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PERSPECTIVE
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Environmental Threats to Early Childhood Development: A Perspective Paper on Pollution, Climate Change, and Adverse Urbanization

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ABSTRACT

As environmental challenges such as pollution, climate change, and adverse urbanisation become increasingly integrated into everyday life worldwide, it is crucial to examine their impacts on early childhood development, particularly across neurological, cognitive, mental, physical, educational, and social-emotional dimensions, to protect and sustain future generations. This conceptual perspective paper critically examines the discourse through three primary lenses: (a) a review of findings from contemporary scientific research on the detrimental effects of these environmental challenges on early childhood development; (b) an analysis of the limitations of existing evidenced-based approaches to prevention and/or mitigation, especially regarding their applicability in real-world contexts; and (c) suggestions of novel frameworks to guide future inquiry, such as a community-driven, participatory design. By doing so, this paper contributes to the global knowledge on environmental stewardship, sustainability, and high-quality early childhood development.

Keywords: Early childhood development, pollution, climate change, adverse urbanization, scientific research, sustainability.

INTRODUCTION

Pollution, climate change, and adverse urbanization represent some of the most pervasive threats to health, biodiversity, and ecosystems in the 21st century. These pressing environmental challenges have raised profound concern among leaders, activists, policymakers, and the public alike, prompting urgent calls for sustainable solutions to prevent or mitigate their far-reaching impacts. These calls take on even greater significance in the context of young children who, as of 2023, constitute approximately 27% of the global population, represent the foundation of future civilization and sustainability efforts, and remain among the most vulnerable to environmental and social disruptions (The Global Economy, 2023; UNICEF, 2023; WHO, 2024). According to Meriem et al. (2020), the children most at risk are typically those in the formative period (ages 0 to 6), when rapid brain development and foundational skills in cognition, language, motor function, and socio-emotional regulation are established.

During this formative stage, the cognitive and physical domains are exceptionally vulnerable to environmental hazards, as they undergo the most rapid and critical development (Burke et al., 2018; Cuartas et al., 2024; Perera, 2017). Recognizing that early developmental disruptions can have long-term consequences and may even reverberate across generations, this conceptual perspective paper examines what modern scientific research reveals about the impacts of environmental challenges on children, evaluates the limitations of current prevention and mitigation approaches, and offers suggestions to enrich and expand scientific inquiry globally.

To conceptually ground this discourse, the paper draws on interdisciplinary literature in environmental sustainability and early childhood development. Furthermore, it is anchored in the transformative paradigm, which centres on equity, human rights, and the protection of vulnerable populations. Through these lenses, the paper advocates for research frameworks that are not only developmentally responsive but also ethically grounded and justice-oriented in their treatment of childhood amid environmental threats. The overarching goal is to foster meaningful dialogue around diverse, evidence-based strategies that safeguard both ecological systems and children's well-being.

POLLUTION

Pollution, which dates back to early human civilization and the Industrial Revolution, refers to introducing harmful substances from various sources into the environment (air, soil, and water) through natural processes or human activities. Pollutants, especially particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2), ground-level ozone (O3), carbon monoxide (CO), sulfur dioxide (SO2), and lead (Pb), have been associated with significant health effects, including cardiovascular, pulmonary, and neurological disorders in children (Fonderson et al., 2024; Meo et al., 2024). In a study by Herting et al. (2024), ambient air pollutants are linked to deficiencies in children's developing brains and increase the risk for cognitive and overall health problems later in life. Furthermore, these pollutants reduce IQ, exacerbate mental health issues (e.g., anxiety, depression, psychotic experiences), lead to concurrent behavioral problems (e.g., inattention), increase the risk of autism spectrum disorder (ASD), and cause differences in cortical thickness of frontal, parietal, cingulate, and temporal regions of the brain.

Perhaps more disturbingly, the putative effects of air pollution may have a delayed onset, meaning there may be no immediate behavioral indicators detectable through neuroimaging, which can delay early diagnosis (Herting et al., 2024). These diagnostic delays can compromise early intervention in various ways, including missed opportunities during critical periods of neuroplasticity, decreased effectiveness of interventions, and impaired attainment of developmental milestones or adaptive functioning (Bora, 2017; Okoye et al., 2023). Figure 1 illustrates the various pathways through which environmental pollutants affect children's health and developmental outcomes.

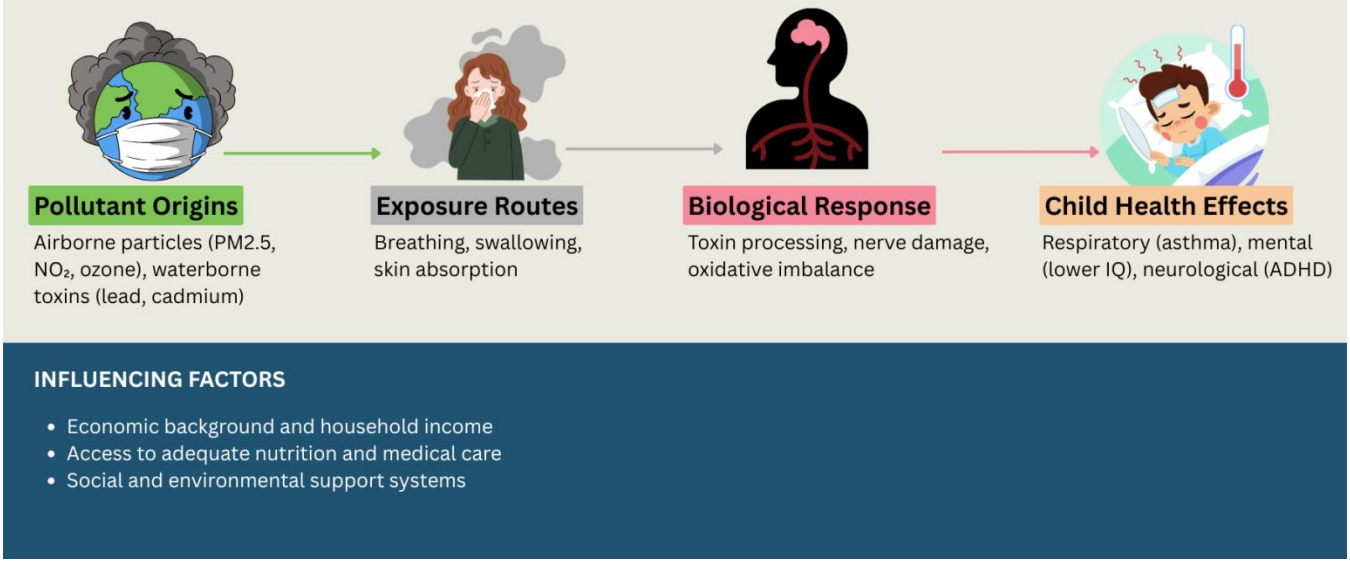

Figure 1: Pollutant–Child Outcome Pathways

In light of these adverse effects, Herting et al. (2024) recommend behavioral changes and environmental regulations as enduring and effective strategies to prevent and reduce the impact of air pollution on children. Additionally, they advocate for non-invasive approaches, such as MRI, to identify biomarker targets and guide early intervention. While these strategies are forward-thinking and plausible means of prevention and reduction, they raise significant concerns that cannot be overlooked. Firstly, environmental regulations, in reality, often meet challenges such as resistance from industries and other stakeholders, economic costs, difficulties in policy coordination, and implementation issues. The European Union's (EU) 2024 Methane Regulation illustrates these challenges, particularly industrial resistance. Methane has an atmospheric lifetime of 9 to 12 years and is over 80 times more potent than carbon dioxide at trapping heat for 20 years (National Academies of Sciences, Engineering, and Medicine, 2024). While not directly toxic, methane significantly degrades air quality by driving the formation of ground-level ozone, a major component of smog and a well-documented respiratory irritant (Anenberg et al., 2012).

Recognizing these threats, the EU developed the Methane Regulation to curb emissions from the energy sector through mandatory measurement, reporting, and verification (MRV) protocols designed to detect and prevent leaks from fossil fuel companies operating within the EU (European Commission, 2024). These reductions are expected to improve air quality by lowering ozone and particulate matter levels, thereby keeping global warming below 1.5°C and enhancing long-term climate mitigation efforts (UNEP & Climate and Clean Air Coalition, 2021). Under these positive environmental conditions, the risk of childhood premature death, illness, and respiratory disorders will significantly decrease (Perera & Lau, 2024).

Despite the clear benefits and significance of the EU's Methane Regulation, industry stakeholders argue that it may lead to higher operational costs, reduce profitability, and create logistical challenges, particularly for smaller energy companies. Additionally, they raised questions about the practicality of enforcing such regulations across the EU's diverse and complex energy landscape, including consistently monitoring methane emissions across various production sites (Nguyen, 2025; Mohlin, 2025). The EU's 2024 Methane Regulation highlights the real-life complexities of implementing environmental regulations as preventive measures.

Unlike regulatory approaches that often encounter industry resistance and require significant enforcement costs, behavioral change involves individual and collective responsibility, making it more adaptable and less resource-intensive. However, these approaches also face challenges. McCarron et al. (2024) note that the “invisible” nature of pollutants often leaves individuals unaware of their exposure, complicating efforts to drive widespread behavioral shifts. This lack of visibility explains why consumer demand remains high and the fast fashion industry continues to thrive, despite its well-documented environmental harms. For instance, the United Nations Environment Programme (UNEP, 2022) found that the fast fashion sector accounts for approximately 10% of global carbon emissions and contributes significantly to water pollution. These consequences are not abstract, as children living near textile manufacturing hubs in countries such as Bangladesh and China have been reported to face high exposure to contaminated water and air (Johnson, 2024; Regan, 2020). Buteau et al. (2020) confirm the debilitating effects of residential exposure to industrial $PM_{2.5}$, NO_2, and SO_2, showing a 19–23% increased onset of childhood asthma. Likewise, Uddin and Bin Alam (2023) highlight how surface waters containing hazardous levels of heavy metals, such as lead, cadmium, iron, magnesium, and chromium, pose serious ingestion-related health risks for children near industrial zones in Bangladesh.

Conversely, advanced imaging techniques like MRI in childhood diagnostics raise concerns about psychological stress and, in some cases, cumulative radiation exposure. In a study assessing the psychological impact of MRI environments on children aged 2 to 7, Malisza et al. (2010) found that only 53% of participants were initially willing to undergo MRI scans. However, nearly half of the sessions ended prematurely due to claustrophobia, fear, and anxiety. Meanwhile, the ionizing radiation from diagnostic imaging, though critical for detecting and managing health conditions, is particularly concerning in early childhood due to children's heightened sensitivity to radiation and their increased risk of developing cancer later in life (Abalo et al., 2020; Jain, 2021). Collectively, these findings underscore the importance of weighing the benefits of early, non-invasive diagnostic approaches against their potential long-term health implications.

CLIMATE CHANGE

Pollution, particularly the increased concentration of anthropogenic greenhouse gas emissions, is unprecedentedly changing the climate. These climate changes range from rising global surface temperatures that cause heatwaves and extreme weather events (e.g., heavy precipitation, droughts, tropical cyclones, and wildfires) to ecosystem shifts and sea-level rise (Helldén et al., 2021). The 2023 global climate illustrates this trend, marking the warmest year in modern history and bringing widespread harm to both human and natural systems, with grave implications for children's health, development, and life expectancy (National Academies of Sciences, Engineering, and Medicine, 2024). Oh et al. (2024) observe that exposure to summer heatwaves specifically increases the risk of hospitalization for heat-related illnesses among children under five. Meanwhile, Helldén et al. (2021) report that both rapid and delayed-onset extreme weather events, such as storms and flooding, increase morbidity and mortality in children. Both findings share a central message: children are disproportionately at risk.

However, unlike pollution, a limited body of research focuses exclusively on the relationship between climate change and children's health, which restricts the availability of identifiable solutions for prevention and reduction. This lack of substantial research is paradoxical and striking, given the evident and alarming implications of climate change for children. Nonetheless, Vieira et al. (2023) suggest that behavioral change, similar to addressing pollution, is a strategy for combating climate change and protecting children.

However, Vieira et al. (2023) further explain that psychological barriers, such as perceiving change as unnecessary, conflicting goals, interpersonal relationships, a lack of knowledge, and tokenism, often moderate the relationship between environmental attitudes and climate action. These psychological barriers result in a significant gap between people's stated concern for the environment and their actual engagement in pro-environmental behaviors. East Africa, where economies heavily require climate-sensitive initiatives, clearly illustrates Vieira et al.'s (2023) claim. East African countries, though increasingly integrating climate change into their education curricula in response to growing global awareness, face significant challenges in knowledge dissemination. These include defining the educator's role, addressing misconceptions, managing the interdisciplinary nature of the subject, and ensuring a comprehensive understanding of climate change education, all of which complicate progress (Apollo & Mbah, 2021).

ADVERSE URBANIZATION

Adverse urbanization, identified as the third environmental challenge in this conceptual perspective paper, is significantly reducing the quality of early childhood development and experiences. This paper introduces adverse urbanization as an umbrella term to capture the harmful and inequitable outcomes that emerge from both urbanization and urban redevelopment. It also accounts for negative consequences stemming from deliberate policy decisions, systemic neglect, or exploitative practices. The outcomes range from, but are by no means limited to, informal settlements, displacement, environmental degradation, and the collapse or inaccessibility of essential infrastructure. Accordingly, this conceptual paper proposes the following operational definition: 'Adverse urbanization refers to the harmful and inequitable outcomes that emerge from both urbanization and urban redevelopment, including poor planning and policy decisions, systemic neglect, and exploitative practices.'

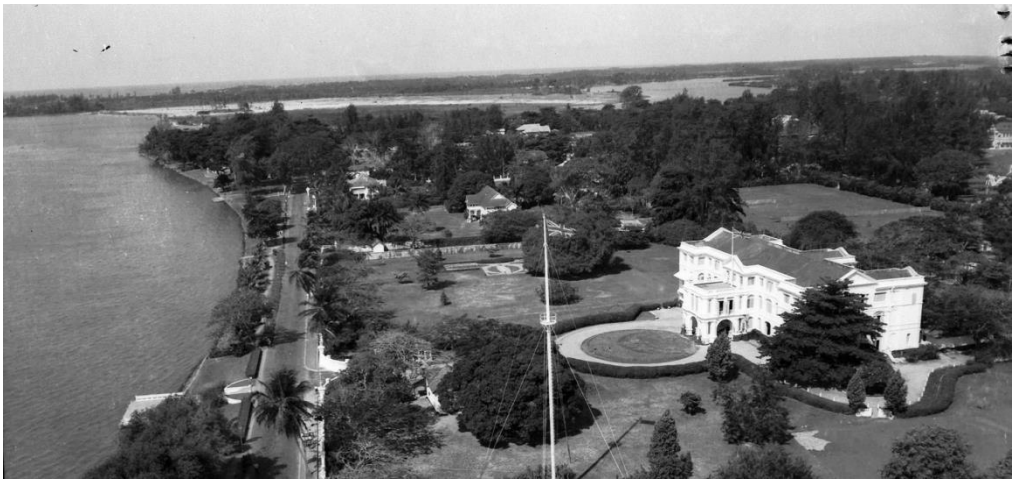

Figure 2: Historical panoramic view of Lagos Island, Nigeria. Source: The Centenary Project (n.d.)

Figure 3: Contemporary panoramic view of Lagos Island, Nigeria. Source: Pen Global (2024)

The depth and presence of adverse urbanization become evident when comparing contemporary urban landscapes with historical aerial photography. As illustrated by Figures 2 and 3, there is a significant shift from green, child-friendly, communal environments to increasingly congested, inaccessible, and fragmented urban spaces globally. There are several ways these changes reduce the quality of early childhood development. One way is by limiting access to green, natural open spaces that support essential developmental activities, such as running, exploring, and playing with peers. Such spaces are not only becoming increasingly rare today but are also being replaced by commercial alternatives, like theme parks, laser tag arenas, and arcade centres. Edmonton, Alberta's sharp decline in vegetation and its exponential growth in amusement park revenues clearly illustrate this shift.

Between 1999 and 2020, Edmonton experienced a 15% decline in vegetation cover (Budde et al., 2024). In between, Fort Edmonton Park underwent a significant expansion, projected in 2017 at CAD 165 million and completed between 2018 and 2021, with new attractions including a roller coaster, a maze, and a revue theatre. The goal was to enhance recreational opportunities for children and youth (Kaspersetz, 2025; Mertz, 2017). While these commercial alternatives are not inherently harmful, they reflect a troubling schema: the initial loss of natural spaces pushes families toward commercial recreation, and in meeting that growing demand, more natural environments are cleared to expand such venues. It is a counterintuitive cycle of lost natural spaces, increased commercial and recreational venues, and further loss of natural spaces.

According to Gemmell et al. (2022), natural play spaces are essential for children's development, and children are inherently motivated to engage in activities within these environments. Participation in such activities shapes neural connections, builds brain architecture, and fosters critical life skills that contribute to long-term well-being and health. Furthermore, exposure to nature is linked to improved cognitive and social development, as well as reduced behavioral problems (Gemmell et al., 2022). Despite these benefits of nature exposure, many children continue to live in densely populated urban areas characterized by narrow streets, overwhelming crowds, and constant sensory overload. Statistically, hundreds of millions of children around the globe dwell in overcrowded and risk-prone urban slums or informal settlements as of 2022 (Cho, 2025). This growing disconnect between urban children and natural systems has profound implications for their present and future well-being (Watchman et al., 2020). Even more concerning, the likelihood of meaningful change remains uncertain, as the United Nations predicts that by 2050, approximately 68% of the world's population will reside in urban areas.

Another way adverse urbanization reduces the quality of childhood development is by increasing children's vulnerability to climate-related risks, particularly through the intensification of urban heat islands (UHIs). UHI refers to

the phenomenon where urban areas experience significantly higher temperatures compared to the nearby or surrounding rural areas (Budde et al., 2024). This increased temperature results in diminished educational attainment and developmental outcomes, particularly for children exposed to extreme heat during early childhood in tropical urban regions (Randell & Grey, 2019). This vulnerability also extends to social scenarios such as gentrification (Oscilowicz et al., 2020). Gentrification, in this context, refers to situations in which urban redevelopment displaces marginalized communities, thereby reinforcing spatial inequalities. Wood et al. (2023) found significant associations between neighborhood poverty, gentrification, and increased depressive symptoms among children aged 3–17 in the United States, with mental health effects that may develop gradually over time.

Complementing Wood et al. (2023), Rick et al. (2022) found that children in rapidly gentrifying New York neighborhoods faced greater exposure to fast-food outlets and reduced supermarket access, leading to higher body mass index (BMI) and obesity risk, particularly among boys. In Detroit, gentrification-driven construction, demolitions, and traffic worsened air quality in newly transformed areas, increasing children's respiratory risks (Hutchings et al., 2023).

Presently, sustainable urban development (SUD) is a scientific research framework designed to address the adverse impacts of urbanization. SUD emphasizes integrated urban planning, infrastructure investment, affordable housing, sustainable transportation, and the inclusion of marginalized communities to promote convenient, livable environments (Samadkulov, 2024). These broad priorities are further broken down into actionable components. For example, urban planning addresses land use, transit, streetscapes, and public services to support compact, mixed-use, and walkable cities (Samadkulov, 2024). Over the years, SUD research has informed and inspired real-world applications, such as biophilic cities and architecture. The term biophilia describes humans' innate affinity for nature and has been integrated into various environmental design patterns, including commercial, healthcare, and urban planning (Verma, 2023). Many Asian cities are rapidly embracing biophilic design, particularly Singapore, whose architecture integrates green corridors, rooftop gardens, and biodiversity conservation into urban living. This integration aims to enhance ecological resilience, improve air quality, and support overall well-being.

More recently, biophilic architecture and design have gained traction in urban schools, premised on the understanding that children spend a significant portion of their time in school and benefit from contact with nature for attention restoration and stress recovery (Watchman et al., 2020). Researchers in sustainable design and architecture outline 71 principles to guide the qualities and conditions of integrating nature into built environments, serving as a key reference for biophilic school design. Yet, as Watchman et al. (2020) note, these principles largely emphasize the subjective experience of space, focusing on a feeling of nature rather than its developmental impact. While this emphasis may appear unproblematic at first glance, it raises concerns when examined through the lens of childhood development, nature, and the role of school. To better understand these concerns, it is useful to reference early childhood theories.

Earlier theorists such as those behind the Reggio Emilia approach, Friedrich Fröbel, and Maria Montessori emphasize the environment as a "third teacher," suggesting that its role is not merely visual but deeply experiential. It requires meaningful, hands-on engagement to support children's development effectively. These theorists, though differing in approach, collectively emphasize the importance of natural spaces for fostering curiosity, sensory exploration, and motor development. In today's context, where urban development increasingly encroaches on green spaces, the intentional integration of nature into built environments becomes not only relevant but essential to uphold the developmental benefits these theorists envisioned.

However, the challenge arises when the notion of "feeling" nature that underpins biophilic architecture stems from an adult-centric lens. This lens prioritizes relaxation, meditation, or the appreciation of aesthetic views. While children certainly benefit from and enjoy such experiences, their developmental needs extend beyond a passive presence in nature. Children do not merely need to feel nature; they need to engage with it actively through embodied interactions that stimulate their senses and support developmental milestones. The absence of these child-specific considerations in biophilic design highlights a critical blind spot in literature: the SUD framework is largely adult-centric rather than child-informed.

Thus far, this conceptual perspective paper has reviewed the current scientific understanding of how pollution, climate change, and adverse urbanization impact early childhood development, alongside existing prevention and mitigation strategies. From this broad overview, three critical issues emerge: (a) a knowledge gap surrounding identifiable, innovative solutions that address climate change's impact on children; (b) practical limitations of existing interventions, such as psychological barriers and the invisibility of environmental threats that restrict behavior change, industrial resistance to regulatory measures, and health risks associated with diagnostic imaging; and (c) a notable lack of inclusive, child-informed research frameworks to effectively address the challenges posed by adverse urbanization. See Appendix A for detailed information on key issues, barriers, research needs, and the developmental domains most impacted by each threat.

It is important to acknowledge that existing solutions have demonstrated successes and should not be dismissed. However, their limitations raise critical questions that warrant further insight. In order to contribute to a robust scientific knowledge base that not only enhances young children's quality of life but also responds to broader environmental challenges, the second half of this paper explores the question: What insights can enrich future scientific research?

PERSPECTIVES

Indigenous Knowledge Systems: A Platform for Cross-Cultural, Transborder, and Transgenerational Scientific Research

Knowledge is power. This well-known quote holds particular weight in the global fight against environmental degradation, where progress depends not only on scientific data but also on the open sharing of information and a strong sense of collective responsibility. For decades, scientific inquiry into environmental issues has generated knowledge that informs individuals, civil society, and high-level policy agendas. This information has been especially influential in shaping social responses to public challenges because relevant stakeholders perceive it as not only credible but also salient and legitimate. In this context, credibility refers to the scientific adequacy of the technical evidence and arguments. Salience speaks to the relevance of the assessment to the needs of decision-makers. Legitimacy reflects the perception that the process of producing information and technology has respected stakeholders' diverse values and beliefs, remained unbiased in its approach, and fairly treated opposing views and interests.

However, the very process that gives scientific knowledge its power (rigorous evidence, peer review, and technical validation) has also contributed to the marginalization of other knowledge systems, particularly Indigenous knowledge. Indigenous Knowledge Systems (IKS) are rooted in centuries of lived experience, ecological stewardship, and cultural wisdom. Yet, they are frequently dismissed or undervalued because they do not conform to Western scientific standards of inquiry. For instance, in Africa and other parts of the Global South, where colonialism was accompanied by European nationalism, knowledge systems that communities had relied on for generations were unilaterally declared unfit, irrelevant, primitive, or even evil (Odora Hoppers, 2021). This epistemic hierarchy marginalizes not only Indigenous contributions but also obscures diverse ways of addressing complex environmental challenges.

Therefore, there is a pressing need to shift the narrative by recognizing and valuing the wisdom embedded in IKS. IKS possesses rich ecological knowledge, such as agroforestry, accumulated through centuries of close interaction with the environment. Agroforestry (combining trees and shrubs with crop and animal farming) has been shown to improve soil health, reduce erosion, and increase carbon sequestration, thereby contributing significantly to climate and ecosystem resilience (Dhyani et al., 2021). The benefits of this farming practice to children's well-being and development unfold across multiple dimensions—nutritionally, by enhancing access to food security and diverse, nutrient-rich foods (Montagnini & Metzel, 2024); economically, by supporting family income that can be directed toward healthcare and education (Sow et al., 2024); and environmentally, by fostering healthier, greener living conditions that reduce exposure to climate stressors (Blaser et al., 2018).

The depth and richness of ecological knowledge systems underscore the urgent need for modern scientific research to prioritize cross-cultural, transgenerational, and transborder collaborations. Such collaborations offer a prudent pathway to uncovering a broader range of sustainable solutions and bridging longstanding knowledge gaps.

Furthermore, they move researchers beyond narrow paradigms and foster the co-creation of more equitable, inclusive, and sustainable responses to global environmental challenges, protecting children in the process.

Participatory Research and Co-Design: Behavioral Inertia and Industrial Resistance

Behavioral inertia remains one of the biggest challenges in tackling environmental and social issues. It undermines the efforts of advocacy programs in advancing pro-environmental practices that protect and support young children. As Vieira et al. (2023) note, behavioral inertia is caused by psychological barriers, which include perceptions that change is unnecessary, conflicting goals, interpersonal relationship issues, a lack of knowledge, and tokenism. However, many of these barriers are not inherent; they are influenced by external factors such as inconsistent behavior within institutions, miscommunication among stakeholders, limited community engagement, low literacy levels, and a lack of cultural relevance in top-down interventions, to mention a few.

Similarly, industrial resistance to environmental regulations complicates pro-environmental practices. This resistance stems from broader systemic issues such as economic constraints, fragmented governance, and limited institutional support. Mokhtar et al. (2024) found that key obstacles to industry's adherence to environmental regulations ranged from high compliance costs, employee attitudes, technological limitations, insufficient management support, public complaints, to jurisdictional conflicts. These obstacles demonstrate how broader systemic issues interplay with individual and organizational behaviors. Both behavioral inertia and industrial resistance have led organizations like UNICEF to call for reforms in Social and Behavior Change (SBC) strategies to promote positive behaviors and embed child-centered practices into daily life (UNICEF, 2022). One way scientific research can respond to this call is by leveraging research methodologies that foster industrial and community engagement, such as participatory action research and co-design.

Participatory Action Research (PAR) is particularly promising because it shifts research participants from passive subjects to active co-investigators. Defined as a systematic inquiry conducted in direct collaboration with those affected by the issue being studied, PAR is an emerging methodology that aims to foster tangible action or change. In this approach, individuals do not need to be formally trained in research as long as they belong to, or represent, the communities at the center of inquiry (Vaughn & Jacquez, 2020). PAR is especially effective in addressing behavioral inertia, as it democratically engages individuals throughout the research process. This engagement fosters understanding, builds ownership, and increases trust, making affected communities more likely to adopt and practice pro-environmental behaviors that protect children.

A recent PAR study by Gustafson (2020) demonstrates how this approach can be mobilized to address environmental injustice in urban spaces. The project engaged undergraduate students and residents in mapping and analyzing air pollution in Manchester. While children were not direct participants, the study focuses on their social and biophysical exposure to toxic and illegal levels of urban air pollution, allowing for a prioritization of their well-being in urban political ecology (UPE). Gustafson's (2020) participatory study highlights how participatory approaches can engage and empower marginalized groups in advocating for environmental justice.

Co-design, on the other hand, is an innovation-focused research method that can support industries in adhering to environmental regulations rather than resisting them. The term describes the organizing of open innovation processes where individuals from various organizations share and combine ideas and knowledge, as well as involve users or customers as participants in the design process (Steen, 2013). This creative, collective, and stakeholder-driven approach can address industrial resistance by fostering shared ownership, reducing friction in decision-making, and opening pathways for sustainable solutions to environmental threats affecting children, such as pollution.

Meath et al.'s (2022) study is a compelling example of co-design as a methodological approach to addressing industrial resistance. The study employed a co-design platform, Infrastructure CoLab, to support the infrastructure industry's transition to a Circular Economy (CE). This model replaces the traditional linear "take-make-dispose" system by minimizing disposal. The CoLab initiative directly responded to the challenges faced by the infrastructure sector by involving stakeholders across micro (product), meso (industry), and macro (urban planning) levels. This participatory structure enabled stakeholders not only to identify and address barriers to implementation but also to build a shared

understanding of the drivers and enablers of CE. The success of Infrastructure CoLab demonstrates that co-design is more than creative collaboration—it is a rigorous, strategic method for overcoming industrial resistance to environmental regulations, which in turn enhances children's well-being.

Finally, scientific research can facilitate behavior change by simplifying its outputs for readability and practical application, particularly in low-literacy settings. Tools such as infographics and visual summaries can make complex findings more accessible and engaging, enabling communities to understand key messages better. These tools are especially critical as Balaj's (2021) study shows that children whose mothers have no formal education are nearly three times more likely to die before age five than those whose mothers completed secondary education. By prioritizing clarity and visual communication, researchers can increase the likelihood of sustained behavioral change while ensuring that high-impact findings reach and benefit a broader audience.

Child-informed Urban Designs: Reframing Research on Sustainable Urban Redevelopment

Children experience environmental pollution, climate change, and adverse urbanization more severely than adults. Hence, there is a need to reframe sustainability research, especially on urban design, to better respond to children's developmental needs and overall well-being. Thus far, urban design has addressed children's needs through biophilic design guidelines, which specify elements such as materials, lighting, vistas, visual connection, sensory variability, etc. (Watchman et al., 2020). However, since children engage with their environments more through interaction and embodied experience than through passive visual perception, it is important not just to include aesthetic features but to make sure these features encourage active exploration.

To achieve this, scientific research can employ participatory methods to capture how children move, play, and make sense of their world. Capturing their views is essential, as children are competent users of urban space, engaging with it according to their values and desires (Cho, 2025). Thus, their inclusion in research is not merely symbolic or methodological; it is ethically essential.

According to Cho (2025), photovoice is a powerful participatory methodology for incorporating children's perspectives. Rooted in PAR and photojournalism, photovoice allows community members to express their most pressing strengths and concerns, reflect on issues through photographs and dialogue, and ultimately inspire policy change. When applied specifically with children, Photovoice reveals a distinctive spatial and experiential knowledge that not only challenges adult-centric narratives but also provides grounded insights for more equitable and child-responsive urban planning.

A compelling example of photovoice's power in revealing children's unique spatial experiences comes from Nguyen and Vellanki's (2022) image-based study involving two-to-five-year-olds. Unlike mainstream photographic representations shaped by dominant adult perspectives, such as iconic images of New York City's Times Square or the Statue of Liberty, children's photographs capture embodied, lived experiences within their local environments. Nguyen and Vellanki's (2022) work highlights how children's images create "new versions of place" that decenter adult-centric views and illuminate children's relationships with both human and more-than-human worlds. Beyond that, it demonstrates that children and adults perceive the world differently and thus cannot be subsumed under urban design principles that prioritize aesthetics over lived experience.

CONCLUSION

Environmental challenges such as pollution, climate change, and adverse urbanization significantly affect children's health and well-being. Scientific research proposes and emphasizes regulatory measures, behavior change, and advanced diagnostic systems to address these threats; however, real-world implementation often poses challenges. These challenges range from regulatory resistance, behavioral inertia to long-term health risks for children. However, embracing cross-cultural, transgenerational, and transborder knowledge systems fosters inclusive, innovative, resilient, and scientifically robust solutions. Additionally, participatory research methodologies such as PAR, codesigning, and photovoice encourage contextually grounded, ethically responsive, and practically implementable strategies that not only encourage pro-environmental behaviors but also protect children.

POLICY CONSIDERATION

Children are among the most vulnerable to the impacts of climate change, pollution, and adverse urbanization, yet current policy frameworks often subsume their specific needs under broader population-based strategies. To address this oversight, policymakers must prioritize child-centered policies, invest in targeted interventions, strengthen social protection systems, and ensure that planning explicitly includes children's health, education, and overall well-being.

CONFLICTS OF INTEREST

The author declares no conflict of interest

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REFERENCES

Abalo, K. D., Rage, E., Leuraud, K., Richardson, D. B., Le Pointe, H. D., Laurier, D., & Bernier, M.-O. (2020). Early life ionizing radiation exposure and cancer risks: systematic review and meta-analysis. *Pediatric Radioflogy*, *51*(1), 45–56. https://doi.org/10.1007/s00247-020-04803-0

Anenberg, S. C., Schwartz, J., Shindell, D., Amann, M., Faluvegi, G., Klimont, Z., Janssens-Maenhout, G., Pozzoli, L., Van Dingenen, R., Vignati, E., Emberson, L., Muller, N. Z., West, J. J., Williams, M., Demkine, V., Hicks, W. K., Kuylenstierna, J., Raes, F., & Ramanathan, V. (2012). Global Air Quality and Health Co-benefits of Mitigating Near-Term Climate Change through Methane and Black Carbon Emission Controls. *Environmental Health Perspectives*, *120*(6), 831–839. https://doi.org/10.1289/ehp.1104301

Apollo, A., & Mbah, M. F. (2021). Challenges and Opportunities for Climate Change Education (CCE) in East Africa: A Critical Review. *Climate*, *9*(6), 93. https://doi.org/10.3390/cli9060093

Balaj, M. (2021). Parental education and inequalities in child mortality: a global systematic review and meta-analysis. *The Lancet*, *398*(10300), 608–620. https://doi.org/10.1016/S0140-6736(21)00534-1

Blaser, W. J., Oppong, J., Hart, S. P., Landolt, J., Yeboah, E., & Six, J. (2018). Climate-smart sustainable agriculture in low-to-intermediate shade agroforests. *Nature Sustainability*, *1*(5), 234–239. https://doi.org/10.1038/s41893-018-0062-8

Bora, E. (2017). A neurodevelopment and neuroplasticity-based framework for early intervention in psychotic disorders. *Psychological Medicine*, *48*(3), 353–361. https://doi.org/10.1017/s0033291717002045

Budde, S., Agrawal, S., & Welegedara, N. (2024). Seasonal Land Surface Temperatures of Local Climate Zones in a High-Latitude City in Canada. *Available at SSRN 4974795*. https://doi.org/10.2139/ssrn.4974795

Burke, S. E. L., Sanson, A. V., & Van Hoorn, J. (2018). The psychological effects of climate change on children. *Current Psychiatry Reports*, *20*(5). https://doi.org/10.1007/s11920-018-0896-9

Buteau, S., Shekarrizfard, M., Hatzopolou, M., Gamache, P., Liu, L., & Smargiassi, A. (2020). Air pollution from industries and asthma onset in childhood: A population-based birth cohort study using dispersion modeling. *Environmental Research*, *185*, 109180. https://doi.org/10.1016/j.envres.2020.109180

Cho, I. (2025). Exploring Urban Slum Education Through Photovoice With Children: Concepts and Techniques for Research. *Journal of Participatory Research Methods*, *6*(1). https://doi.org/10.35844/001c.127533

Cuartas, J., McCoy, D. C., Torres, I., Burghardt, L., Shonkoff, J. P., & Yoshikawa, H. (2024). The developmental consequences of early exposure to climate change-related risks. *Child Development Perspectives*. https://doi.org/10.1111/cdep.12503

Dhyani, S., Murthy, I. K., Kadaverugu, R., Dasgupta, R., Kumar, M., & Adesh Gadpayle, K. (2021). Agroforestry to Achieve Global Climate Adaptation and Mitigation Targets: Are South Asian Countries Sufficiently Prepared? *Forests*, *12*(3), 303. https://doi.org/10.3390/f12030303

European Commission. (2024). *Methane emissions - European Commission*. Energy.ec.europa.eu. https://energy.ec.europa.eu/topics/carbon-management-and-fossil-fuels/methane-emissions_en

Fonderson, M. S., Meel, E. R. van, Bindels, P., Bohnen, A., Burdorf, A., & Schepper, E. de. (2024). Air pollution and childhood respiratory consultations in primary care: a systematic review. *Archives of Disease in Childhood*. https://doi.org/10.1136/archdischild-2023-326368

Gemmell, E., Ramsden, R., Brussoni, M., & Brauer, M. (2022). Influence of Neighborhood Built Environments on the Outdoor Free Play of Young Children: a Systematic, Mixed-Studies Review and Thematic Synthesis. *Journal of Urban Health*, *100*(1), 118–150. https://doi.org/10.1007/s11524-022-00696-6

Gustafson, S. (2020). Children breathe their own air: Reflections on children's geographies, the urban political ecology of air pollution, and ongoing participatory action research with undergraduates near an east London primary school. *Area*. https://doi.org/10.1111/area.12663

Helldén, D., Andersson, C., Nilsson, M., Ebi, K. L., Friberg, P., & Alfvén, T. (2021). Climate change and child health: a scoping review and an expanded conceptual framework. *The Lancet Planetary Health*, *5*(3), e164–e175. https://doi.org/10.1016/s2542-5196(20)30274-6

Herting, M. M., Bottenhorn, K. L., & Cotter, D. L. (2024). Outdoor air pollution and brain development in childhood and adolescence. *Trends in Neurosciences*, *47*(8). https://doi.org/10.1016/j.tins.2024.06.008

Hutchings, H., Zhang, Q., Grady, S., Mabe, L., & Okereke, I. C. (2023). Gentrification and Air Quality in a Large Urban County in the United States. *International Journal of Environmental Research and Public Health*, *20*(6), 4762–4762. https://doi.org/10.3390/ijerph20064762

Jain, S. (2021). Radiation in medical practice & health effects of radiation: Rationale, risks, and rewards. *Journal of Family Medicine and Primary Care*, *10*(4), 1520. https://doi.org/10.4103/jfmpc.jfmpc_2292_20

Johnson, S. (2024, May 29). *Alarming levels of "forever chemicals" found in water near Bangladesh garment factories*. *The Guardian*. https://www.theguardian.com/global-development/article/2024/may/29/alarming-levels-of-forever-chemicals-found-in-water-near-bangladesh-garment-factories

Kaspersetz, E. (2025, February 6). *Inside The Box: Galaxyland's Challenging New Coaster Project - Coaster101*. Coaster101.com. https://www.coaster101.com/2025/02/06/inside-the-box-galaxylands-challenging-new-coaster-project/#google_vignette

Malisza, K. L., Martin, T., Shiloff, D., & Yu, D. C. T. (2010). Reactions of young children to the MRI scanner environment. *Magnetic Resonance in Medicine*, *64*(2), 377–381. https://doi.org/10.1002/mrm.22438

McCarron, A., Semple, S., Swanson, V., Gillespie, C., Braban, C., & Price, H. D. (2024). Piloting co-developed behaviour change interventions to reduce exposure to air pollution and improve self-reported asthma-related health. *Journal of Exposure Science & Environmental Epidemiology*, 1–12. https://doi.org/10.1038/s41370-024-00661-2

Meath, C., Karlovšek, J., Navarrete, C., Eales, M., & Hastings, P. (2022). Co-designing a multi-level platform for industry-level transition to circular economy principles: A case study of the infrastructure CoLab. *Journal of Cleaner Production*, 131080. https://doi.org/10.1016/j.jclepro.2022.131080

Meo, S. A., Shaikh, N., Alotaibi, M., Abdullah Abdulziz AlWabel, & Hamid Alqumaidi. (2024). Effect of air pollutants particulate matter (PM2.5, PM10), sulfur dioxide (SO2) and ozone (O3) on cognitive health. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-70646-6

Meriem, C., Khaoula, M., Ghizlane, C., Asmaa, M. A., & Ahmed, A. O. T. (2020). Early Childhood Development (0 - 6 Years Old) from Healthy to Pathologic: A Review of the Literature. *Open Journal of Medical Psychology*, *9*(3), 100–122. https://doi.org/10.4236/ojmp.2020.93009

Mertz, E. (2017, March 3). *Feds chip in funds for Fort Edmonton Park year-round expansion*. Global News. https://globalnews.ca/news/3286105/feds-chip-in-funds-for-fort-edmonton-park-year-round-expansion/

Mokhtar, Z., Kenway, S., & Irdayanti Mat Nashir. (2024). Challenges for Compliance with Industrial Effluent Regulations—An Industry Perspective. *Challenges*, *16*(1), 1–1. https://doi.org/10.3390/challe16010001

Mohlin K. (2025, April 17). *Clearing the air: The EU's methane regulation is a climate solution — not a trade pawn - Energy Exchange*. Energy Exchange. https://blogs.edf.org/energyexchange/2025/04/17/clearing-the-air-the-eus-methane-regulation-is-a-climate-solution-not-a-trade-pawn/

Montagnini, F., & Metzel, R. (2024). The Contribution of Agroforestry to Sustainable Development Goal 2: End Hunger, Achieve Food Security and Improved Nutrition, and Promote Sustainable Agriculture. *Advances in Agroforestry*, 21–67. https://doi.org/10.1007/978-3-031-54270-1_2

National Academies of Sciences, Engineering, and Medicine. (2024). *A Research Agenda Toward Atmospheric Methane Removal*.https://nap.nationalacademies.org/catalog/27157/a-research-agenda-toward-atmospheric-methane-removal

Nguyen A. (2025, May 14). *Germany's Merz urges EU to scrap green business rules*. Seneca ESG. https://senecaesg.com/insights/germanys-merz-urges-eu-to-scrap-green-business-rules/

Nguyen, T., & Vellanki, V. (2022). Decentering the Adult Gaze: Young Children's Photographs as Provocations for Place-Making. *Language Arts, 99*(4), 227–239. https://doi.org/10.58680/la202231740

Odora Hoppers, C. (2021). Research on Indigenous knowledge systems: the search for cognitive justice. *International Journal of Lifelong Education, 40*(4), 310–327. https://doi.org/10.1080/02601370.2021.1966109

Oh, J., Kim, E., Kwag, Y., An, H., Kim, H. S., Shah, S., Lee, J. H., & Ha, E. (2024). Heat wave exposure and increased heat-related hospitalizations in young children in South Korea: A time-series study. *Environmental Research, 241*, 117561. https://doi.org/10.1016/j.envres.2023.117561

Okoye, C., Obialo-Ibeawuchi, C. M., Obajeun, O. A., Sarwar, S., Tawfik, C., Waleed, M. S., Wasim, A. U., Mohamoud, I., Afolayan, A. Y., & Mbaezue, R. N. (2023). Early Diagnosis of Autism Spectrum Disorder: A Review and Analysis of the Risks and Benefits. *Cureus, 15*(8). https://doi.org/10.7759/cureus.43226

Oscilowicz, E., Honey-Rosés, J., Anguelovski, I., Triguero-Mas, M., & Cole, H. (2020). Young families and children in gentrifying neighbourhoods: how gentrification reshapes use and perception of green play spaces. *Local Environment, 25*(10), 765–786. https://doi.org/10.1080/13549839.2020.1835849

Pen Global. (2024). *Lagos Island: The Richest Local Government Area in Nigeria*. Penglobalinc.com. https://www.penglobalinc.com/lagos-island-the-richest-local-government-area-in-nigeria

Perera, F. P. (2017). Multiple Threats to Child Health from Fossil Fuel Combustion: Impacts of Air Pollution and Climate Change. *Environmental Health Perspectives*, *125*(2), 141–148. https://doi.org/10.1289/ehp299

Perera, F., & Lau, K. (2024). A review of studies assessing the benefits of clean air and climate mitigation policies for child and adult health. *The Journal of Climate Change and Health, 21*, 100369. https://doi.org/10.1016/j.joclim.2024.100369

Randell, H., & Gray, C. (2019). Climate change and educational attainment in the global tropics. *Proceedings of the National Academy of Sciences of the United States of America, 116*(18), 8840–8845. https://doi.org/10.1073/pnas.1817480116

Regan, H. (2020, September 29). *Why our colorful clothes are killing the environment*. CNN. https://www.cnn.com/style/article/dyeing-pollution-fashion-intl-hnk-dst-sept

Rick, C., Han, J., Elbel, B., & Schwartz, A. E. (2022). The Link between Gentrification, Children's Egocentric Food Environment, and Obesity. *Housing Policy Debate, 33*(1), 1–22. https://doi.org/10.1080/10511482.2022.2125788

Samadkulov, M. (2024). The Urbanization Economy: Difficulties and Approaches for Sustainable Growth. *International Journal of Artificial Intelligence, 4*(03), 258–263. https://www.academicpublishers.org/journals/index.php/ijai/article/view/564

Sow, S., Ranjan, S., Smruti Ranjan Padhan, Nath, D., & Kumar, N. (2024). *Agroforestry and Soil Carbon Sequestration: A Nexus for System Sustainability*. 103–126. https://doi.org/10.1007/978-981-97-5004-7_5

Steen, M. (2013). Co-Design as a Process of Joint Inquiry and Imagination. *Design Issues, 29*(2), 16–28. https://doi.org/10.1162/desi_a_00207

The Centenary Project. (n.d.). *Colonial Footprints: Lagos, Then and Now*. Google Arts & Culture. https://artsandculture.google.com/story/LAUBxuvCARsA8A

The Global Economy. (2023). *Percent Children by Country, Around the world*. TheGlobalEconomy.com. https://www.theglobaleconomy.com/rankings/percent_children/

The United Nations Environment Programme (UNEP). (2022). *The environmental costs of fast fashion*. UNEP. https://www.unep.org/news-and-stories/story/environmental-costs-fast-fashion?

Uddin, M., & Bin Alam, F. (2023). Health risk assessment of the heavy metals at wastewater discharge points of textile industries in Tongi, Shitalakkhya, and Dhaleshwari, Bangladesh. *Journal of Water and Health, 21*(5), 586–600. https://doi.org/10.2166/wh.2023.284

United Nations Environment Programme and Climate and Clean Air Coalition. (2021). *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*.

United Nations International Children's Emergency Fund. (2022). *Social and behaviour change*. Unicef.org. https://www.unicef.org/social-and-behaviour-change

United Nations International Children's Emergency Fund. (2023). *Progress on Children's Well-being: Centering Child Rights in the 2030 Agenda—For Every Child*.

Vaughn, L. M., & Jacquez, F. (2020). Participatory Research Methods – Choice Points in the Research Process. *Journal of Participatory Research Methods, 1*(1). https://doi.org/10.35844/001c.13244

Verma, P. (2023). Qualitative Benefit and Enhancement in Well Being Towards the Biophilic Design in Office Building. *International Journal for Research in Applied Science and Engineering Technology*, *11*(3), 29–37. https://doi.org/10.22214/ijraset.2023.49205

Vieira, J., São Luís Castro, & Souza, A. S. (2023). Psychological barriers moderate the attitude-behavior gap for climate change. *Plos One*, *18*(7), e0287404–e0287404. https://doi.org/10.1371/journal.pone.0287404

Watchman, M., Demers, C. M. H., & Potvin, A. (2020). Biophilic school architecture in cold climates. *Indoor and Built Environment*, 1420326X2090830. https://doi.org/10.1177/1420326x20908308

Wood, B. M., Cubbin, C., Rubalcava Hernandez, E. J., DiNitto, D. M., Vohra-Gupta, S., Baiden, P., & Mueller, E. J. (2023). The Price of Growing Up in a Low-Income Neighborhood: A Scoping Review of Associated Depressive Symptoms and Other Mood Disorders among Children and Adolescents. *International Journal of Environmental Research and Public Health*, *20*(19), 6884. https://doi.org/10.3390/ijerph20196884

World Health Organization. (2024). *Children's environmental health*. Who.int; World Health Organization: WHO. https://www.who.int/news-room/facts-in-pictures/detail/children%27s-environmental-health?

APPENDIX A

Table of Key Issues, Barriers, and Needs in Child-Centered Environmental Research

Issues	Developmental Domain Affected	What's Needed?	Barriers	Guiding Questions
Limited targeted interventions for children's climate resilience	Physical and mental	Innovative child-focused solutions	Limited research, low visibility in policy	What scientific solutions can address children's vulnerability to climate change?
Industrial resistance to environmental regulations	Physical	Corporate responsibility and accountability strategies	Compliance costs, employee attitudes, technological limitations, insufficient management support, and jurisdictional conflicts.	How can scientific research help overcome challenges associated with adhering to environmental regulations?
High-risk Diagnostic systems	Physical and mental/psychological	Safer diagnostic techniques	Cumulative radiation exposure	What scientific knowledge is needed to develop low-risk diagnostic systems or make existing ones safe?
Behavioral Inertia to pollution	Cognitive and neurological	Social and behavior change strategies	Psychological and structural barriers	How can scientific research drive behavior change as it pertains to pollution?
Tokenistic child considerations in sustainable urban development research	Social-emotional and physical.	Child-specific considerations in SUD research	Adult-centric models and guidelines	How can scientific research on sustainable urban development integrate children's developmental needs in design and architecture?

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