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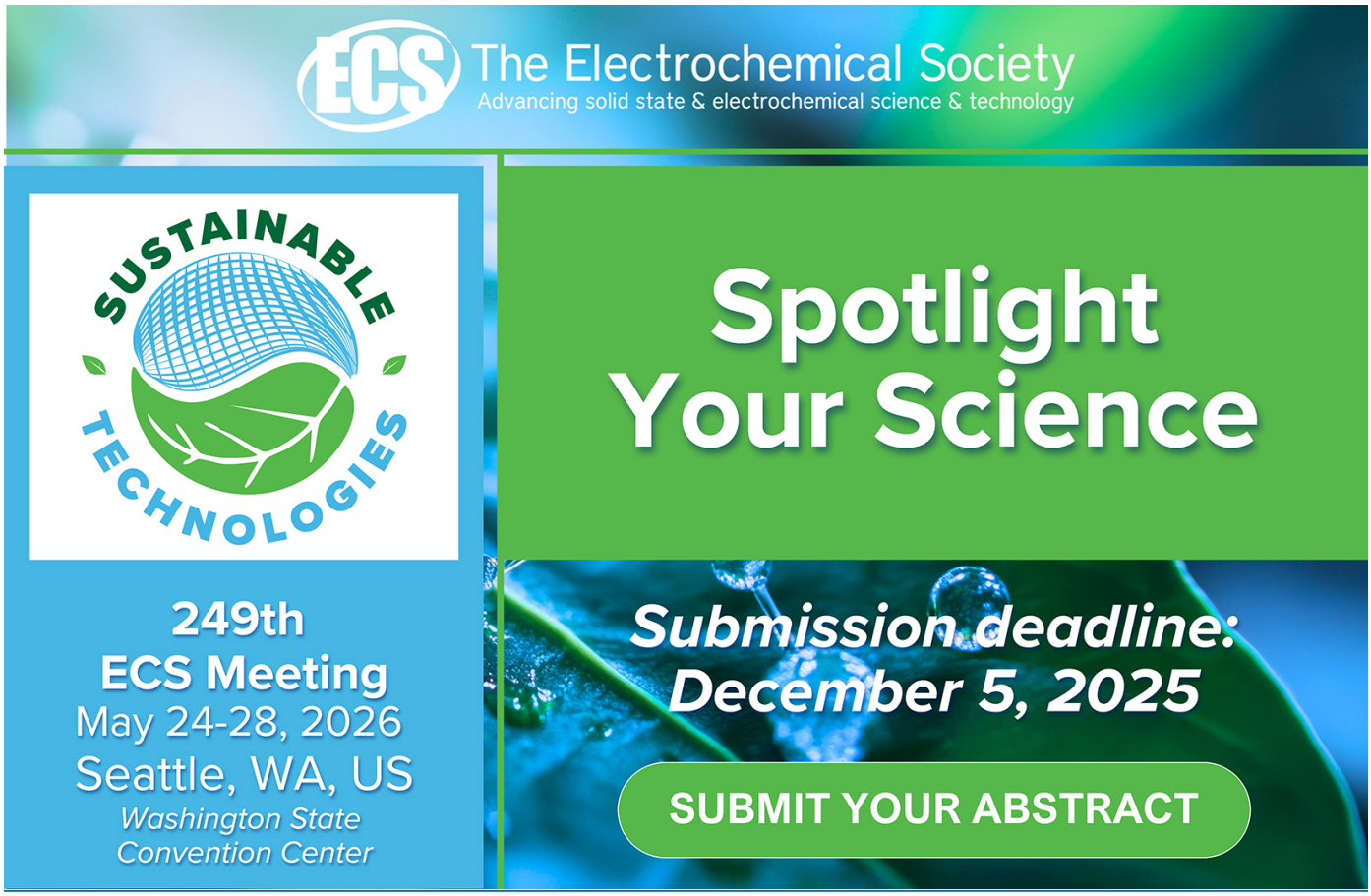

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Climate extremes, food price spikes, and their wider societal risks

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1. Main

2024 was the hottest year on record [1], with global temperatures exceeding 1.5 °C above preindustrial climate conditions for the first time and records broken across large parts of Earth's surface. Among the widespread impacts of exceptional heat, rising food prices are beginning to play a prominent role in public perception, now the second most frequently cited impact of climate change experienced globally, following only extreme heat itself [2]. Recent econometric analysis confirms that abnormally high temperatures directly cause higher food prices, as impacts on agricultural production [3] translate into supply shortages and food price inflation [4, 5]. These analyses track changes in overall price aggregates which are typically slow-moving, but specific food goods can also experience much stronger short-term price spikes in response to extreme heat. In this perspective, we document numerous examples from recent years in which food prices of specific goods spiked in response to heat, drought and heavy precipitation extremes. By evaluating the extremity of the associated climate conditions, we thereby build a global and climatological context for this phenomenon. We further review the knock-on societal risks which these effects may bring with the ongoing intensification of extremes under climate change. These range from increasing economic inequality and the burden on health systems, as well as destabilising monetary and political systems. We discuss challenges and priorities for research and policy to address these risks.

2. Recent food price spikes from unprecedented climate extremes

We bring together reports by national and international media of food prices spiking in response to climate extremes across a range of countries to build a global picture (figure 1). These reports typically rely on interviews with local producers, consumers and industry specialists in order to link price increases to recent weather conditions. As such, they provide a valuable narrative approach leveraging local knowledge to connect price changes with weather, which complements recent statistical analyses relying on a detailed causal modelling framework [4, 5]. To limit potential biases, we rely on cases which were reported widely across different media sources, and where government or other official statistics are available as sources of food price data (see supplementary methods and table S1 for further details and discussion). While reductions in yields due to climate extremes are consistently the trigger of these events, we note that more complex socioeconomic settings can modulate the price response, for example when coupled with shifting demand, transportation disruptions or speculation [6] (see table S1). Moreover, effects on other input factors may play an additional role to yield declines, for example with regards to heat stress on agricultural labour [7],or flood damage to infrastructure [8].

Amongst the examples we identify, recent spikes in the price of food were often associated with heat, drought and heavy precipitation conditions that

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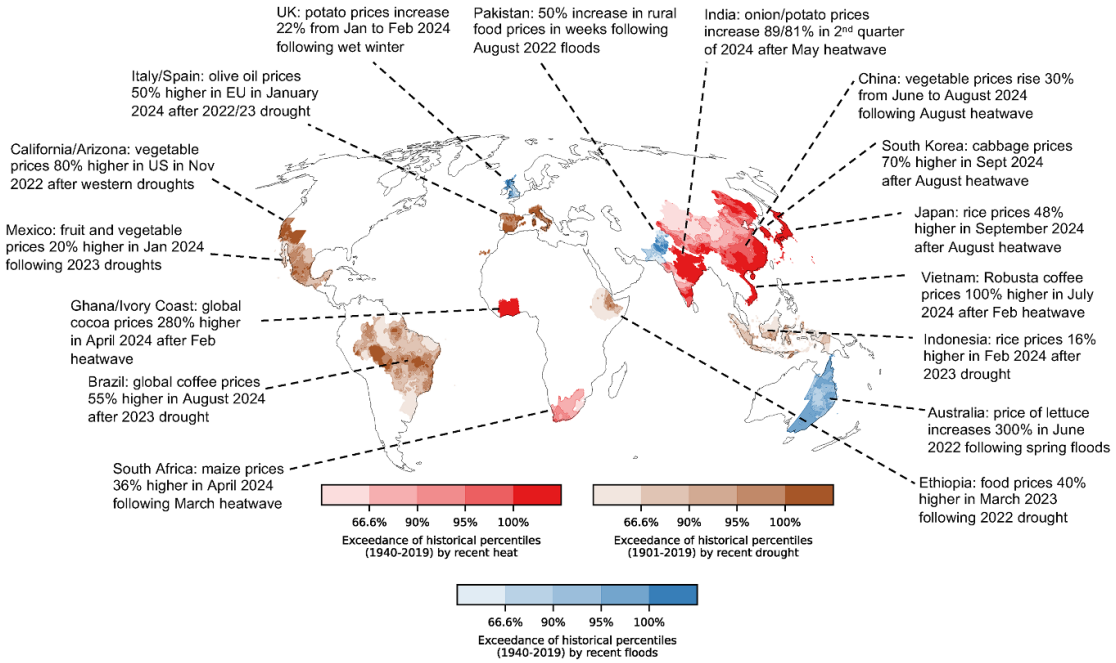

Figure 1. The climatological context of recent climate-induced food price spikes. The map shows examples since 2022 in which food price increases were reported in association with extreme climate conditions. Underlying shading represents the extent to which the associated climate conditions exceeded percentiles of the historical distribution. Colours are shown in red for heat events (assessed using monthly average surface air temperatures from ERA5 with data covering 1940–2024), in brown for drought events (assessed using the standardised precipitation evapotranspiration index database based on data of monthly precipitation and temperature data from CRU covering the period 1901–2023), and in blue for heavy precipitation events (assessed using either multi-month averages, or maximum daily totals within a given timeframe depending on the event type as documented in table S1 and the supplementary methods, with data from ERA5 covering 1940–2024). For each event type, the darkest shading indicates events which have no precedent in the historical record prior to 2020. See table S1 for a full documentation of sources of information on price changes and extreme event definitions, as well as further methodological discussion. (*Source*: author; see the data and code availability statement for further information on accessing the underlying data and reproducing this figure).

were so extreme as to completely exceed all historical precedent prior to 2020 (figure 1). Other socioeconomic factors were only rarely noted as an additional contributing factor (see table S1). For example, heatwaves across East Asia during 2024 led to unprecedented monthly temperatures across virtually all of South Korea and Japan, as well as large parts of China and India. Government statistics (see Supplementary Materials Table S1) indicate that these events lead to substantial increases in the price of Korean cabbage (70% higher in September 2024 compared to September 2023), Japanese rice (48% higher in September 2024 compared to September 2023), and overall vegetable prices in China (30% increase between June and August).

Far from being confined to Asia, prominent impacts were also seen across advanced Western economies. With California accounting for over 40% of US vegetable production, unprecedented drought across California and Arizona in 2022 contributed to an 80% year-on-year increase in US vegetable producer prices by November 2022. With Spain producing over 40% of global olive oil, unprecedented droughts in Southern Europe across 2022/23 drove year-on-year price increases of 50% across the EU by January 2024, on top of price increases in the previous year.

As well as effects in domestic markets, recent climate extremes also raised global market prices of important food commodities. For example, Ghana and the Ivory Coast produce nearly 60% of global cocoa. Unprecedented monthly temperatures across the majority of both countries in February 2024, on top of a prolonged drought in the prior year, led to increases in global market prices of cocoa of around 300% by April 2024 compared to the previous year. Similar effects were observed for coffee following heatwaves and drought in Vietnam and Brazil in 2024. Such effects in international markets bring challenges for suppliers and potential price rises for consumers in countries far from the region directly affected by weather extremes.

3. A catalyst for wider societal risks

Importantly, these climate-driven food price spikes can aggravate risks across a range of sectors of society. First, rising food prices have direct implications for food security [9],particularly for low-income households. This can result in (a) households spending the same but buying less (either going hungry or depending on sources of charity); (b) spending the same but buying cheaper options (typically cutting out nutritious foods like fruits and vegetables which are more expensive sources of calories) (c) spending an even higher proportion of their income on

food (with knock on effects on other areas of essential expenditure). These effects can be strongly regressive given the substantial disparities in the share of income spent on food by low- and high-income households. For example, in the USA the lowest income quintile spends approximately 33% of income on food compared to 8% in the highest income quintile [10]. The fact that larger price increases occur in hotter and typically poorer countries will further amplify these effects [4].

Second, food price increases exacerbate risks for public health. When price increases shift consumer spending towards cheaper, often less nutritious options, or when climate extremes directly affect the prices of nutritious foods such as fresh fruit and vegetables, this can have knock-on consequences for the quality of diets. With diet-related diseases responsible for more deaths than any other risks [11],climate-induced price increases could thereby exacerbate a range of health outcomes from malnutrition and associated co-morbidities (particularly among children whose nutritional needs are higher), to a range of chronic diet-related conditions including coronary heart disease, type 2 diabetes and many cancers. Combined with the growing body of evidence connecting food insecurity and poor diets with mental health outcomes [12], this implies strong risks for the health sector and necessary public spending from climate-induced food price increases.

Third, recent evidence indicates that heat impacts on food prices also raise headline inflation [4, 5]. Central bank mandates for price stability may become increasingly challenging to deliver if more frequent extreme weather events make food prices less stable domestically and in global markets [13]. This is particularly a risk for developing economies, where the weight of food prices in headline inflation is much greater. These challenges may be magnified if persistent temperature increases cause a sustained upward pressure on inflation [4],or inflation volatility results in lower credibility and a de-anchoring of inflation expectations. Moreover, raising interest rates to dampen inflationary effects risks exacerbating any reduction in economic growth that may also be caused by the extreme event.

Fourth, food price inflation associated with climate-extremes may come to bear increasing political relevance. Anecdotal evidence from across history often cites food price increases as a precursor to political unrest and social upheaval (from the French and Russian revolutions of the 18th and 20th centuries, to the 2008/09 food crisis and 2011 Arab Spring). Such links are substantiated further by evidence showing a robust relationship between food prices and social unrest at monthly time-scales [14]. Moreover, high rates of inflation can directly alter election outcomes in modern democracies. For example, high inflation reduced support for incumbent Democrats in the 2024 US election [15],and boosted support for extremist, anti-system and populist parties in elections held in advanced economies since 1948 [16]. These effects can be particularly strong when inflation affects real wages [16],as is the case with food prices.

4. Focus points for research and policy

These examples highlight the ongoing societal risks posed by the impacts of unmitigated climate change on the food system—a reminder of the urgency to enact policies that reduce greenhouse gas emissions and limit global warming in line with globally agreed targets. This remains the fundamental lever for reducing risk. However, with current trajectories implying that further warming is inevitable, we discuss the research and policy needed to facilitate adaptation and build resilience against the widespread societal risks which may propagate from climate-induced food price increases.

Firstly, seasonal to multi-annual climate predictions may offer early warning of short-term exposure to climate extremes and their impact on yields. At the producer-level, timely information on climate conditions can enable optimization of crop choices or scheduling to limit exposure and impacts [17]. Climate predictions even have useful skill for forecasting prices of specific commodities [17], which may prove increasingly useful at financial and governmental levels. For example, HSBC recently highlighted how temperatures are now a better metric for forecasting food prices across India compared to reservoir levels as used historically in their financial models [18]. Such opportunities for valuable information from climate forecasts may grow with increasingly severe conditions, offering windows to initiate decisions by governments and/or Central Banks which limit the down-stream effects of higher food prices on further societal outcomes. Nevertheless, substantial barriers still remain in terms of their technical implementation, accessibility and uptake [17].

Agricultural adaptation strategies for the long-term will therefore also be vital. Crop switching and irrigation are widely discussed as offering theoretical value, but challenges in their implementation have also been raised, for example in the context of increasing water demand driven by both population growth and climate change [3]. In Catalonia where prolonged droughts recently contributed to rising olive oil prices (figure 1), the regional government subsequently passed new regulations to reduce agricultural irrigation by 80% during drought periods [19]. While crucial for sustainable water use, these policies point to limits in the capacity of irrigation as an effective adaptation strategy when competing with other demands. This highlights the resource, economic and potentially political constraints which may often impede adaptation strategies [20],an area

requiring careful consideration by research and policymakers to identify effective adaptation strategies.

The further risks to food security, health, and monetary and political stability which we highlight entail complex interactions between environmental and socio-economic systems. These risks therefore involve large uncertainty, despite clear evidence that the necessary mechanisms exist for them to materialise. Multi-disciplinary research efforts will therefore be crucial to effectively trace effects across systems and to quantify their likelihood, magnitude and distribution. These should aim to fill gaps where current research results are likely insufficient to warrant systematic policy shifts. Key gaps include how to navigate a balance between local production and international trade which facilitates greater resilience to climate impacts [21]; as well as the role of farming subsidies in incentivizing shifts towards more climate resilient agricultural practices.

Despite these uncertainties, we note that many of the downstream risks relate closely to the affordability of food. Policy efforts which strengthen the resilience of households to cope with inflationary shocks under increasingly unprecedented climate extremes are therefore likely to be effective in mitigating these risks. These could include, for example, index-linked social security programmes and nutritional safety nets targeted towards at-risk groups such as children, pregnant women and the elderly. Such efforts to ensure the affordability of food under pressures from climate change may face financial constraints but would likely limit potential downstream effects on health outcomes and political tensions.

5. Future outlook

The unprecedented nature of many of the climate conditions behind recent food price spikes highlights the ongoing threats to food security as climate change continues to push societies towards ever less familiar climate conditions. While the 2023/24 El Niño likely played a role in amplifying a number of these extremes, their increased intensity and frequency is in line with the expected and observed effects of climate change (see supplementary text). With current policies and actions set to lead to global warming of between 2.2 °C and 3.4 °C above pre-industrial levels, unprecedented conditions are set to become increasingly common across the world. At the same time, new records for extreme conditions will continue to be set, further from those to which agricultural production and economic systems are currently adapted. This underlines the necessity and urgency of mitigating greenhouse gas emissions, associated increases of climate extremes, and the consequential disruptions of food production. Subsequent increases in food prices could act as a catalyst from which further risks materialize across a range of important sectors of society. With ongoing warming very likely, research needs to focus on tracing impacts across sectors to quantify these risks, crucial for supporting the decisions and policies needed to actively address them.

Data availability statement

Data on reported food price changes are documented in the supplementary materials table S1. Data on climate conditions are publicly available from Copernicus (https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels?tab=overview) and the Global SPEI Database (https://spei.csic.es/database.html). Code necessary to produce figure 1 is publicly available from the following Zenodo repository: https://doi.org/10.5281/zenodo.15543488.

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Methodology: MK, MGD, TL, MP.
Investigation, Visualization: MK.
Writing—original draft: MK.
Writing—review & editing: PS, MGD, SV, TL, AT, MP.

Conflict of interest

The authors declare that they have no competing interests.

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References

[1] Copernicus 2024 Copernicus: 2024 virtually certain to be the warmest year and first year above 1.5 °C (available at: https://climate.copernicus.eu/copernicus-2024-virtually-certain-be-warmest-year-and-first-year-above-15degc)
[2] Globe Scan 2024 Top ways people are experiencing climate change (available at: https://globescan.com/2024/09/25/insight-of-the-week-top-ways-people-are-experiencing-climate-change/)
[3] Rezaei E E, Webber H, Asseng S, Boote K, Durand J L, Ewert F, Martre P and MacCarthy D S 2023 Climate change impacts on crop yields *Nat. Rev. Earth Environ.* **4** 831–46
[4] Kotz M, Kuik F, Lis E and Nickel C 2024 Global warming and heat extremes to enhance inflationary pressures *Commun. Earth Environ.* **5** 1–13
[5] Faccia D, Parker M and Stracca L 2021 Feeling the heat: extreme temperatures and price stability *ECB Working Paper Series* (https://doi.org/10.2139/ssrn.3981219)
[6] Lawson J, Alam R and Etienne X 2021 Speculation and food-grain prices *Appl. Econ.* **53** 2305–21
[7] de Lima C Z, Buzan J R, Moore F C, Baldos U L C, Huber M and Hertel T W 2021 Heat stress on agricultural workers exacerbates crop impacts of climate change *Environ. Res. Lett.* **16** 044020
[8] Bremond P, Grelot F and Agenais A-L 2013 Economic evaluation of flood damage to agriculture–review and analysis of existing methods *Nat. Hazards Earth Syst. Sci.* **13** 2493–512
[9] Gregory C A and Coleman-Jensen A 2013 Do high food prices increase food insecurity in the United States? *Appl. Econ. Perspect. Policy* **35** 679–707
[10] Sweitzer M and Davidenko V (US Department of Agriculture) 2024 *Food Spending as a Share of Income Declines as Income Rises* (available at: www.ers.usda.gov/data-products/chart-gallery/chart-detail?chartId=58372)
[11] Afshin A *et al* 2019 Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the global burden of disease study 2017 *Lancet* **393** 1958–72
[12] Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, Symonds M E and Miraghajani M 2020 Food insecurity and mental health: a systematic review and meta-analysis *Public Health Nutr.* **23** 1778–90
[13] Kuik F, Nickel C, Parker M and Modery W 2023 The price of inaction: what a hotter climate means for monetary policy *The ECB Blog* (available at: www.ecb.europa.eu/press/blog/date/2023/html/ecb.blog231218~6291e67d1e.en.html)
[14] Bellemare M F 2015 Rising food prices, food price volatility, and social unrest *Am. J. Agric. Environ.* **97** 1–21
[15] Steinberg D, McDowell D and Aytac E 2024 The impact of inflation on support for Kamala Harris in the 2024 presidential election *SSRN* (https://doi.org/10.2139/ssrn.5019711)
[16] Federle J, Mohr C and Schularick M 2024 Inflation surprises and election outcomes *Kiel Working Papers* (https://doi.org/10.2139/ssrn.5032871)
[17] O'Kane T J *et al* 2023 Recent applications and potential of near-term (interannual to decadal) climate predictions *Front. Clim.* **5** 1121626
[18] HSBC 2024 India: feeling the heat (available at: www.hsbc.co.in/content/dam/hsbc/in/en_in/wealth/pdf/market-outlook/india-economics/india-economics-2024-aug-v1.pdf)
[19] Gencat 2024 Catalonia declares a drought emergency and activates measures to address it (available at: https://exteriors.gencat.cat/en/ambits-dactuacio/afers_exteriors/delegacions_govern/ue/actualitat/not_240201_drought_emergency)
[20] Callahan C W 2025 Present and future limits to climate change adaptation *Nat. Sustain.* **8** 336–42
[21] Kummu M, Kinnunen P, Lehikoinen E, Porkka M, Queiroz C, Röös E, Troell M and Weil C 2020 Interplay of trade and food system resilience: gains on supply diversity over time at the cost of trade independency *Glob. Food Secur.* **24** 100360