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"Greening" Education for Climate Resilience: Strategies, Implementation, and Curriculum Integration

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Abstract

The increasing urgency of the climate crisis has necessitated a transformative approach to education that prepares learners to act as agents of sustainable change. This working paper synthesizes UNESCO's Greening Curriculum Guidance with contemporary academic insights to propose a comprehensive framework for embedding climate change education into formal and non-formal learning environments. Drawing on theoretical models, empirical evidence, and international policy frameworks, the paper articulates strategies for greening the curriculum, outlines actionable steps for institutional implementation, and analyzes pedagogical methods that cultivate cognitive, socio-emotional, and behavioral competencies. The role of intersectionality, justice, and indigenous knowledge systems is emphasized to ensure an inclusive and context-sensitive transition toward climate-resilient education systems.

Keywords: Curriculum Greening; Climate Education; Sustainability; Pedagogical Strategies; UNESCO; ESD.

JEL codes: Q01; Q56; I21; D90.

1. Introduction

The multidimensional impacts of climate change on ecosystems, economies, and societies have elevated the role of education in shaping a climate-conscious citizenship. As highlighted by UNESCO (2024), education must move from knowledge transmission to transformative learning to equip individuals with the competencies required for climate adaptation, mitigation, and resilience-building. This paper explores the concept of greening education through the lens of the "Greening Curriculum Guidance" developed by UNESCO, placing it within the broader discourse on Education for Sustainable Development (ESD), climate change education (CCE), and global sustainability goals.

While global frameworks such as the UN's Sustainable Development Goals (SDGs) and the Paris Agreement underscore the necessity of climate education (UNESCO, 2024), national curricula often fall short in integrating climate issues comprehensively (Von Wehrden et al., 2021). The absence of clear curricular benchmarks, teacher preparedness, and cross-sectoral collaboration exacerbates this gap. Drawing from a synthesis of current literature and UNESCO's guidance, this work provides a robust framework for establishing climate change education as a standard practice. Furthermore, it presents a roadmap to foster educational transformation that aligns with national and global sustainability agendas.

The importance of greening education is also highlighted by the gaps identified in teacher training and student understanding of climate change issues. According to UNESCO (2024), nearly half of national curriculum frameworks fail to mention climate change, and only one-third of educators feel adequately prepared to teach its impacts. These alarming figures suggest that current educational structures are not adequately equipping students with the tools to address the climate emergency. In response, the Greening Education Partnership was launched in 2022 to encourage collaborative action between governments, civil society, and youth, with the objective of embedding climate change education in 90% of national curricula by 2030.

Education has long been viewed as a vital channel for social and environmental change. It not only disseminates knowledge but also models worldviews, shapes values, and fosters behavioral transformation (Gkargkavouzi et al., 2018; 2019). ESD, which forms the backbone of greening education, promotes the integration of environmental, social, and economic dimensions of sustainability into

teaching and learning. As a dynamic and participatory process, ESD seeks to empower learners to become active contributors to a more sustainable world (Fernando & Tajan, 2024). The integration of climate justice, equity, and diversity into ESD further amplifies its relevance in a world facing overlapping crises (Trrott et al., 2023).

In addition to promoting sustainability literacy, greening education contributes to building emotional and psychological resilience. With rising levels of eco-anxiety among youth, climate education must also address emotional responses to environmental degradation, providing students with the tools to channel their concern into positive action. In this context, climate education becomes a form of empowerment, enabling learners to navigate uncertainty, build hope, and foster a sense of purpose (Liu et al., 2025).

This paper is structured as follows: Section 2 examines the theoretical foundations of greening education, including key pedagogical principles and the role of justice. Section 3 outlines strategic approaches to integrating climate change into curriculum design, pedagogy, and learning environments. Section 4 presents an implementation framework based on UNESCO's ten-step roadmap. Section 5 identifies current challenges and opportunities. The paper concludes by underscoring the imperative of sustained investment in greening education and proposes directions for future research.

2. Theoretical Underpinnings of Greening Education

The conceptual foundation of greening education is deeply rooted in transformative learning theory, which seeks to foster profound changes in learners' worldviews through critical reflection and active engagement (Xiao et al., 2025). Transformative learning challenges learners to examine underlying assumptions, confront cognitive dissonance, and reconstruct their perspectives considering new knowledge. In the context of climate education, this means not only understanding the science of climate change but also reimagining social, political, and economic systems toward sustainability (Eilks & Linkwitz, 2022).

Central to greening education is Education for Sustainable Development (ESD), which equips learners with the knowledge, skills, values, and attitudes necessary to promote environmental integrity, economic viability, and social equity. ESD is explicitly aligned with the United Nations Sustainable Development Goal 4.7,

which calls for education that fosters sustainable development, human rights, gender equality, and global citizenship (UNESCO, 2024). Greening education, as an extension of ESD, focuses on climate change as a cross-cutting issue that intersects with all domains of sustainability.

A defining feature of ESD and greening education is their multidimensional approach to learning. Rather than focusing solely on cognitive knowledge, these paradigms emphasize socio-emotional learning and behavioral change. As such, greening education integrates three core domains:

- Cognitive: understanding climate science, systems thinking, and sustainability principles.
- Socio-emotional: cultivating empathy, resilience, and ethical reasoning.
- Behavioral: translating values and knowledge into concrete action for sustainability.

The holistic nature of greening education requires a shift from traditional didactic teaching to participatory, learner-centred, and action-oriented pedagogies. It promotes critical thinking and problem-solving, encouraging learners to engage with real-world challenges and co-create solutions in collaboration with peers and community stakeholders.

Another theoretical pillar of greening education is climate justice, which highlights the unequal distribution of climate impacts and the responsibility to address these disparities. Climate justice pedagogy requires learners to understand how historical and contemporary systems of oppression contribute to climate vulnerability, particularly for marginalized populations (Randall et al., 2022). Integrating climate justice into education demands a reorientation of content and pedagogy towards equity, agency, and systemic critique.

Intersectionality further enriches the theoretical grounding of greening education. It encourages educators and learners to consider how overlapping identities, such as gender, race, ethnicity, socioeconomic status, and geographic location, shape individuals' experiences of climate change and access to resources (Kwauk & Wyss, 2022). An intersectional approach not only enhances inclusivity but also fosters solidarity and social cohesion in addressing climate-related challenges.

Moreover, indigenous knowledge systems offer valuable epistemologies for sustainability education. Indigenous communities possess rich traditions of

environmental stewardship, emphasizing reciprocity, interconnectedness, and long-term thinking. By integrating these perspectives into curricula, greening education honours diverse worldviews and enhances relevance and cultural sensitivity (Onyeaka & Akinsemolu, 2024).

The theoretical underpinnings of greening education are diverse yet synergistic. They include transformative learning, ESD, climate justice, intersectionality, and indigenous knowledge systems, all of which contribute to a dynamic and responsive educational framework. These foundations guide the development of curriculum, pedagogy, and policy interventions that are attuned to the complexities of the climate crisis and the urgent need for sustainable transformation (Gkargkavouzi & Halkos, 2025).

3. Strategies for Greening the Curriculum

Greening the curriculum involves a systematic and inclusive reorientation of educational content, pedagogy, and learning environments toward sustainability and climate resilience. The UNESCO Greening Curriculum Guidance (2024) identifies three guiding questions, what to learn, how to learn, and where to learn, that structure a strategic framework for educational transformation.

3.1. What to Learn: Integrated and Interdisciplinary Climate Content

The first step in greening the curriculum is to define the knowledge, skills, and values that learners need to become climate-resilient citizens. This involves the development of content that integrates climate science, ecological literacy, social justice, and economic sustainability. Key topics include the greenhouse effect, carbon and water cycles, biodiversity, ecosystem services, renewable energy, climate justice, sustainable consumption, and post-carbon economies (UNESCO, 2024).

Importantly, the curriculum should emphasize systems thinking or the ability to understand the interconnectedness of human and natural systems. Learners should be equipped to analyze feedback loops, tipping points, and the long-term consequences of environmental decisions. This interdisciplinary approach breaks down traditional subject silos, enabling students to see climate change not only as a scientific issue but also as an ethical, cultural, and economic challenge (Ahmad et al., 2024).

Age-appropriate learning outcomes must also be delineated. For example, primary school learners might explore concepts of nature and care for the environment, while secondary students can examine policy dimensions, climate modelling, and global governance mechanisms. The lifelong learning perspective of ESD ensures that education for climate resilience continues into adulthood and across professional fields (Benlaria & Almawishir, 2025).

3.2. How to Learn: Transformative Pedagogies

Effective delivery of climate content hinges on pedagogy. Traditional didactic approaches must be replaced by active, experiential, and transformative learning methods that cultivate not only knowledge but also action and agency. Techniques such as project-based learning, field-based inquiry, simulations, role-play, community mapping, and storytelling create emotionally engaging and contextually relevant learning experiences (Laurie et al., 2016).

Learner-cantered approaches empower students to take ownership of their education. Inquiry-based learning, for instance, enables students to explore local climate issues, conduct investigations, and propose community interventions. Reflective practices—including journaling, group discussions, and value clarification exercises—promote deeper understanding and emotional processing, essential for dealing with climate anxiety (Stevenson & Peterson, 2016).

Educators should also incorporate digital tools to enhance engagement and access. Extended reality (XR), serious games, and AI-based platforms allow learners to visualize climate impacts and experiment with mitigation strategies (Zhou et al., 2024). Moreover, media literacy training is critical to help students discern misinformation and critically analyze environmental narratives across platforms (Lewandowsky, 2021).

3.3. Where to Learn: Expanding Learning Spaces

Greening the curriculum is not confined to formal classroom settings. It must extend into non-formal and informal education spaces such as community centres, museums, religious institutions, and online platforms. These settings are crucial for reaching marginalized and out-of-school populations, promoting inclusivity, and reinforcing learning through multiple modalities (Qureshi, 2020).

Learning environments themselves can serve as laboratories for sustainability. Schools can adopt whole-institution approaches that model eco-friendly practices such as waste reduction, water conservation, and renewable energy use. Students should be involved in sustainability audits, green infrastructure projects, and local advocacy campaigns, thereby bridging theory with action (Abeynayake & Illeperuma, 2025).

Moreover, community partnerships amplify the impact of greening initiatives. Collaborations with local governments, NGOs, indigenous groups, and businesses can provide mentorship, resources, and real-world problem-solving opportunities. These engagements strengthen civic responsibility and promote a sense of collective agency in climate action (Pan & Hung, 2025).

In summary, greening the curriculum requires a radical transformation of what is taught, how it is taught, and where learning takes place. It involves embedding interdisciplinary climate content, adopting transformative pedagogies, and expanding learning environments to foster inclusive, context-sensitive, and action-oriented education for sustainability. The next section outlines practical steps for implementing these strategies within educational institutions and systems.

4. Implementation Framework

Translating the conceptual and pedagogical foundations of greening education into practice requires a strategic, phased approach to implementation. UNESCO's ten-step roadmap for curriculum greening (2024) provides a comprehensive model that encompasses policy alignment, stakeholder participation, instructional design, capacity building, and continuous evaluation. This section elaborates on the critical components necessary to operationalize climate education within institutional frameworks.

4.1. Policy Integration and Curriculum Review

The foundation for greening education begins with the review and revision of existing education policies. Ministries of Education and national curriculum bodies must identify opportunities to integrate sustainability and climate content into curricular standards, textbooks, and learning outcomes. This policy alignment ensures coherence between education and national climate strategies, such as Nationally Determined Contributions (NDCs) under the Paris Agreement (UNESCO, 2024).

Curriculums audits help assess the presence and quality of climate-related content across disciplines. These audits should examine whether learning outcomes reflect the cognitive, emotional, and behavioral domains of sustainability and whether they address issues of justice, equity, and cultural relevance (Von Wehrden et al., 2021).

4.2. Stakeholder Engagement and Participatory Design

Inclusive stakeholder engagement is essential to ensure that curriculum development reflects diverse perspectives and needs. Governments, teachers, students, parents, indigenous groups, civil society organizations, and private sector actors must be involved in co-constructing educational content and implementation strategies (Aedi, 2024).

Youth participation is particularly crucial. As the primary beneficiaries of education systems and the most affected by climate change, young people bring unique insights and energy to curriculum transformation. Mechanisms for youth input, such as advisory councils or co-design workshops, strengthen ownership and relevance (UNESCO, 2024).

4.3. Curriculum Development and Instructional Resources

Once policy frameworks and stakeholder networks are established, curriculum teams must develop or revise syllabi to reflect the goals of greening education. This process should prioritize spiral curriculum structures that revisit key concepts across grade levels with increasing complexity. Content should be contextualized to reflect local ecological and cultural conditions while maintaining alignment with global sustainability frameworks (Leeuw et al., 2015).

Supporting resources like textbooks, digital content, teacher guides, assessment tools, must be developed concurrently. These materials should incorporate real-world examples, interdisciplinary case studies, and opportunities for student-led inquiry and action. Collaboration with universities and research institutions can enhance the scientific rigor and relevance of content (Gazo & Taşdemir, 2020).

4.4. Teacher Training and Professional Development

Teachers are the linchpins of curriculum implementation. However, studies show that many educators lack confidence and training in climate change education (UNESCO, 2024). Comprehensive pre-service and in-service training programs are required to build content knowledge, pedagogical skills, and emotional resilience among educators.

Professional development should emphasize learner-cantered and action-oriented approaches, including experiential learning, critical pedagogy, and interdisciplinary instruction. Training must also address climate psychology, enabling educators to support students experiencing eco-anxiety or grief (Daddow, 2022).

Peer learning networks, communities of practice, and online platforms can support ongoing professional growth and collaboration among teachers. Partnerships with teacher unions and associations can institutionalize climate education within professional standards and evaluation metrics (Cole & Altenburger, 2019).

4.5. Institutional and Community Integration

Greening the curriculum should occur within the broader context of whole-institution transformation. Schools and universities must model sustainability in infrastructure, operations, and governance. This includes adopting green building practices, reducing carbon footprints, and fostering participatory decision-making processes (Abeynayake & Illeperuma, 2025).

Community partnerships are essential for contextualizing learning and extending impact. Schools can collaborate with local governments, NGOs, and businesses to organize environmental campaigns, service-learning projects, and internships that connect students with real-world climate solutions (Pan & Hung, 2025).

4.6. Monitoring, Evaluation, and Continuous Improvement

Robust monitoring and evaluation (M&E) systems are vital to assess the effectiveness of greening education initiatives. Indicators should capture changes in learner knowledge, attitudes, and behaviors, as well as institutional practices and community outcomes (Wissinger et al., 2019). M&E frameworks should employ both quantitative and qualitative methods, including surveys, classroom observations,

portfolio assessments, and participatory evaluations. Feedback loops must be established to allow for continuous refinement of curriculum content, pedagogy, and support structures.

Governments and donors should invest in longitudinal studies to examine the long-term impacts of climate education on students' career choices, civic engagement, and environmental behaviors (Weiss & Barth, 2019). Dissemination of findings through networks and conferences fosters shared learning and innovation across contexts.The successful implementation of greening education requires sustained political commitment, adequate funding, institutional coordination, and an unwavering focus on equity and inclusion. The next section explores common challenges and emerging opportunities in advancing this agenda.

5. Challenges and Opportunities

While the momentum for greening education is growing, its realization is impeded by several persistent challenges that affect all stages of implementation, from policy development to classroom practice. However, these challenges coexist with transformative opportunities thatcould drive systemic and scalable change in education for sustainability.

5.1. Challenges

One of the most formidable challenges is the lack of political will and policy coherence. In many countries, climate change education is not viewed as a national priority, leading to inconsistent integration into curriculum frameworks and insufficient budget allocations. This results in a fragmented approach where sustainability topics are addressed sporadically or superficially across subjects (Von Wehrden et al., 2021).

Curriculum overload is another significant barrier. Teachers are often overwhelmed with existing content and struggle to incorporate additional material without proper guidance, time, or resources. The pressure of high-stakes testing and standardized assessments further disincentivizes innovative, interdisciplinary teaching approaches that are central to greening education (Wissinger et al., 2019).

Teacher capacity gaps persist globally. A substantial number of educators lack adequate training in climate science, sustainability pedagogy, and emotional literacy. In some regions, teachers also face ideological resistance from communities sceptical of climate science, which complicates curriculum delivery and undermines educators' confidence (UNESCO, 2024).

Financial and infrastructural constraints are equally limiting. Implementing green campus initiatives, acquiring updated instructional materials, and offering continuous professional development require sustained investment. In low-income contexts, such resources may be unavailable or unevenly distributed, exacerbating educational inequities (Benlaria & Almawishir, 2025).

Finally, the absence of robust monitoring and evaluation mechanisms makes it difficult to measure the impact of greening education initiatives. Without clear indicators, longitudinal data, and accountability systems, efforts remain ad hoc and lack the evidence base needed for policy advocacy and refinement (Weiss & Barth, 2019).

5.2. Opportunities

Despite these challenges, significant opportunities exist to mainstream climate education and transform learning systems. One such opportunity is the alignment of national education strategies with global climate commitments, including the Paris Agreement, SDG 4.7, and the UNESCO Greening Education Partnership. These frameworks provide political legitimacy and potential funding streams for greening initiatives (Abo-Khalil, 2024; UNESCO, 2024).

Digital technology presents powerful tools for scaling access to quality climate education. Online learning platforms, open educational resources (OERs), and virtual collaboration networks can democratize access to high-quality materials and training, particularly in remote or underserved areas. Moreover, digital storytelling and interactive media enhance student engagement and critical reflection (Zhou et al., 2024).

Youth-led climate activism represents another avenue for change. Young people around the world are demanding systemic transformation and climate justice. Their engagement offers schools and universities opportunities to co-create responsive curricula, host environmental campaigns, and legitimize student voice in institutional governance (Randall et al., 2022).

Transdisciplinary research and practice communities are also emerging as vital actors in greening education. Collaborations among educators, scientists, community leaders, and policymakers can yield context-sensitive solutions that integrate scientific rigor with local relevance (Gazo & Taşdemir, 2020; McGeown & Sjölund, 2025). Such networks foster innovation and enable the cross-pollination of ideas across regions and sectors.

International donor agencies, philanthropic foundations, and corporate social responsibility programs increasingly recognize the role of education in climate resilience. Strategic partnerships and blended financing models can mobilize resources for curriculum reform, teacher training, and green infrastructure development (Abeynayake & Illeperuma, 2025; Gkargkavouzi & Halkos, 2025).

6. Conclusions

Greening education is no longer a supplementary initiative; it is a foundational imperative in the face of the escalating climate crisis. This paper has outlined a comprehensive framework grounded in UNESCO's guidance and contemporary academic literature for transforming educational systems into engines of climate resilience and sustainability. The case for greening the curriculum rests on a strong theoretical foundation, spanning transformative learning, ESD, climate justice, and indigenous knowledge systemsand is supported by an array of proven strategies and implementation practices.

As demonstrated, the process of greening education requires an integrated approach that redefines what learners should know, how they should learn it, and where learning should take place. It calls for institutional reform that begins with curriculum policy alignment and extends through teacher training, pedagogical innovation, community engagement, and the development of monitoring and evaluation systems (UNESCO, 2024). These transformations must be grounded in inclusion, equity, and cultural relevance to ensure that no learner is left behind.

Despite formidable challenges including limited policy support, resource constraints, and gaps in educator preparedness the momentum behind this movement is undeniable. Opportunities abound in digital innovation, youth activism, global policy alignment, and cross-sector partnerships. The international case studies examined in this paper affirm the viability of greening education across regions and

income levels, reinforcing that meaningful progress is not only possible but already underway.

Moving forward, sustained investment in research and practice is crucial. Longitudinal studies should explore the long-term effects of green curricula on learner outcomes, civic participation, and environmental stewardship. Additionally, scalable models of whole-institution transformation, cross-cultural pedagogical tools, and robust assessment frameworks will be vital for advancing this agenda. It is worth mentioning that addressing synergistic effects is critical in climate change education, as they underscore the link with wider air pollution concerns (Halkos, 1993; 1994).

In conclusion, education is not just a pathway to individual empowerment; it is a cornerstone of collective survival and planetary regeneration. Greening the curriculum is both a response to and a driver of systemic transformation. By fostering the competencies, values, and agency necessary for sustainable living, education can fulfil its potential as a catalyst for a just, equitable, and climate-resilient future.

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