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Schools on the Frontline

A Spatial Assessment of Children's Exposure to Climate Extremes across Brazil

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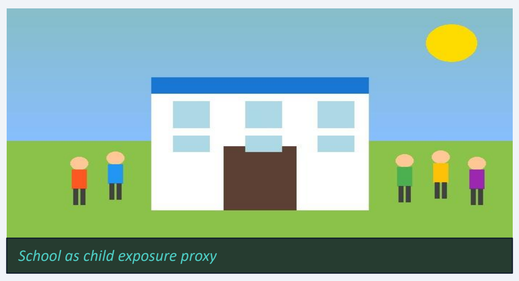
01 BACKGROUND & OBJECTIVE

Understanding how climate extremes affect children requires spatially explicit approaches that move beyond aggregate indicators. This study proposes a child-centered framework to assess climate risk by analyzing the exposure of schools to extreme climate events across Brazil (1985–2024). Using geolocated school data as a proxy for child presence, the study quantifies exposure to multiple climate hazards — including heatwaves, extreme temperatures, and flood events — derived from high-resolution observational datasets (Xavier et al., 2022). Extreme precipitation indices (R95p/R99p) are used as a proxy for flood hazard.

OBJECTIVE

Develop a child-centered spatial framework to assess climate risk using geolocated school data as a proxy for child presence — quantifying exposure to compound climate hazards across Brazil (1985–2024) and synthesizing results into the School Climate Exposure Index (SCEI), validated against observed disaster records.



School as child exposure proxy

40
Years
Long-term 1985–2024

5,570
Municipalities
Full national coverage

3
Hazard Types
Heat · Temp · Floods

02 METHODOLOGY

1

Data Integration

Geolocated school records integrated with high-resolution observational climate datasets (Xavier et al., 2022), providing consistent 40-year national coverage across Brazil.

2

Hazard Characterization

Climate extremes characterized by frequency, intensity and recurrence: heatwaves and extreme temperatures via standard indices; flood hazard proxied by extreme precipitation indices R95p and R99p (Xavier et al., 2022).

3

Spatial Overlay

School locations overlaid with hazard layers. Event-specific metrics extracted at each site, enabling site-level exposure quantification across all three hazard types.

4

Multi-Hazard Analysis

Co-occurrence and cumulative effects of compound stressors identified. Schools exposed simultaneously to extreme heat and flooding flagged as compound-risk sites.

03 HAZARD EXPOSURE ACROSS BRAZIL — EXPECTED RESULTS

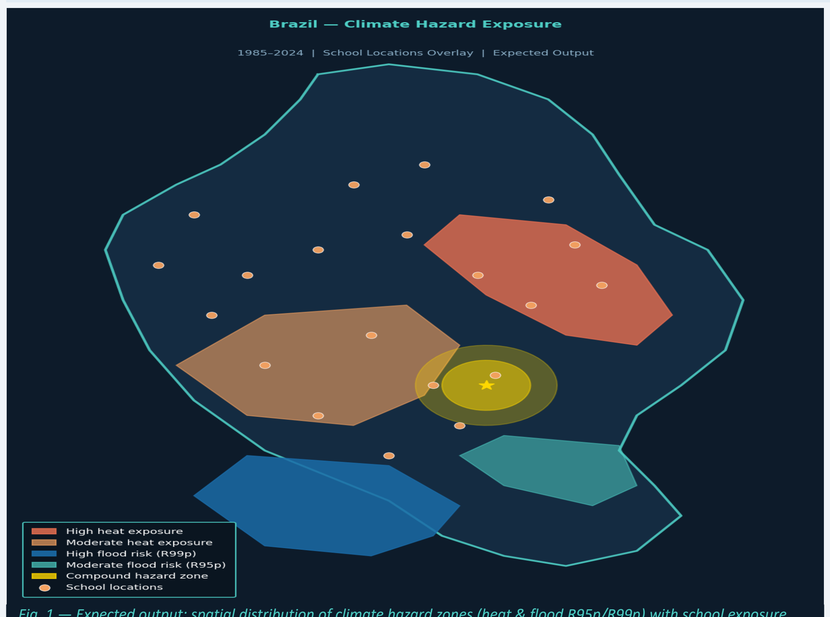
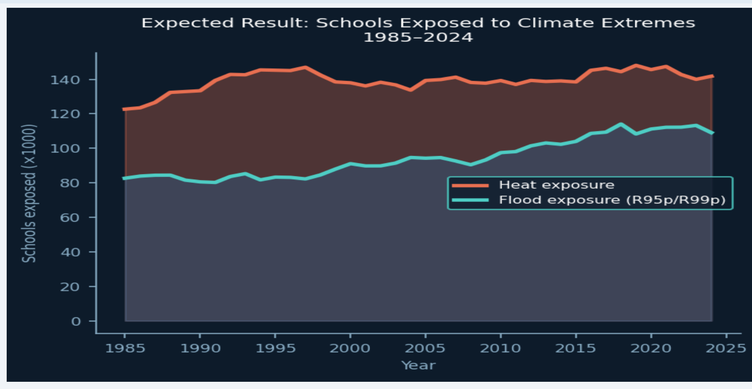
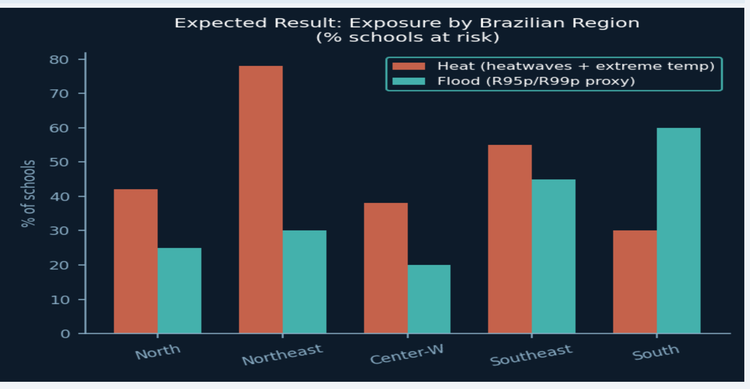
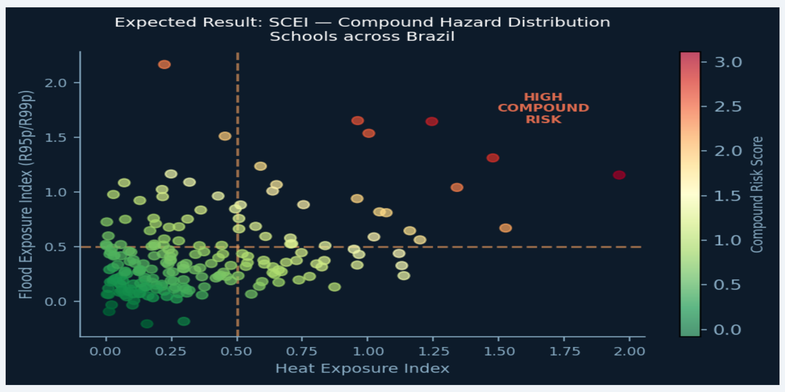


Fig. 1 — Expected output: spatial distribution of climate hazard zones (heat & flood R95p/R99p) with school exposure locations across Brazil (1985–2024)







04 SCHOOL CLIMATE EXPOSURE INDEX (SCEI)

The SCEI synthesizes hazard frequency, intensity, and multi-hazard exposure — including the co-occurrence of extreme heat and flood events (R95p/R99p) — into a single unified metric per school, enabling direct spatial comparisons across Brazil's diverse climate regions.

Hazard Frequency → **Hazard Intensity** → **Multi-Hazard Exp.** = **SCEI** (Unified Score)

05 VALIDATION FRAMEWORK

EXTERNAL VALIDITY

S2iD Cross-Validation

The SCEI is validated against event-based records from Brazil's national disaster information system (S2iD). SCEI scores are compared with historical damage reports to evaluate whether high-exposure hotspots correspond to locations with documented climate impacts. Spatial agreement is quantified using correlation measures and hotspot overlap statistics.

06 EXPECTED OUTCOMES & IMPACT

1

Spatial Hotspots

Spatial hotspots where schools are persistently exposed to climate extremes, highlighting elevated risks to children's safety, well-being, and learning.

2

Inequality Exposure

Spatial inequalities in child exposure that remain invisible in conventional population-based indicators are uncovered at school level.

3

Scalable Framework

A scalable and transferable approach applicable beyond Brazil — wherever geolocated school and observational climate data are available.

4

Policy Tool

Support climate-resilient planning, targeted interventions, and risk-informed decision-making to safeguard children in a changing climate.

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Ref:
Xavier, A. C., Scanlon, B. R., King, C. W., & Alves, A. I. (2022). New improved Brazilian daily weather gridded data (1961–2020). International Journal of Climatology, 42(16), 8390– 8404. https://doi.org/10.1002/joc.7731

Ministry of Integration and Regional Development (MIDR). (2024). *Integrated Disaster Information System* (S2iD). Government of Brazil. https://s2id.mi.gov.br