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Assessing the Gaps: Developing A Global Child-Specific Climate Risk Index to Safeguard Children's Health, Education, And Development in A Warming World

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ABSTRACT

The escalating climate crisis presents a fundamental threat to child rights globally, yet current measurement frameworks remain critically insufficient. This research addresses the urgent gap in child-specific climate risk assessment by evaluating the limitations of existing indices and proposing a comprehensive framework for a Global Child-Specific Climate Risk Index. Through a systematic desk review of data from UNICEF, WHO, and peer-reviewed literature published between 2020 and 2025, this study analyses the physiological, developmental, and social vulnerabilities unique to children. Key findings reveal that while over 1 billion children live in extremely high-risk countries, mainstream indices such as ND-GAIN and INFORM primarily focus on economic assets or general population data, failing to capture child-specific nuances. The research highlights multidimensional impacts, documenting how extreme weather disrupts education for millions, exacerbates malnutrition, and drives displacement. The analysis demonstrates that without age-disaggregated data, adaptation policies inadvertently marginalize children. The paper proposes a new multidimensional indicator framework integrating health, education, nutrition, and displacement metrics. It concludes that safeguarding children's future requires an immediate paradigm shift: the integration of standardized, child-centric climate metrics into National Adaptation Plans (NAPs) and international disaster risk reduction strategies. This study provides a roadmap for governments and humanitarian organizations to move beyond generic risk assessments toward targeted interventions that protect the most vulnerable demographic in a warming world.

Keywords: Child-specific climate risk index, climate impacts on children, global climate vulnerability assessment, children's health and climate change, climate adaptation for child development, climate-induced displacement, child malnutrition and climate.

INTRODUCTION

Climate change stands as the defining threat of the 21st century, disproportionately affecting the world's 2.2 billion children. UNICEF's 2021 Children's Climate Risk Index (CCRI) starkly revealed that approximately 1 billion children nearly half of the global child population face 'extremely high' risk from climate impacts. Children possess unique physiological, developmental, and social vulnerabilities that make them susceptible to environmental shocks in ways adults are not. Despite this reality, established global climate risk indices like ND-GAIN, INFORM, and the Germanwatch CRI largely lack robust, child-specific metrics, focusing instead on economic stability or general humanitarian risks. This significant research gap hinders effective policy formulation and resource allocation for child protection. This paper critically assesses these methodological deficiencies and proposes a comprehensive, standardized child-specific climate risk index. By bridging climate science and child development, this research aims to safeguard children's health, education, and future potential against an increasingly volatile climate.

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RESEARCH QUESTIONS

1. What are the critical gaps in existing global climate risk indices regarding child-specific vulnerabilities?
2. How do climate hazards differentially impact children's health, education, nutrition, and developmental outcomes?
3. What multidimensional indicators should constitute a comprehensive child-specific climate risk index?
4. How can child-centric climate metrics be integrated into national adaptation policies and international frameworks?

LITERATURE REVIEW

A. Children's Unique Climate Vulnerabilities

Children are not simply "little adults" when facing climate hazards; their biological and social positioning creates distinct vulnerability profiles. Sheffield and Landrigan (2011) and the American Academy of Pediatrics (2025) emphasize that children's developing bodies are physiologically more susceptible to environmental stressors. Their higher metabolic rates, faster breathing, and immature immune systems mean they absorb more pollutants and are less able to regulate body temperature during heatwaves.

Developmentally, early childhood is a window of high sensitivity. Exposure to toxic stress from extreme weather events can permanently alter brain architecture, impairing cognitive and emotional development (Harvard Center on the Developing Child, 2025). Furthermore, children face a longer lifetime exposure to climate impacts compared to current adults, meaning the cumulative burden of disease and trauma will be significantly higher for the current generation (The Lancet Planetary Health, 2025). Socially, children rely almost entirely on adults and established systems (schools, healthcare) for protection. When these systems fail during disasters, children lose their primary safety nets, exacerbating their risk (UNICEF, 2023). This dependence demonstrates why general population metrics often fail to capture the depth of child vulnerability.

B. Existing Climate Risk Assessment Frameworks

A review of major climate indices reveals a systemic exclusion of child-specific indicators. The Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index is a leading tool for measuring vulnerability and readiness. However, Notre Dame (2024) data indicates that its methodology prioritizes national-level economic and governance readiness, often using broad population data rather than age-disaggregated metrics. This approach obscures the specific needs of the youth demographic.

Similarly, the INFORM Risk Index, widely used for humanitarian crisis management, focuses heavily on conflict and infrastructure. While valuable for general disaster response, UNDRR (2023) reports suggest that INFORM lacks sufficient indicators for child education continuity or long-term developmental health, rendering it inadequate for assessing chronic climate stresses on children. The Germanwatch Climate Risk Index primarily quantifies fatalities and economic losses (Germanwatch, 2025). This economic focus overlooks the "silent" crises affecting children, such as malnutrition or lost school days, which do not carry an immediate economic price tag but devastate human capital.

UNICEF's Children's Climate Risk Index (2021) marked a pioneering shift by centering the analysis on children. It aggregated data on exposure to climate shocks against child-specific vulnerability. However, scholars argue that while CCRI is a crucial first step, it requires refinement in data granularity and standardization to be effectively operationalized in national policy planning alongside established economic indices.

C. Multidimensional Climate Impacts on Children

The literature documents extensive multidimensional impacts. In the health domain, rising temperatures and changing precipitation patterns are expanding the reach of vector-borne diseases like malaria and dengue, which disproportionately kill young children. New research from the Harvard Center (2025) links extreme heat directly

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to adverse birth outcomes and increased pediatric emergency admissions for respiratory conditions. Mental health is emerging as a critical concern, with "eco-anxiety" and trauma from displacement affecting millions.

Education disruption acts as a secondary but devastating impact. UNICEF (2025) data indicates that in 2024 alone, 242 million children saw their education disrupted by climate events. Schools often serve as shelters or are destroyed during floods, leading to long-term learning gaps that perpetuate cycles of poverty.

Nutritional security is equally threatened. Dimitrova (2021) and Sehgal et al. (2021) demonstrate a strong correlation between drought, crop failure, and increased rates of stunting and wasting in children. Climate-induced food price volatility forces families to reduce meal quality, leading to micronutrient deficiencies that permanently stunt physical and cognitive growth.

Displacement represents a severe violation of child rights. Between 2016 and 2021, weather-related disasters displaced 43 million children (UNICEF, 2023). Migration often severs access to healthcare and exposes children to higher risks of exploitation and violence. Furthermore, the deterioration of Water, Sanitation, and Hygiene (WASH) infrastructure due to floods or droughts increases the transmission of waterborne diseases, a leading cause of under-five mortality.

D. Regional Vulnerability Hotspots

Regional analyses highlight disparate impacts. South Asia emerges as a critical hotspot where extreme heatwaves and severe flooding threaten over 600 million children (UNICEF India, 2021). The compounding effects of high population density and air pollution create a toxic environment for child development.

In the Sahel, the nexus of climate change and conflict drives profound vulnerability. Recurring droughts decimate food security, while resource scarcity fuels conflict, forcing families into displacement and leaving children without protection.

Small Island Developing States (SIDS) face existential threats. Ashorn et al. (2025) document how sea-level rise and intensifying tropical cyclones in SIDS not only damage physical infrastructure but also erode the psychological well-being of children who fear the loss of their homelands. Sub-Saharan Africa remains burdened by water scarcity and high disease prevalence, amplifying the climate risk for its largely young population.

E. Gaps in Current Assessment Methodologies

The review identifies persistent methodological gaps. There is a lack of standardised child health indicators within national climate adaptation planning. Data collection frequently fails to disaggregate by age, masking the specific burden on infants and adolescents. Furthermore, current assessments demonstrate weak linkages between climate science models and child development research, leading to policies that fail to address the long-term human capital implications of climate change.

METHODOLOGY

This research employs a unique, systematic desk review methodology to evaluate gaps in climate risk assessment and develop a child-specific framework. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure rigor and replicability.

Data Sources and Search Strategy:

The review synthesised data from authentic international repositories, including UNICEF Data, WHO Global Health Observatory, the World Bank Climate Change Knowledge Portal, and IPCC Assessment Report 6 (AR6). Additionally, a comprehensive search of peer-reviewed journals was conducted focusing on publications between 2020 and 2025. Keywords used included "child climate vulnerability," "climate risk indices," "pediatric environmental health," and "adaptation metrics."

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Inclusion Criteria:

The study selected documents that: (1) were published in English between 2020 and 2025; (2) focused specifically on children aged 0-18 years; (3) provided quantitative or mixed-methods analysis of climate impacts; and (4) discussed measurement frameworks or policy adaptations.

Analysis Framework:

The collected data underwent a comparative analysis. Existing indices (ND-GAIN, INFORM, Germanwatch) were deconstructed to identify their component indicators and weighting mechanisms. These were then cross-referenced against the child vulnerability factors identified in the literature review (health, education, nutrition, displacement). This gap analysis facilitated the synthesis of a new, proposed set of indicators.

Ethical Considerations and Limitations:

As a desk review utilising publicly available secondary data, ethical approval for human subjects was not required. However, the research adhered to strict data accuracy and attribution standards. Limitations include the reliance on existing literature which may reflect publication bias toward the Global North, and significant data gaps in low-income countries where child climate monitoring systems are weak. Despite these constraints, the methodology provides a robust foundation for proposing a standardised global index.

RESULTS

A. Comparative Analysis of Existing Climate Risk Indices

The comparative analysis of major global climate risk indices reveals a significant divergence between general risk assessment and child-specific reality. Table 1 summarizes the focus, coverage, and limitations of the primary indices reviewed.

Table 1: Comparison of Major Climate Risk Indices

Index Name	Primary Focus	Child-Specific Indicators	Limitations For Child Assessment
ND-GAIN Country Index	National vulnerability & readiness for investment	Minimal (uses general population data)	Focuses on economic readiness; lacks age-disaggregated health or education metrics.
INFORM Risk Index	Humanitarian crisis & disaster management	Limited (some health/nutrition proxies)	Prioritizes acute conflict/disaster; misses chronic developmental impacts like learning loss.
Germanwatch CRI	Economic losses & fatalities from extreme weather	None	Purely retrospective; overlooks non-economic losses crucial to child wellbeing.
UNICEF CCRI	Child exposure & vulnerability	Comprehensive	Pioneering but currently lacks integration into mainstream economic planning tools.

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The analysis indicates that ND-GAIN and INFORM predominantly use population age structure merely as a demographic weight rather than analyzing direct outcomes for children. For instance, a country might score well on "health readiness" based on hospital beds per capita, ignoring that pediatric care capacity is non-existent. The Germanwatch index, by focusing on economic losses, completely renders invisible the "loss and damage" to a child's development, which has no immediate market price. Only the UNICEF CCRI explicitly centres on the child, yet its isolation from broader economic and security indices limits its influence on hard policy decisions. There is a clear temporal mismatch; climate data models look decades ahead, while child health surveillance often looks at immediate retrospective statistics, creating a gap in predictive protection.

B. Multidimensional Climate Impacts on Children: Evidence Synthesis

Synthesizing recent evidence confirms that climate hazards impact children through complex, cascading pathways. The quantitative data extracted paints a stark picture of the current crisis.

Table 2: Climate Hazards and Child-Specific Outcomes (Evidence Synthesis 2020-2025)

Climate Hazard	Health Impact	Education Impact	Nutrition Impact	Key Statistic
Extreme Heat	Heat stress, respiratory distress, vector-borne disease	School closures due to cooling lack; cognitive slowing	Reduced crop yield affecting diet diversity	40% increase in diarrheal disease in children during heatwaves (Harvard, 2025).
Floods & Storms	Injury, waterborne diseases (Cholera), trauma	Infrastructure destruction, use of schools as shelters	Crop destruction, supply chain disruption	242 million children had education disrupted in 2024 (UNICEF, 2025).
Drought	Dehydration, malnutrition complications	Drop-out to fetch water (girls disproportionately)	Stunting, Wasting, Micronutrient deficiency	Rising temperatures linked to slowing early childhood milestones (Lancet, 2025).
Displacement	Loss of continuity of care, vaccination gaps	Total loss of access, language barriers	Dependency on aid, food insecurity	13 million school-age children displaced 2020-2023 (UNICEF).

The evidence synthesis highlights that impacts are rarely isolated. A single flood event not only destroys a school (Education) but contaminates water sources (Health/WASH) and destroys crops (Nutrition), creating a "polycrisis" for the child. The statistic that 242 million children faced education disruption in 2024 is particularly alarming, as it represents a massive loss of future human capital. Furthermore, the correlation between heat exposure and a 40% increase in diarrheal disease underscores the physiological fragility of children.

This world map visualisation in Figure 1 clearly demonstrates extremely High Risk Zones (Dark Red):

1. Sahel Region (West/Central Africa)

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– Chad, Niger, Mali, Burkina Faso, Mauritania, Sudan

– Primary threats: Drought, Food Insecurity

2. South Asia

– India (north and central regions), Pakistan, Bangladesh, Afghanistan

– Primary threats: Extreme Heat, Floods, Cyclones

3. Small Island Developing States (SIDS)

– Caribbean: Haiti, Dominican Republic, small island nations

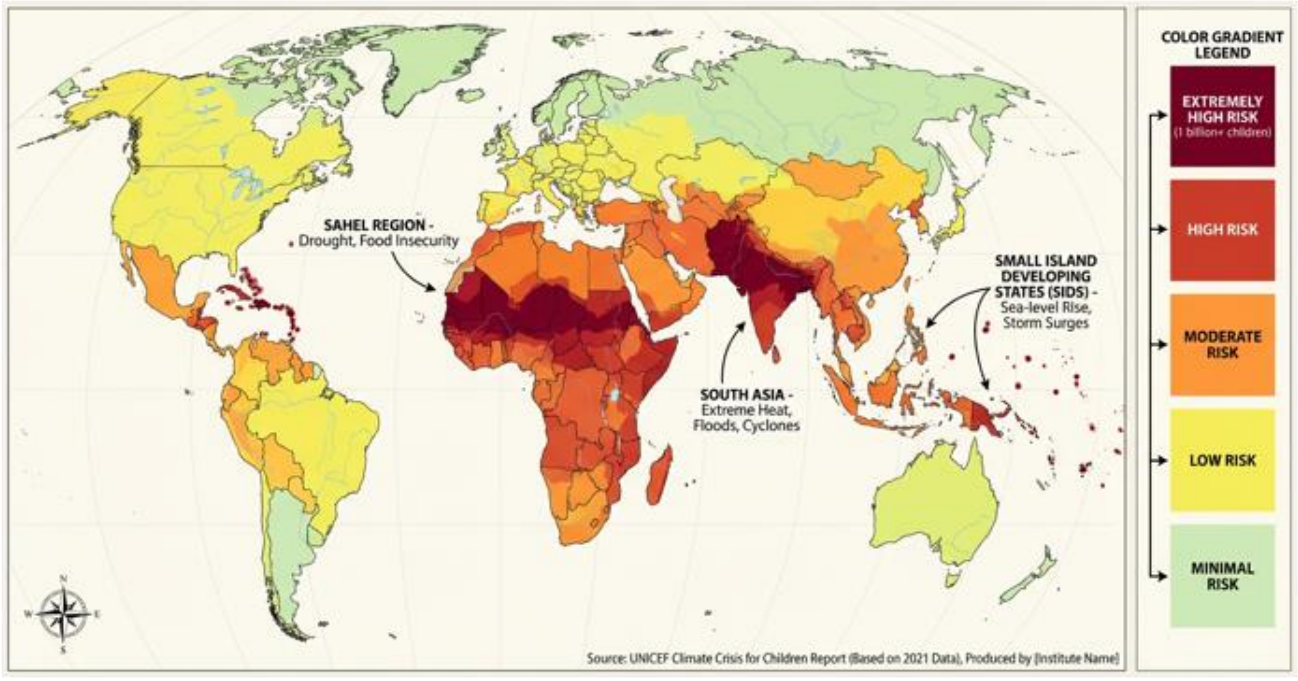
– Pacific: Vanuatu, Kiribati, Tuvalu, Fiji

– Indian Ocean: Maldives, Comoros

– Primary threats: Sea Level Rise, Cyclones

Figure 1 is a heat-map visualisation showing geographical inequality of climate risk exposure among children globally. Extremely high-risk zones (dark red) concentrate in the Sahel region, South Asia (India, Pakistan, Bangladesh, Afghanistan), and Small Island Developing States. The map illustrates that 1 billion children live in 33 countries classified as extremely high risk, with climate hazards including drought, extreme heat, flooding, and sea-level rise.

Figure 1: Global Distribution of Child Climate Vulnerability.



Data sources: UNICEF Children's Climate Risk Index (2021-2025), WHO climate and health indicators.

C. Critical Indicator Gaps in Current Assessments

Based on the gaps identified in current indices and the multidimensional nature of the risks, this study proposes a comprehensive set of indicators necessary for a robust Child-Specific Climate Risk Index. These indicators move beyond generic measures to capture child-centric realities.

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Table 3: Proposed Child-Specific Climate Risk Indicators

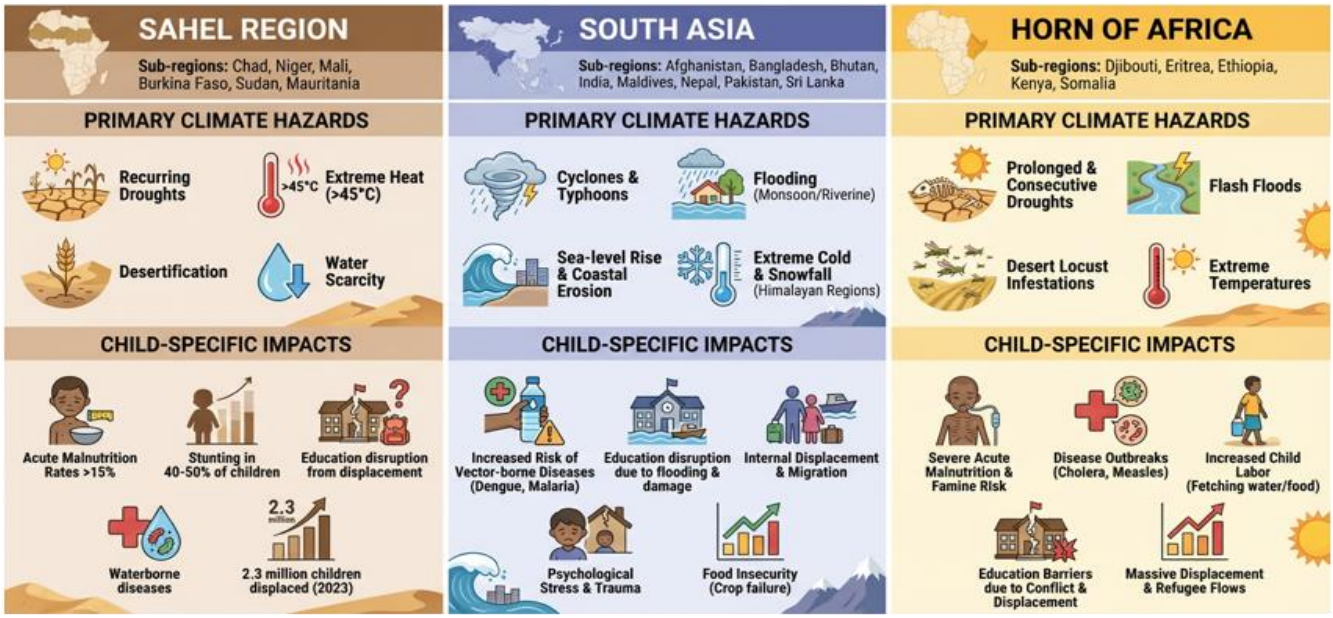
Category	Proposed Indicators	Rationale
1. Exposure	- Frequency of heatwaves >35°C - Flood return periods relative to school locations - PM2.5 concentrations at child height - Drought duration in growing seasons	Captures physical hazards specifically relevant to child physiology and daily routines (e.g., school attendance).
2. Sensitivity	- Under-5 mortality rate - Prevalence of stunting/wasting - Immunization coverage rates - Baseline respiratory disease prevalence	Measures the pre-existing health conditions that make children less able to withstand shocks.
3. Adaptive Capacity	- Child-sensitive social protection coverage - School infrastructure resilience score - Youth participation in climate policy - WASH access in schools and homes	Assesses the specific systems (schools, safety nets) required to support child resilience.

These proposed indicators fill the critical voids identified. For example, measuring "PM2.5 at child height" acknowledges that children breathe closer to the ground where some pollutants settle. Including "School infrastructure resilience" links disaster risk directly to education continuity, a connection missing in indices like ND-GAIN.

D. Regional Case Study Analysis

The application of this lens to specific regions reveals distinct vulnerability profiles.

Figure 2: Regional Vulnerability Profiles: Climate Hazards and Child-Specific Impacts.



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Below is an analysis of primary climate hazards and child-specific impacts across three extremely high-risk regions.

South Asia: The analysis confirms South Asia as a region of compound risk. With over 600 million children exposed, the primary drivers are extreme heat and flooding. The high population density means that even localized hazards affect millions. Air pollution acts as a constant multiplier of health risk.

The Sahel: This region exhibits the highest scores for nutritional insecurity. The convergence of climate change (drought) and conflict creates a unique profile where adaptive capacity is severely eroded. Children here are most at risk of "wasting" and displacement, creating a generation with profound developmental trauma. The Sahel faces drought-driven malnutrition crises with stunting rates of 40-50%.

SIDS (Small Island Developing States): While total child populations are smaller, the risk is existential. The primary indicator here is displacement risk due to sea-level rise and intensifying cyclones. Unlike other regions where adaptation might mean changing crops, for SIDS children, it may mean losing their national identity and citizenship, a psychological burden unmatched elsewhere.

The common vulnerability factor across all regions is inadequate child-critical services (healthcare, education, WASH), which amplifies climate impacts on children's health and development.

DISCUSSION

A. Critical Gaps in Existing Climate Risk Indices

Addressing the first research question, this study argues that mainstream climate indices inadequately capture child vulnerabilities because they were designed for economic and geopolitical stability, not human development. ND-GAIN and Germanwatch view climate risk through the lens of GDP protection and state stability. Consequently, the "quiet" violence of climate change against children such as a gradual increase in malnutrition or a subtle decline in cognitive development due to heat goes unmeasured.

Data availability remains a significant barrier. Many nations do not collect age-disaggregated data on climate impacts. When a disaster strikes, death tolls are often reported in totals, obscuring how many children perished. Methodological biases toward economic metrics incentivize investments in physical infrastructure (roads, bridges) over social infrastructure (schools, pediatric clinics). This confirms the hypothesis that without specific child-sensitive indicators, as referenced in the literature, adaptation planning will continue to exhibit a "blind spot" toward the youngest demographic.

B. Differential Climate Impacts on Children’s Wellbeing

Regarding the second research question, the results demonstrate that climate hazards do not impact children and adults equally. The mechanisms of vulnerability are distinct. In health, the Harvard Center (2025) findings on heat stress illustrate physiological vulnerability; a heatwave that is uncomfortable for an adult can be fatal for an infant. In education, the cascade effects are profound. A destroyed school does not just mean missed classes; it often leads to permanent dropout, early marriage for girls, or entry into hazardous child labour.

Intersectionality plays a crucial role. A disabled child in a flood-prone region of Bangladesh faces exponentially higher risks than a non-disabled peer. Gender norms also dictate vulnerability; in drought-affected areas of the Sahel, girls are often the first to be pulled from school to walk longer distances for water. This differential impact confirms that a "one size fits all" adaptation strategy is fundamentally flawed.

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C. Framework for Comprehensive Child-Specific Climate Risk Index

Addressing the third research question, this paper proposes an integrated framework built on the IPCC's definition of vulnerability: Exposure, Sensitivity, and Adaptive Capacity.

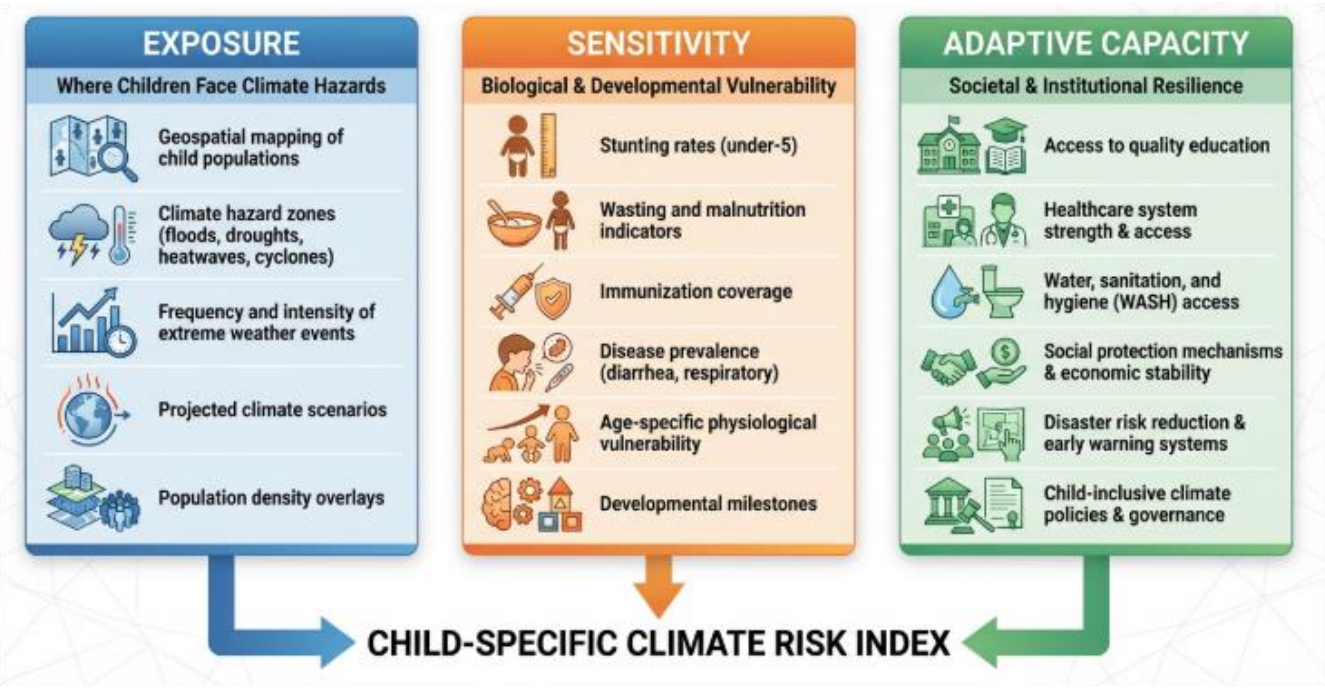
Exposure metrics must move beyond national averages to geospatial mapping of child populations against hazards.

Sensitivity must incorporate biological and developmental indicators like stunting and immunization rates, which serve as proxies for a child's biological reserve.

Adaptive Capacity must be redefined to include "child-critical services." It is not enough that a country has a disaster fund; the question is, does that fund specifically allocate resources for rebuilding schools and restoring nutrition programs?

This proposed framework aligns with recent improvements in the UNICEF CCRI but pushes further by advocating for the inclusion of "future-oriented" indicators, such as projected education loss, rather than just historical data.

Figure 3: Framework for Comprehensive Child-Specific Climate Risk Index



The index integrates three core pillars based on IPCC vulnerability framework: Exposure (geospatial mapping of climate hazards), Sensitivity (biological and developmental vulnerability), and Adaptive Capacity (child-critical services and future-oriented indicators). The integrated risk score calculation advances beyond existing indices by incorporating child-specific metrics and forward-looking projections.

D. Policy Integration and Implementation Pathways

Finally, addressing the fourth research question, the integration of these metrics into policy is paramount. National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) serve as the primary vehicles for climate action. Currently, the ECDAN report (2025) notes that young children are frequently invisible in these documents.

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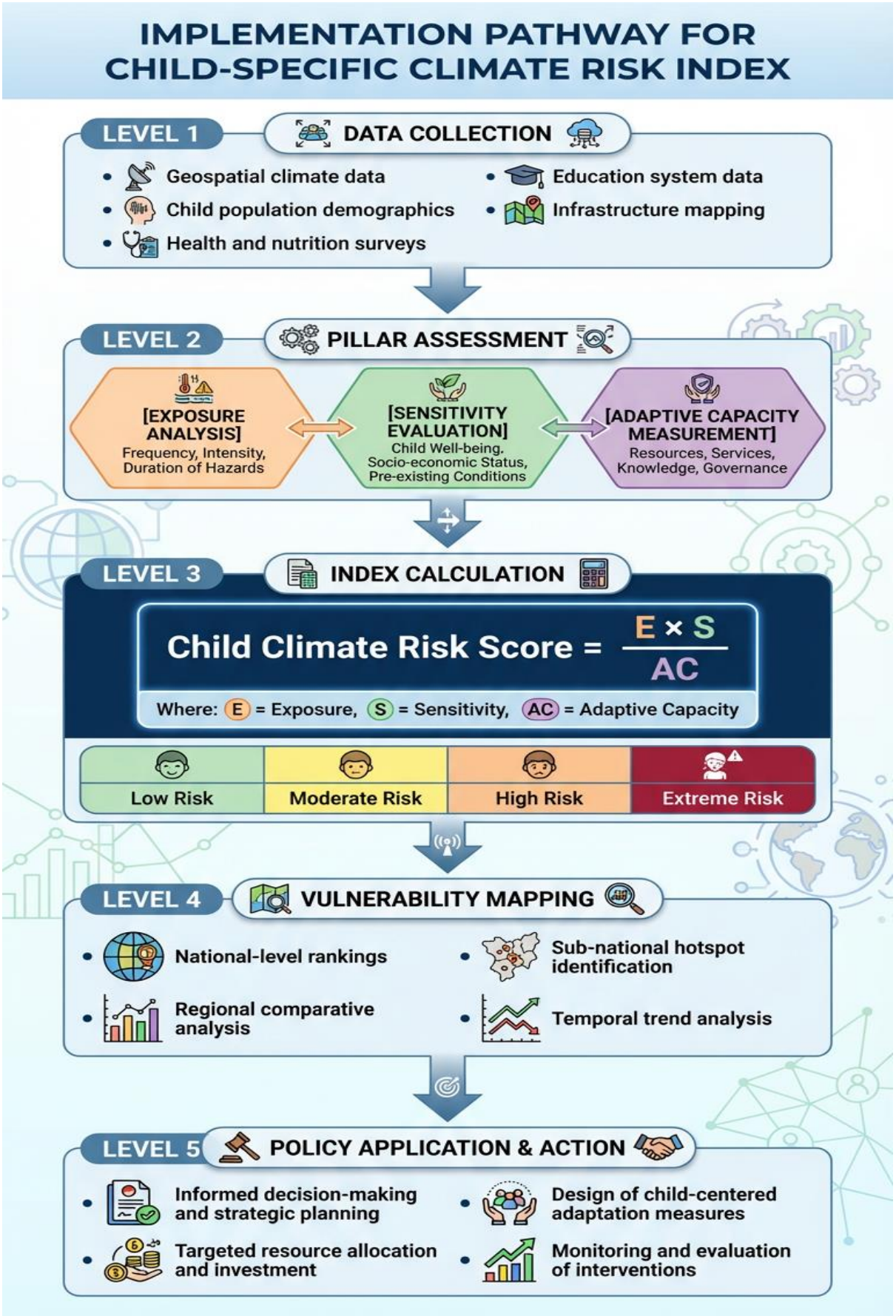
UNICEF and WHO have a critical role in standardizing these metrics. By establishing a global monitoring framework, they can provide the data confidence governments need to invest. Furthermore, child participation is essential.

Figure 4: Implementation Pathway for Child-Specific Climate Risk Index



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Policies designed "for" children often fail; policies designed "with" children, utilizing their unique insights into local risks, are more resilient. Implementation requires breaking silos; Ministries of Health, Education, and Environment must share data to create a holistic view of child risk.

The operational framework in Figure 2 progresses through five stages from data collection to policy integration, emphasizing the translation from geospatial analysis to actionable policy interventions through National Adaptation Plans (NAPs), Nationally Determined Contributions (NDCs), and child protection frameworks

The flowchart in Figure 2 shows the operational application of the framework from data collection to policy integration:

- **Stage 1: Data Collection**: Multi-source data gathering (climate, demographics, health, education)
- **Stage 2: Pillar Assessment:** Parallel evaluation of Exposure, Sensitivity, and Adaptive Capacity
- **Stage 3: Index Calculation:** Formula application with risk categorization (Low → Extreme)
- **Stage 4: Vulnerability Mapping:** National rankings and sub-national hotspot identification
- Stage 5: Policy Integration: Integration into NAPs, NDCs, DRR strategies, and child protection frameworks

RECOMMENDATIONS

To safeguard children in a warming world, governments must immediately integrate the standardised child-specific indicators proposed in this study into their National Adaptation Plans (NAPs) and disaster risk reduction strategies. UNICEF and WHO should collaborate to establish a robust global monitoring framework that mandates age-disaggregated data collection for all climate-related impacts. International climate finance mechanisms, including the Green Climate Fund, must prioritise and track funding specifically for child-focused adaptation interventions in high-risk regions like the Sahel and SIDS. Furthermore, research institutions need to foster deep interdisciplinary collaboration between climate scientists, public health experts, and child development specialists to refine predictive models. Finally, policymakers must institutionalize meaningful child and youth participation in climate governance, ensuring that the voices of those most affected shape the solutions that will define their future.

CONCLUSION

This research has identified a critical and dangerous gap in current global climate risk assessment: the systemic invisibility of children. With over 1 billion children currently facing extreme climate risk, the reliance on generic, economic-focused indices is no longer tenable. This paper contributes a comparative analysis of existing frameworks and proposes a necessary shift toward a multidimensional, child-specific risk index. The findings underscore that the climate crisis is fundamentally a child rights crisis, threatening health, education, and survival. A standardised index is not merely an academic exercise but an imperative tool for survival, guiding targeted intervention where it is needed most. Future research must focus on validating these proposed indicators through regional pilot studies and establishing longitudinal tracking. Safeguarding the next generation requires that we measure what matters, moving from general observation to precise, child-centred action.

ETHICAL CONSIDERATIONS

This research was conducted as a desk review utilizing publicly available secondary data and reports. As such, it did not involve direct interaction with human subjects, and formal ethical approval was not required. The author declares no conflicts of interest.

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Data Availability

All data analysed in this study are derived from publicly available repositories, including UNICEF Data, the World Bank Climate Change Knowledge Portal, and open-access peer-reviewed literature.

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