Developing a bespoke indicator for the Lancet Countdown on Health and Climate Change
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Climate change, manifested through increasing frequency of heatwaves and droughts is already negatively affecting food and nutrition security through multiple transmission channels including impacts of heat stress and droughts on crop yields, on agricultural labour and therefore crop production and agricultural income, on non-agricultural labour and non-agricultural income, on health and the ability to earn enough to afford food, on food prices and therefore the affordability of food, and on food supply chains and therefore the variety of food.

Elizabeth Robinson and Shouro Dasgupta have designed and developed a bespoke "Food Insecurity" indicator for the Lancet Countdown. This indicator tracks the association between change in the share of the population reporting moderate or severe food insecurity due to changes in heatwave days and drought months from a 1981-2010 baseline, as indicative of adaptation gaps in the context of access to food and in turn on nutritional health.

Developing a climate and food insecurity indicator for the Lancet Countdown

This indicator combines data from the Food and Agriculture Organization Food Insecurity Experience Scale (FAO FIES) from 124 countries with the frequency of heatwave days and drought months (12-month Standardised Precipitation Evapotranspiration Index) during the growing seasons of maize, rice, sorghum, and wheat, using a time-varying panel regression. The indicator is updated on an annual basis. Each year we have a new round of survey data. We have also been able to increase the coverage in terms of number of countries, and have adjusted the methodology as we learn from conversations with experts as to how best to provide a bespoke indicator that is useful for specific countries and regions.

FIES “represents a significant change in approach to food insecurity measurement compared to traditional ways of assessing it indirectly through determinants such as food availability or consequences such as poor-quality diets, anthropometric failures and other signs of malnutrition”. The indicator is “developed by professionals from the nutrition field,” includes quantity and quality measures, making it particularly relevant for the Lancet Countdown and its focus on climate change and health. “FIES provides a tool for the nutrition and food security community to build on existing knowledge regarding relationships between the experience of food insecurity and indicators of malnutrition”.

The indicator is featured annually in the global, European, and Small Island Developing States Reports. Year on year, our research confirms that climate change, as proxied by the increasing frequency of heatwaves and drought days, is having a real and measurable impact on the number of people reporting difficulty in accessing sufficient and sufficiently nutritious food. The effects are not just due to how climate affects the production of food, but also how climate and weather affect people’s ability to source and purchase a healthy diet, which could be through reduced labour capacity and therefore reduced earnings, or through increasing food prices.

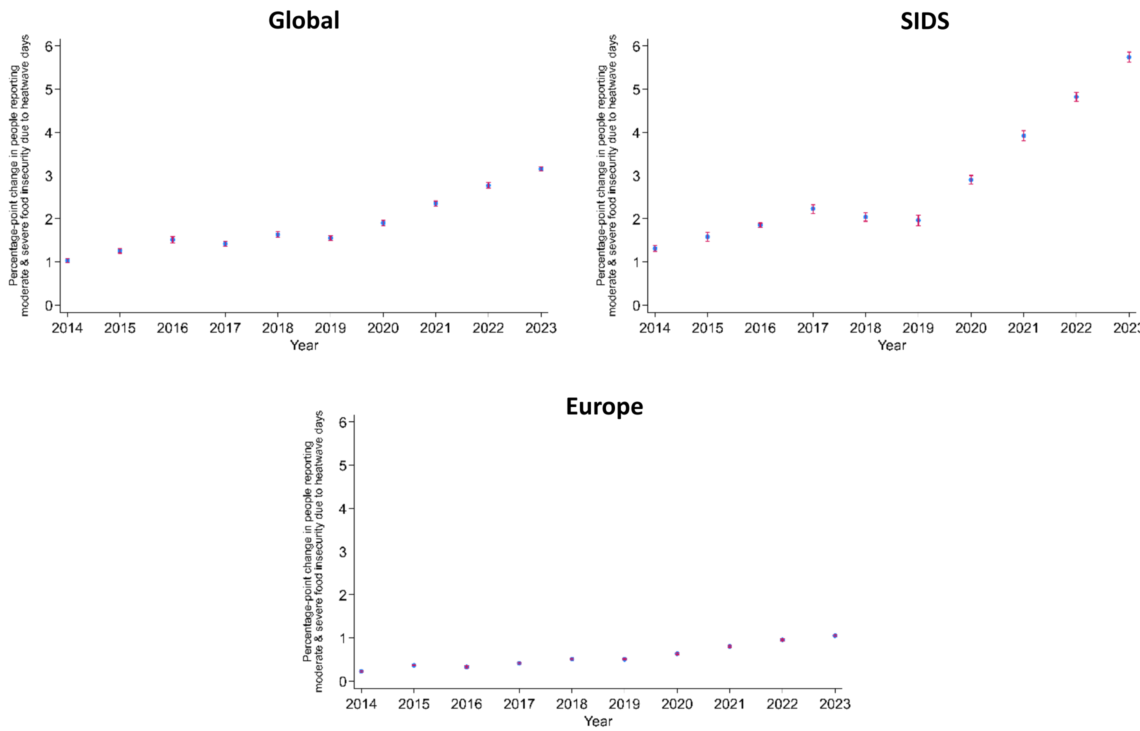

Figure 1: Change in the share of moderate or severe food insecure population (percentage point change) due to changes in heatwave days (left-panel) compared to 1981-2010 average

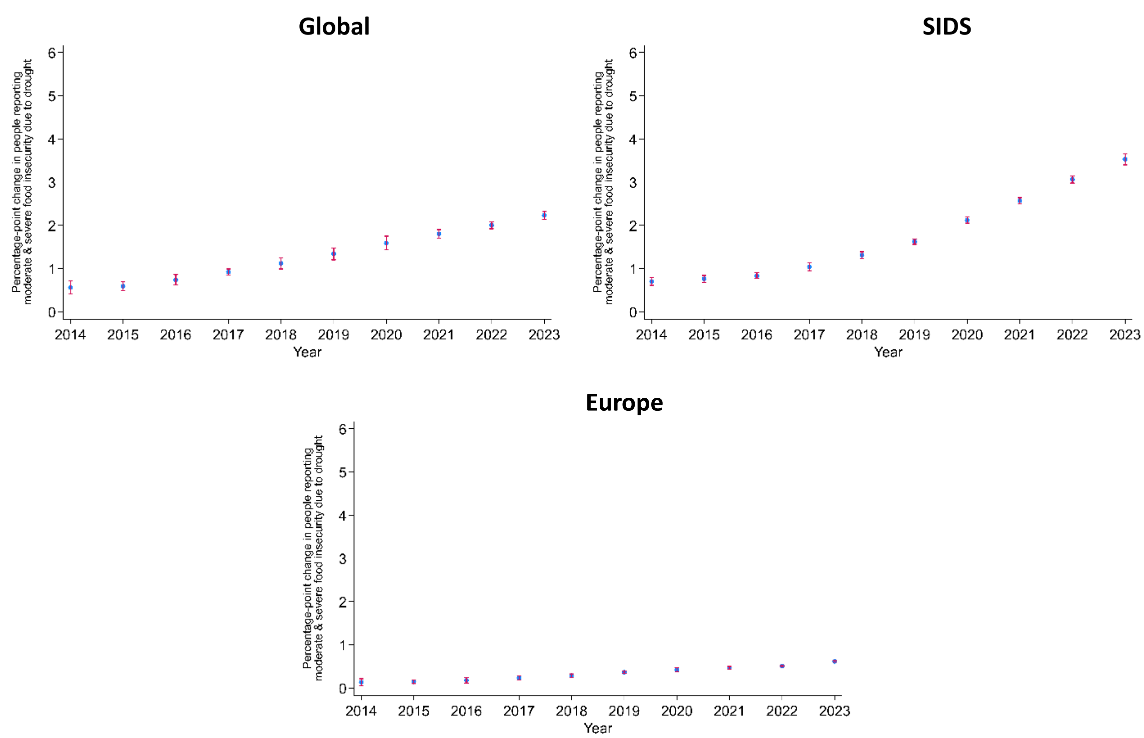

Figure 2: Change in the share of moderate or severe food insecure population (percentage point change) due to changes in the frequency of drought months compared to 1981-2010 average

This Lancet Countdown indicator has evolved over the past decade since the Countdown's first annual report in 2015. Initially the indicator focused on food production and specifically yield potential. As such, the indicator was focused on availability of food. Over time we have changed the focus of the indicator to reflect the critical issue of food security in a climate insecure world, namely, whether households experience being unable to access to a sufficient and nutritious diet. This is the dependent variable of our econometric analysis, which still incorporates production. For example, to calculate our indicator we explicitly address how crop production is affected by heat and extremes of precipitation during the growing seasons of four key crops (maize, rice, sorghum, wheat). But we also socio-economic status (income), and non-climatic shocks such as the Covid pandemic include in our econometric specification.

As a Lancet Countdown Working Group One indicator, our food security indicator was initially designed to quantify the extent to which insufficient mitigation is driving negative health impacts, specifically food and nutritional insecurity, and therefore the health co-benefits of climate change mitigation. However, by evolving the indicator to explicitly attribute impacts of climate and weather shocks on food security and nutritional security, controlling for a wide range of other factors, this indicator can be used to track the adaptation gap and inform targeted interventions such as safety nets (food and/or cash). This indicator has an explicit climate signal and can be disaggregated by gender and income groups, and changes in food insecurity can disentangled between climatic and non-climatic drivers.

Though not the primary aim of our indicator development, our broader analysis also provides some clues as to how food security can be improved in this ever more challenging environment. For example, our bespoke analysis of food security and climate in Small Island Developing States shows that higher dependence on food imports correlates with higher levels of food insecurity. Related analysis, using a similar methodology and data for Ethiopia finds that farmers who are able to store grain or save are less food insecure, and government food and cash safety nets are also effective at reducing food insecurity.

Implications for future food insecurity

Our food insecurity indicator was selected for, and included in, the 2022 Climate Vulnerability Monitor Third Edition: A Planet on Fire (CVM3). This is a unique global assessment at the national level of present and potential future climate change impacts on the environment, economy and public health. The Monitor consolidates the latest research from the scientific literature on the attribution of climate change in 32 distinct indicators of socioeconomic and environmental change and impact phenomena. CVM3 and its scenarios and modelling are informed by the Intergovernmental Panel on Climate Change's (IPCC) latest report, Sixth Assessment Report. Combining empirical estimates from Dasgupta and Robinson (2022) with future warming scenarios, we compute plausible impacts of future climate change on food insecurity. The findings show that during the 2021-2040 period, under the lower-emission scenario of SSP1-RCP2.6, moderate or severe food insecurity is projected to be 3.7 percentage-points higher than the reference period of 1995-2014, but only 1.9 percentage-points higher during the 2081-2100 period, reflecting the benefits of achieving a net zero target by 2050 (Figure 3). Under the high-emission SSP3-RCP7.0 scenario, moderate-severe food insecurity is projected to be 4.1 percentage-points higher during the 2021-2040 period than the reference period, and 12.8 percentage-points higher during the 2081-2100 period, demonstrating the detrimental effects of not reaching the net zero target. We use ISIMIP data for temperature and precipitation. We consider these projections to be lower-bound estimates because this type of methodology does not account for extreme climate shocks on crop yields, systemic risks, supply chain shocks, and biophysical and socio-economic tipping points being breached.

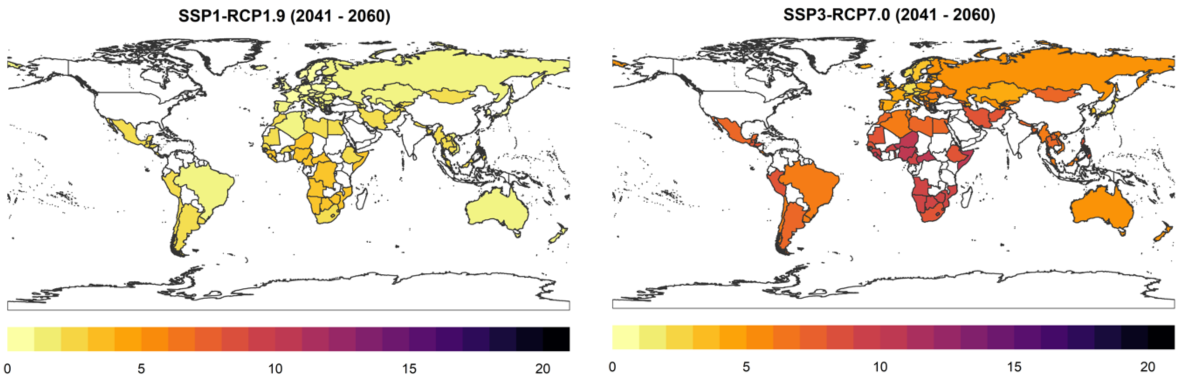

Figure 3: Change (percentage points) in moderate to severe food insecurity due to climate change with respect to the 1995–2014 baseline

Findings from indicator were also included in the 2024 European Climate Risk Assessment (EUCRA). For Europe, the indicator is available at the country-level.

Lancet Countdown Indicator Methodology

Details of the indicator are provided here, and can also be found in the Lancet Countdown report appendices. We recognise explicitly that climatic stressor (heatwaves and droughts) can affect food insecurity through multiple pathways. These can variously be through the impacts of heat stress and droughts on crop yields, on agricultural labour and therefore crop production and agricultural income, on non-agricultural labour and non-agricultural income, on health and the ability to earn enough to afford food, on food prices and therefore the affordability of food, and on food supply chains and therefore the variety of food. These effects can be summarised as food supply and food supply effects.

The indicator methodology is based on Dasgupta and Robinson (2022). To track the impact of climate change and income on the incidence of food insecurity, we use a panel data regression with coefficients that vary over time. To operationalise the concept of climate change, we focus on the number of heatwave days, and the frequency of droughts, during the four major crop growing seasons in each region. A heatwave is defined as a period of at least two days where the daily maximum temperatures are above the 95th percentile of the respective climatologies in each region. The gridded temperatures are taken from the ERA5-Land hourly dataset. We use the one year lagged number of heatwave days and number of drought month (measured by SPEI-12) during the crop growing seasons for each year during 2014-2023. SPEI-12 was computed using precipitation data from ERA5-Land monthly averaged dataset and the SPEI package in R.

We focus on the probability of moderate to severe food insecurity from the FAO Food Insecurity Experience Scale (FIES). To account for unobserved heterogeneity such as differences in food and storage policies across countries, and changes in the prices of food items from year to year, our specification includes a rich set of fixed-effects. The standard errors are clustered at the country-level.

Our panel data specification is written as follows:

$$FIES_{it} = \beta'(\tau_t)V_{(it)} + \gamma'(\tau_t)X_{(it)} + \alpha_{(i)} + \mu_{(it)}$$

$FIES_{it}$ is the probability of moderate or severe food insecurity or probability of severe food insecurity in year t at sub-national level *i.* β is a vector of the effects of either heatwave days or drought months on food insecurity in a given year; $\boldsymbol{V}_{it}$ is a vector of the difference between the number of heatwave days and the frequency of drought months during the four major crop growing season, compared with the 95th percentile of frequency during the reference period of 1981-2010; and $\boldsymbol{X}_{it}$ is a vector of two relevant variables affecting food insecurity, household income and a dummy variable to control for the COVID-19 pandemic in 2020. τ_t is a time-varying parameter that allows the coefficient β_i (representing the effect of heatwave days or drought months) to vary over time. $\alpha_{(i)}$ is the location fixed effect and $\boldsymbol{\mu}_{it}$ is a random error term. The time-varying coefficients allow us to examine whether the relationship between climate change and food insecurity has evolved over time.

Our analysis explores the extent to which food insecurity may have been affected by climate change, as proxied by changes in heatwaves and droughts. The dynamic nature of our time-varying approach captures how the impact of heatwaves or droughts on food insecurity may change across different years, rather than assuming a constant effect over the entire period where the effect of heatwaves or droughts can be larger in some years and smaller in others. As such, this methodology estimates the distinct magnitude of climatic change on food insecurity for every year, reflecting potentially changing sensitivities in different years. In a standard panel regression, the parameter β would estimate a constant effect across time of a heatwave day/drought month on food insecurity. The methodological flexibility is particularly valuable for estimating whether successive climate events have greater impacts on food insecurity over time.

Several potential interconnected mechanisms might explain the impacts of heatwaves and droughts on food insecurity. OLS regressions assume constant relationships between covariates and outcomes over time. However, when examining complex climate-food security relationships, this particular assumption can be restrictive. Time-varying coefficient regression addresses this limitation by allowing the relationship to evolve over time, reflecting complex interactions between climatic change and socioeconomic conditions. These plausible mechanisms behind the relationship between climatic stressors and food insecurity include the cumulative impacts of pre-existing vulnerabilities at the household-level such as income inequality, decoupling between economic growth and food security, and reduced effectiveness of adaptation strategies such as safety nets. The accumulation of these factors compound food insecurity, and time-varying coefficient regression captures this accumulation process by allowing the impact coefficient to vary over time as systems become more vulnerable to climate stress.