05 Sep 2025 -09:05

Inequality in human exposure to future climate extremes is rising

As the climate warms, extreme events are becoming more frequent and intense worldwide. But who will be most exposed in the decades ahead, and why? A new study by researchers at the Royal Meteorological Institute of Belgium (RMI), Ghent University, the University of Antwerp, and the University of Alabama answers this by comparing future exposure to four hazards: floods, heatwaves, droughts, and compound hot–dry events (when heat and dryness coincide). The study finds that people in lower-income countries will face higher future exposure to climate extremes than those in wealthier countries, and that this inequality is driven primarily by population growth rather than climate change alone.

Low-income countries hardest hit by extreme weather events

Low-income countries face amplified risks from heatwaves, droughts, and floods due to inadequate infrastructure, limited access to essential services, the absence of multihazard early warning systems, and ineffective disaster risk reduction strategies, all of which hinder their ability to prepare for and recover from such disasters. High-income regions, with their stronger institutional and individual capacities, will be better able to adapt to warming trends compared to low-income regions.

Importantly, the gap varies by hazard and by how extreme the events are. For heatwaves, the inequality is largest; for compound hot–dry events, it is smaller because those events increase almost everywhere, reducing the relative difference between country groups.

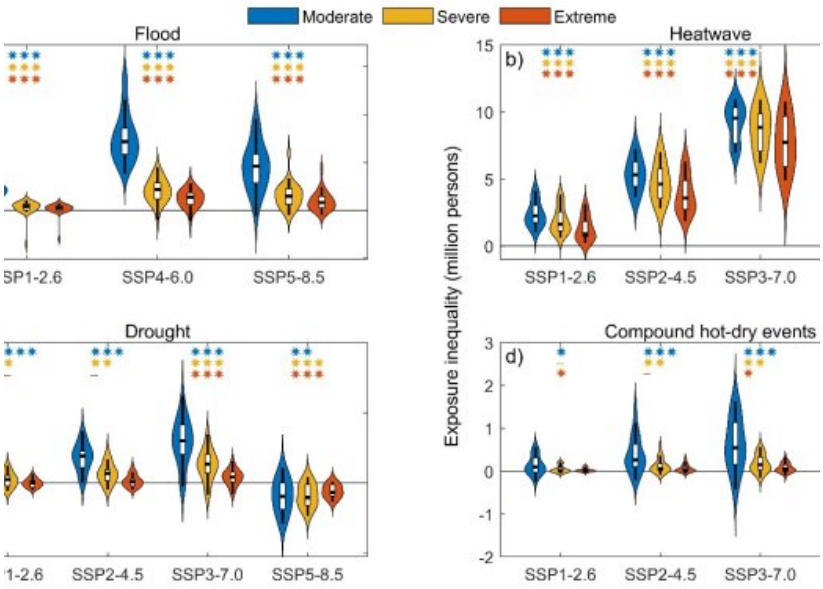

Fig. Inequality in projected changes in population exposure to extreme events of different severities across various future scenarios. The plots show the difference in projected changes in population exposure to extreme events between low- and high-income countries, with positive values indicating higher exposure in low-income countries.

First, exposure increases almost everywhere, but the extent differs by hazard. By late century, the share of countries with increased exposure is 71–83% for floods, 99–100% for heatwaves, 59–74% for drought, and 83–91% for compound hot–dry events (depending on scenario and severity). This widespread rise is most pronounced for heatwaves and compound hot–dry events.

Second, inequality in exposure is clear and often significant. Heatwaves show the largest inequality between income groups, while compound hot–dry events show the smallest. For floods and heatwaves, inequality remains significant across severities and scenarios; for drought and compound events, significance depends on scenario and severity. Notably, inequality generally decreases as events become more extreme.

Population growth: the main factor contributing to inequality

What drives the inequality? Mostly population growth. The exposure inequality was defined as the difference in projected changes in population exposure between low and high-income countries. In most cases, the demographic contribution dominates, though it shrinks at the most extreme severities where the climate signal grows stronger.

Low-income countries are expected to have substantially higher population growth rates, leading to more people living in vulnerable areas. Lower-income countries with higher fertility rates will have a younger population, meaning many will face climate risks throughout their lives.

For example, population growth accounts for roughly 54–81% of exposure inequality for moderate heatwaves (scenario-dependent), 46–75% for severe, and 19–40% for extreme; for drought, it explains ~53–82% (moderate), 48–77% (severe), and 46–75% (extreme).

Finally, development choices matter. Inequalities are highest in the slower, more fragmented development scenario and lowest in the sustainable and inclusive development scenario. For heatwaves, exposure inequalities in the former scenario are 4 to 9 times greater than in the latter scenario, depending on severity.

Global cooperation and support

In response to these inequalities in exposure, COP27 decided to create a fund to help developing countries compensate for losses and damage caused by extreme weather events. This agreement represents a crucial step in the fight against the disproportionate impacts of climate change on the world's poorest communities and highlights the urgent need for global cooperation and support.

Hossein Tabari, scientist at the RMI: *« This study advances climate research by providing a unified, global picture of inequality in future exposure across floods, heatwaves, droughts, and compound hot–dry events, and by quantifying the relative roles of population growth and climate change in driving that inequality. Because the analysis is harmonized across hazards, severities, and development pathways, it gives decision-makers comparable metrics to benchmark progress and evaluate how different development choices change equity outcomes.* »

Methodology

The authors combined large climate and hydrological model ensembles with global population projections. Heatwaves, droughts, and compound hot–dry events were quantified using 26 CMIP6 global climate models under multiple shared socioeconomic pathways (SSPs). Flood exposure was assessed with seven global hydrological models from the ISIMIP project. Exposure was defined as the product of event probability and the number of people affected, and results were grouped by World Bank country income categories.

More information

Read the paper (*Nature Communications)* : https://www.nature.com/articles/s41467-025-63385-3

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