giss.nasa.gov/impacts/agmipcf/; https://pcmdi.llnl.gov/?cmip5 and https://esgf-node.llnl.gov/projects/esgf-llnl/. The spatial data of harvest area, yield, crop calendar, irrigation portion and chemical N input for barley that support the simulation with crop model (DSSAT) were extracted from http://mapspam.info/ and (SAGE) HYPERLINK "http://www.sage.wisc.edu/" http://www.sage.wisc.edu; the soil data that support the simulation with crop model (DSSAT) in this study were collected from WISE database (https://www.isric.online/index.php/); digital Soil Map of the World (DSMW) was collected from (http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1026564/). W. Xie and T.A. downloaded the data and parameters for economic model from (https://www.gtap.agecon.purdue.edu/databases/v9/default.asp); they also extracted other data that support splitting of barley and beer from the original database GTAP 9 from FAOSTAT (http://www.fao.org/faostat/en/#data) and UN Comtrade Database (https://comtrade.un.org/data).
Timing and spatial scale	The timing of the historical analysis sample and the future projection sample ranges over 1981-2010 and 2010-2099, respectively. The spatial scale of future (2010-2099) climate scenario data, selection of extreme years and changes in barley yield change was 0.5° x0.5°horizontal resolution. The timing of the economic data was 2011 and the corresponding spatial scale was country/region at global level.
Data exclusions	No data were excluded from the analyses.
Reproducibility	Our study did not involve comparisons of treatment groups or populations so we did not employ traditional experimental design and ANOVA techniques. Therefore, replication of experimental units is not applicable to our study design. The reliability of our results was evaluated based on reported uncertainty analyses.
Randomization	We use crop model and economic supply-demand model, so randomization is not relevant.
Blinding	Ours is an integrated method including crop model and economic model, so no relationship with blinding.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

Materials & experimental systems

n/a	Involved in the study
☒	☐ Unique biological materials
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☒	☐ Animals and other organisms
☒	☐ Human research participants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging