Projections of children's exposure to multiple environmental hazards

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Abstract

As the frequency and intensity of extreme weather events increase, children's health, well-being, and development face growing threats. Children are particularly vulnerable to environmental hazards due to their physiological, cognitive, and social characteristics. Risks are further exacerbated by vulnerability as operationalized by the Human Development Index here. In this paper, we provide a global, grid-level analysis of environmental compound hazards, child population exposure, and vulnerability to assess future risk patterns under pre-industrial, historical, and future climate change scenarios with a focus on 2000–2050. The findings indicate that child population exposure increases in sub-Saharan Africa, while declining in South-East Asia and the Pacific. In absolute terms, compound multi-hazard exposure is concentrated on these three regions. We find that compound hazards disproportionately affect low-HDI locations, with the correlation increasing under climate change. Going beyond overall changes in hazard exposure, we plan to decompose risk changes into climate change and population components.

Keywords: children, projection, risk, compound hazard, exposure, vulnerability

Extended abstract

Extreme weather events related to climate change can have severe effects on children, both physically and mentally. Rapid-onset events such as floods and storms can result in injury, loss of shelter, and disruption of access to clean water, sanitation, and healthcare (Sheffield and Landrigan 2011; Anderko et al. 2020). The increased risk of disease and malnutrition is particularly harmful for children since their long-term development can be impaired by early life events and result in stunted growth, lower education and earnings, and higher risk for chronic diseases (Adair et al. 2013; Dimitrova and Muttarak 2020). Beyond physical harm, the trauma of experiencing or witnessing such events has psychological consequences, including anxiety, depression, and post-traumatic stress disorders (Burke et al. 2018; Helldén et al. 2021; Clemens et al. 2022). The destruction of schools and community networks can further compound these effects by interrupting education and social support systems (Burke et al. 2018; Vergunst and Berry 2022).

These risks are particularly pronounced in low-income countries with limited capacity to respond to disasters, manage slow-onset events, and invest in climate change adaptation (Hanna and Oliva 2016). At the same time, many of these countries are still in the demographic transition towards low fertility, implying that child populations are still growing in these contexts. Accordingly, children often face greater challenges in terms of exposure, hazards, and vulnerability in lower than in higher income contexts. The interrelation of demographic trends, climate change, and socio-economic development requires an integrated, forward-looking perspective (Jurgilevich et al. 2017). Combining scenario-based projections of different risk factors can help to anticipate future patterns and hotspots under different policy assumptions. Such an approach allows for the identification of regions where children may face the highest compound risks, thereby informing targeted adaptation strategies.

In this paper, we analyze projection data to highlight the exposure of child populations to droughts, heatwaves, river floods, tropical cyclones, wildfires, and compound hazards, using scenarios data of the Shared Socioeconomic Pathways (SSPs) and the Representative Concentration Pathways (RCPs). While single and compound environmental hazards for the whole population under a single scenario have been studied (Lange et al. 2020; Thiery et al. 2021), here we focus on the child population, highlighting also the changes in exposure as a risk factor. Fertility assumptions of scenarios can lead to large differences in child populations also over the relatively short time spans considered here. Coupling higher greenhouse gas concentrations with larger populations and worse socio-economic outcomes further improves the plausibility of the scenarios. Relying on the harmonized model runs of Lange et al. (2020), we assess model uncertainty over combinations of four global circulation models (GCMs) and various impact models for each hazard type. Counterfactual model runs under pre-industrial climate allow us to attribute changes in hazard to climate change. Additionally, we investigate whether hazard exposure correlates with Human Development Index (HDI), World Bank income classification, and world regions to take into account socio-economic vulnerability and regional heterogeneity.

We find that child populations stagnate until 2050 in most regions under the business-as-usual scenario SSP2, with the exception of increases in sub-Saharan Africa (SSA) and decreases in South Asia (SA) and East Asia and the Pacific (EAP). These three regions also exhibit the largest differences between SSPs. Exposure to single and compound environmental hazards differs over time, hazard type, and scenarios. During the baseline period there is a significant increase in the global number of children exposed to heatwaves due to climate change. Increases in child exposure under the high-end climate change scenario compared to the baseline period under pre-industrial conditions are observed for heatwaves, river floods, and multi-hazards, particularly in SSA, EAP, and SA. Considering socio-economic vulnerability, we find that environmental hazards disproportionately affect children in low-HDI countries, with the strongest correlation for droughts and multi-hazards. The negative correlation between HDI and multi-hazard exposure increases with climate change.

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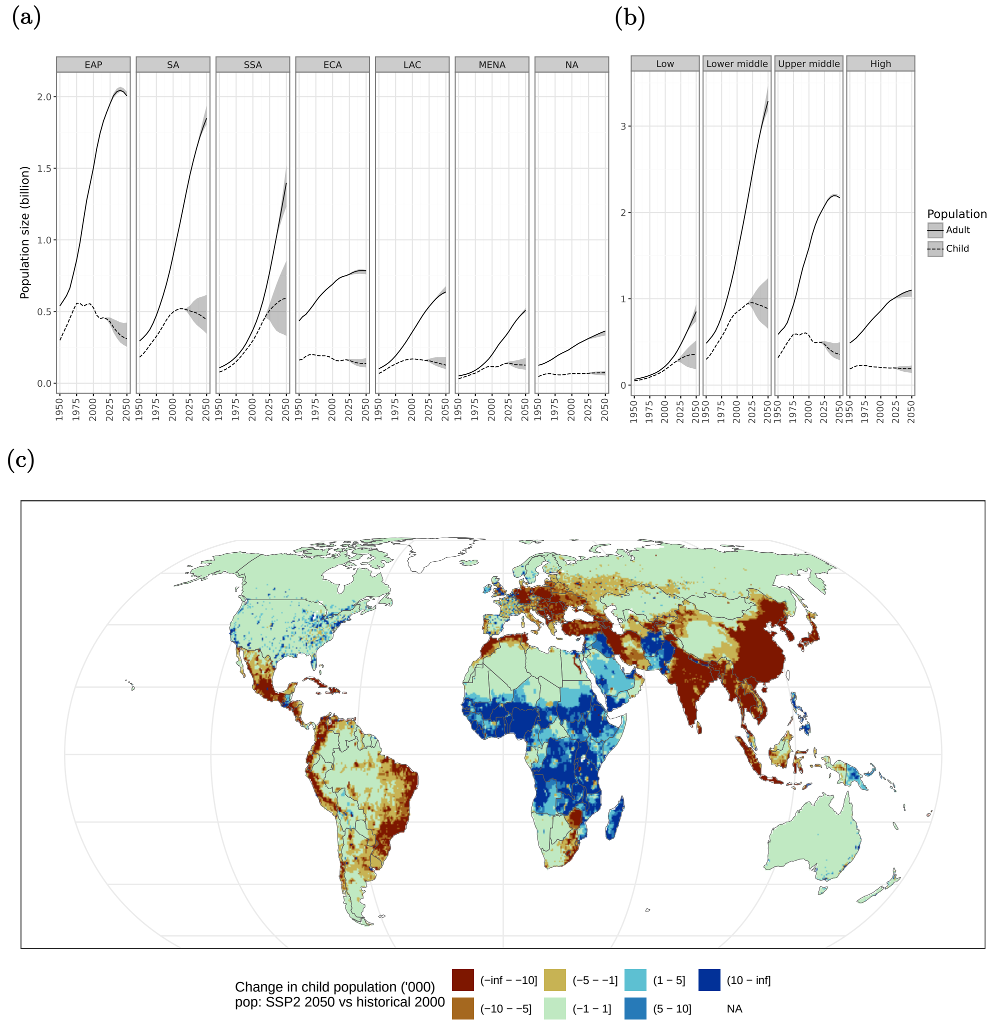


Fig. 1: Population trajectories of children and adults 1950–2050 in the SSPs by (a) world region and (b) World Bank income classification. Lines indicate historical and SSP2 value. The lower and upper bound of the shaded area refer to SSP1 and SSP3, respectively. (c) shows change of child population under SSP2 in 2050 from historical values in 2000.

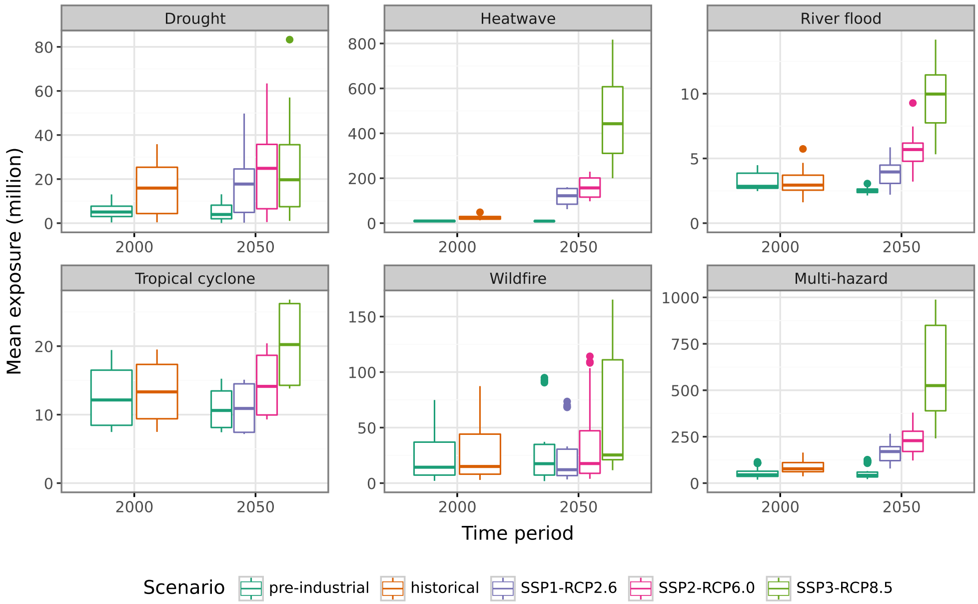
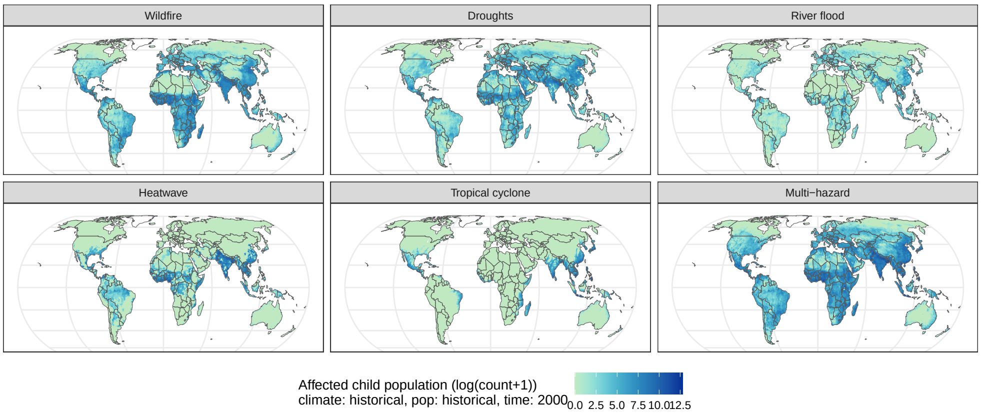


Fig. 2: Global exposure of children to environmental hazards. Boxplots show the distribution of multi-year mean exposure by GCM-impact model combination. Multi-hazard refers to the intersection of any of the single hazards, assuming they overlap as much as possible on the subgrid scale. Population exposure is based on historical data for the baseline period, on SSP1 for RCP2.6 climate, on SSP2 for pre-industrial and RCP6.0 climate, and on SSP3 for RCP8.5.

(a)



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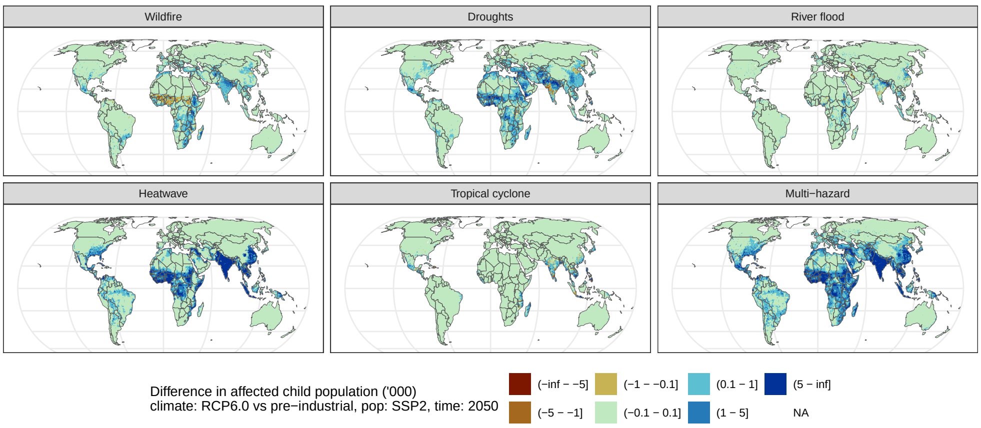
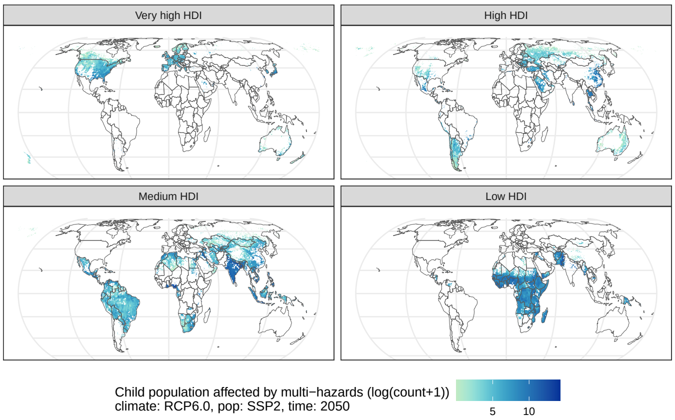


Fig. 3: Exposure of children to environmental hazards: (a) historical climate in 2000 and (b) difference between RCP6.0 and pre-industrial climate in 2050 with SSP2 population.

(a)



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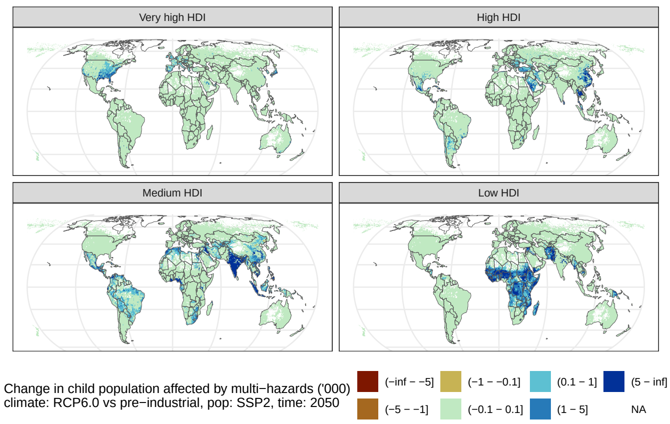
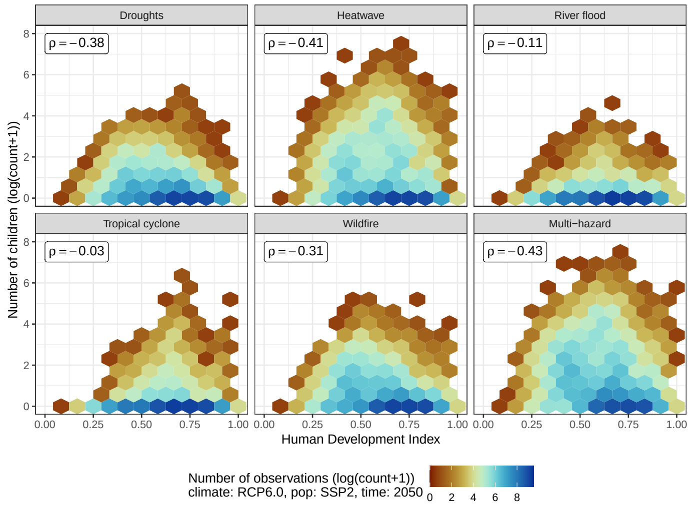


Fig. 4: Grid-level exposure of children to environmental hazards (2050) by Human Development Index classification (2019): (a) number of children in SSP2-RCP6.0 affected by hazard type and, (b) change in number of children in RCP6.0 vs pre-industrial climate.

(a)



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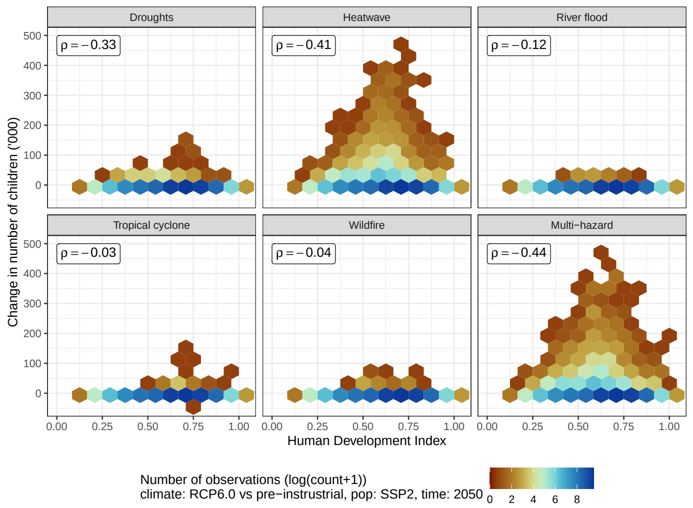

Fig. 5: Grid-level correlation of exposure of children to environmental hazards (2050) with Human Development Index (2019) by hazard type. ρ is the Spearman correlation coefficient between HDI and the multi-model mean of multi-year mean exposure. Outliers above 500,000 children are excluded from the plot but included in the calculation of ρ. Multi-hazard refers to the intersection of any of the single hazards, assuming they overlap as much as possible on the subgrid scale.