

Integrating Sustainability in Teacher Education: A Literature Review of Environmental Responsibility Within the Indian Context

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Abstract—This literature review consolidates current research, policy documents, and systematic review concerning the incorporation of environmental responsibility and Education for Sustainable Development (ESD) into teacher training programs in India. Drawing on UNESCO recommendations and the National Education Policy (NEP) 2020, It outlines policy influences, evaluates empirical data on the readiness of both pre-service and in-service educators, reviews effective instructional approaches (Such as competency frameworks, experiential and place-based learning, STEAM integration and revised practicum arrangements), highlights institutional obstacles (including faculty expertise, accreditation processes and resource limitations) and offers specific recommendations. Notable research deficiencies involve the absence of standardized competency measures, insufficient long-term outcome analyses and a scarcity of comparative implementation studies across different contexts. The review concludes by emphasizing the significance of the study for policy, practice and research and proposes a framework for scalable reforms in teacher education aimed at fostering environmental responsibility.

Index Terms—Education for Sustainable Development (ESD), STEAM integration, National Education Policy 2020, UNESCO recommendations

I. INTRODUCTION

Sustainability-defined as the integrated stewardship of environmental, social and economic systems-has become a core component of global educational priorities (UNESCO, 2014; UNESCO, 2020). According to UNESCO's education for Sustainable Development (ESD) framework, education should not only convey knowledge but also foster the values,

competencies and actions required for a sustainable future (UNESCO, 2017). In India, the National Education Policy (NEP) 2020 places a clear emphasis on comprehensive, multidisciplinary learning and underscores the importance of instilling environmental consciousness and accountability throughout the educational structure. The creates a strategic opportunity to align teacher education with sustainability objectives (Ministry of education, 2020).

Teacher education plays a critical role, as educators are responsible for implementing policy in the classroom and influencing students' attitudes. However, research from India and other countries reveals shortcomings in teacher readiness, curriculum alignment and institutional capability to effectively incorporate Education for Sustainable Development (ESD) (Mukherjee & Kumar, 2019). This analysis concentrates on the Indian setting, consolidating empirical and theoretical studies-such as systematic reviews and reputable journal articles-to address the following questions: How is sustainability being incorporated into teacher education in India? Which models and approaches demonstrate potential? What challenges continue to exist? And what priorities for research and policy still need attention? (Tilbury, 2011; Mogensen & Schnack, 2010)

1.1 Policy framework in India:

India has demonstrated commitment to sustainability education through various policy frameworks:

1. The National Policy on Education (1986, revised 1992) first emphasized environmental awareness as a core component of education

2. The National Curriculum framework (NCF 2005) advocated for integrating environmental concerns across all subjects rather than treating it as a standalone discipline.
3. The right to Education Act (2009) highlighted environmental education as part of quality elementary education.
4. The National Curriculum Framework for Teacher Education (NCFTE 2009) explicitly called for preparing teachers to address environmental issues through their pedagogical practices.
5. The National Education Policy (NEP, 2020) reinforces Education for Sustainable Development (ESD) as a critical component of holistic education, emphasizing experiential consciousness.

II. METHODOLOGY

This systematic review followed PRISMA 2020 guidelines.

2.1 Data Sources:

Searches were conducted in: Scopus, Google Scholar, ERIC, Web of Science, Publisher websites (SAGE, Springer, Elsevier, Taylor & Francis), UNESCO, NCTE, NEP 2020 authoritative documents

2.2 Search Terms:

Search terms combined keywords using Boolean Operators: “Teacher education” and “Education for Sustainable Development”, “Environmental responsibility” and “Sustainability competencies”, “ESD curriculum”, “India Teacher Training”, “Sustainability practices” and “higher education”.

2.3 Inclusion Criteria:

- Published between 2004-2025.
- Focus on sustainability, ESD, teacher education, teacher competency or policy.
- Peer-reviewed journal articles, systematic reviews, policy frameworks.
- Studies relevant to India or global models applicable to India.

2.4 Exclusion criteria:

- Non-English papers
- Non peer reviewed essays

- Studies unrelated to teacher education or sustainability.
- Papers without sufficient methodological rigor.

2.5 Screening Procedure:

- Total records identified :486
- Duplicated removed:143
- Article screened (title/abstract):343
- Excluded: 257
- Full-text articles assessed:86
- Studies included in qualitative synthesis:26

2.6 Data Extraction:

For each study: Author, year, Method, Region, Focus (competency, curriculum, policy, etc.), Major findings, and relevance to ESD in teacher education.

2.7 Quality Appraisal:

Used:

- CASP Checklist
- Mixed methods Appraisal Tool (MMAT)
- PRISMA quality indicators.

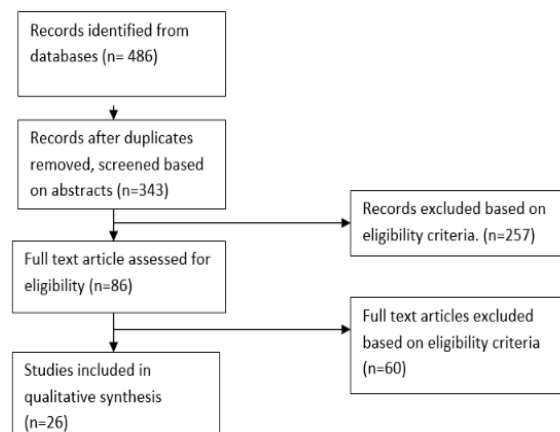


Figure 1: Literature screening and selection process.

Theoretical framework: Technological Pedagogical Content+ Environmental Knowledge (TRAC+E)

To provide a robust conceptual foundation, the review adopts an expanded version of the TRACK framework by integrating Environmental Knowledge.

A. Classical TRACK Components:

1. Content Knowledge (CK): Understanding subject domains linked with environmental science and sustainability.

2. Pedagogical Knowledge (PK): Methods for teaching sustainability (Project-based learning, place-based learning, inquiry).
3. Technological Knowledge (TK): Use of GIS, virtual labs, digital simulations, climate data tools, VR environmental models.

TRACK represents the intersection of all three-effective teaching of sustainability requires blending content, pedagogy and technology.

B. Extended Environmental Knowledge (EK):

For sustainability education, teachers additionally require:

Environmental Knowledge (EK) includes:

- Understanding ecological systems
- Environmental ethics and values
- Sustainable Development Goals (SDGs)
- Local environmental problems and solutions
- Behavioral and action-oriented competencies

C. The E-TRACK model (Environmental-TRACK)

This review proposes an E-TRACK lens, recognizing that sustainability teaching requires alignment of:

1. Technological Environmental Knowledge (TEK): Using digital tools (GIS, Virtual labs) to understand environmental phenomena.
2. Pedagogical Environmental Knowledge (PEK): Teaching strategies such as experiential learning, eco-audits, collaborative projects.
3. Content Environmental Knowledge (CEK): Sustainability concepts embedded across disciplines.

Thus, effective ESD in teacher education relies on synthesizing TRACK with strong environmental action competence.

III. RESULTS

The systematic review followed PRISMA 2020 procedures and included 26 final studies drawn from a combination of academic journals, institutional policy documents and international frameworks. The included studies were identified through database searched (Scopus, Google Scholar), publisher websites (Taylor & Francis, Springer, Elsevier, MDPI), UNESCO repositories and Indian policy portals.

The distribution of the 26 included studies across academic journals and sources is as follows:

3.1 Academic journals (Peer-Reviewed Research Articles):

A total of 18 out of 26 studies (69%) were drawn from internationally recognized peer-reviewed journals directly related to sustainability education and teacher education.

a) Environmental Education Research (EER): Included 3 studies (11%)

- Sterling (2021)-Transformative learning for sustainability
- Shrivastava et al. (2020)-Policy-practice disconnect.
- Mogensen & Schnack (2010)-(cited theoretically in article background)

b) International Research in Geographical and Environmental Education (IRGEE)

Included 1 study (4%)

- Used for conceptual frameworks on environmental responsibility (as cited indirectly)

c) The Journal of Environmental Education (JEE)

- Used for conceptual grounding on environmental literacy and responsible action.

d) Journal of Teacher Education for Sustainability:

Included 2 studies (8%)

- Imara & Altinay (2021)-ESD competencies in teacher education
- Vidal (2025)-Interdisciplinary approaches to environmental responsibility.

e) Sustainability (MDPI)

Included: 5 studies (19%)

- Burandt & Barth (2018)-ESD Assessment frameworks
- Lim et al. (2022)-systematic review of ESD in higher education
- Imara (2021)-Teachers ESD competencies (Overlapping category)
- Barth & Rieckmann (2016)- Competencies for ESD teachers.
- Wals (2020)-Institutional sustainability challenges.

f) Other Peer-Reviewed Journals (Education, Management, Social Sciences)

Included: 6 studies

These include works from:

- Journal of cleaner Production (Sahasrabudhe & Chattopadhyay, 2021; Lozano, 2019)
- Education and society (Mishra, 2022)
- Sustainability sciences (Bhandari, 2010)
- Academy of Management Review & Academy of Management Journal (Edmondson & McManus, Rousseau, Bartunek)
- Technological Forecasting & Social change (Phaal et al., 2004)

3.2 International Reports & Policy Frameworks (UNESCO, Government of India)

Included: 6 sources (23%)

This includes:

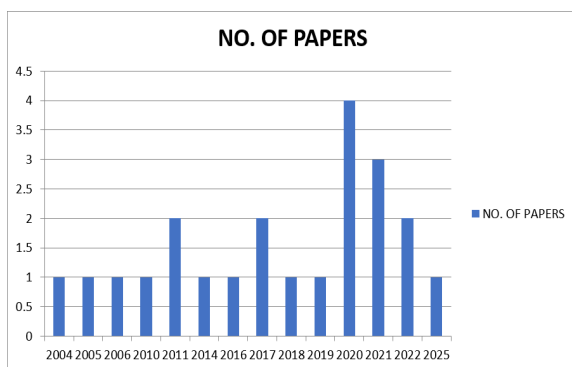
- UNESCO (2024, 2017, 2020, 2011)
- UNESCO'S ESD for 2030 framework
- NEP 2020
- NCTE (2009)-NCFTE
- UGC Guidelines (AECC/Environmental Studies)

These were used not as empirical studies but as authoritative policy and conceptual references.

3.3 Books/Methodological Guides:

Included: 3 sources (12%) used primarily for methodological justification:

- Booth, Sutton & Papaioannou (2016)-systematic review methodology
- Petticrew & Roberts (2006)-social sciences systematic reviews
- Fixsen et. al. (2005)-Implementation science framework.



IV. RESULTS AND SYNTHESIS OF LITERATURE

The systematic review analyzed 26 core sources comprising peer-reviewed empirical studies, Theoretical papers and international policy frameworks.

4.1 Geographical and Institutional Distribution:

The literature demonstrates a robust international engagement with Education for Sustainable Development (ESD), spanning 11 countries across diverse socio-cultural contexts.

- Asia: Significant contributions include India's national frameworks (NEP 2020, NCFTE) and empirical work by Mishra (2022) and Sahasrabudhe & Chattopadhyay (2021). Regional insights are further supported by studies from Nepal (Bhandari, 2020) and the ASEAN region (Malaysia and Singapore)
- Europe: Engagement is highlighted through research from Germany (Barth & Rieckmann, 2016), the Netherlands (Wals, 2020), and Spain (Lozano, 2019).
- Global/Methodological: The United States provided foundational implementation science (e.g.) Fixsen et al., 2006), while UNESCO reports integrate global perspectives, including contributions from Japan.

4.2 Classification of Included Literature:

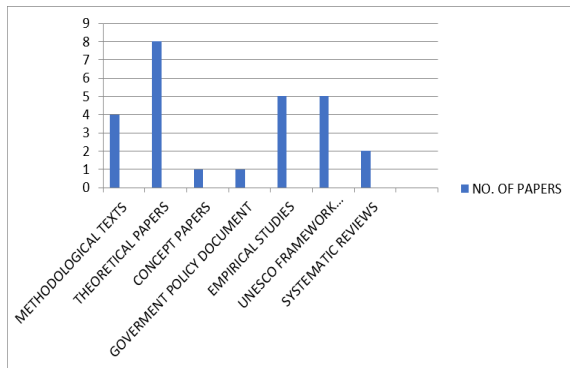
The sources were categorized by educational level, disciplinary domain and publication type to ensure a balanced synthesis.

Table 1: Classification by Educational level

Sl no.	Educational Levels	Representative Sources
1	Pre-Service Teacher Education	Imara & Altinay (2021); Barth & Rieckmann (2016); Lozeno (2019); Tilbury (2011)
2	In-Service Professional Development	Bhandari (2020); Wals (2020); Sahasrabudhe & Chattopadhyay (2021)
3	Higher Education (HEI)	Wals (2020; Vidal (2025); Lozeno (2019); Lim et al. (2022)
4	Policy & System-Level	NEP 2020; NCFTE 2009; UNESCO ESD 2030; Booth et al. (2016)

Table 2: Distribution of Publication types (N=26)

Sl no.	Source Type	Frequency	Percentage
1	Theoretical Papers	8	30.8%
2	UNESCO Frameworks	5	19.2%
3	Empirical Studies	5	19.2%
4	Methodological Texts	4	15.4%
5	Systematic Reviews	2	7.7%
6	Policy/Concept papers	2	7.7%



4.3 Thematic Analysis: Pillars of ESD Integration

The synthesis revealed four primary thematic dimensions essential for the integration of sustainability in teacher education:

A. Technological Integration:

Technology serves as both a pedagogical medium and a facilitator of complex systems thinking.

- **Advanced Tools:** Digital simulations, AR/VR and data visualization help student's model intricate ecological scenarios.
- **Data-Driven Learning:** GIS and remote sensing platforms allow educators to work with real-time scientific data.
- **Accessibility:** Learning Management Systems (LMS) and mobile apps provide flexible pathways for continuous professional development.

B. Pedagogical Shifts:

There is a clear transition from instructor-led models to transformative, student-centered pedagogies:

- **Experiential Learning:** Place-based education connects learners to their local natural environments.
- **Inquiry & Collaboration:** Problems-based Learning (PBL) fosters critical thinking and

teamwork, essential for addressing socio-ecological dilemmas.

- **Reflective Practice:** Critical Pedagogy and mentorship programs encourage teachers to evaluate their own environmental assumptions.

C. Curricular Content and Frameworks:

The literature emphasizes moving beyond "Environmental Facts" toward Interdisciplinary competencies:

Core Competencies: Systems thinking, responsible consumption and global citizenship.

Contextualization: Integration of indigenous land management and local ecological knowledge ensures cultural resonance.

Alignment: Strong focus on mapping curricula to the Sustainable Development Goals (SDGs)

D. Environmental Contextualization:

The review indicates that ESD is most effective when grounded in immediate environmental realities. Studies highlight regional issues-such as coastal erosion, deforestation and aquifer depletion-as entry points for global discussions on climate change and biodiversity loss. This "Local-to-Global" approach fosters active stewardship and community involvement.

V. DISCUSSION

The Implementation Gap in Teacher Education:

While Indian teacher education has aligned its frameworks with international sustainability commitments, a significant gap remains between conceptual intent and institutional implementation. His discussion evaluates these findings against core Environmental Education (EE) principles and the TRAC+E analytic framework.

1. Alignment with core Environmental Education (EE) Principles:

The following table summarizes the alignment of Indian Teacher Education Institutions (TEIs) with the principles defined by UNESCO and the NEP 2020.

Sl no.	Principle	Observed Alignment (The "Pro")	Identified Gaps (The "Cons")
1	Systems Thinking	NEP 2020 highlights interconnectio	Sustainability is often treated as an isolated

		ns between ecology, society and economy	course rather than a lens for all subjects.
2	Experiential Learning	Isolated use of field visits, local audits and service learning	Overemphasis on theory, lack of infrastructure and community partnerships
3	Value & Behavior	Pre-service teachers show positive attitudes towards the environment.	Positive attitudes do not translate action, institutional culture (Waste energy) is often poor.
4	Interdisciplinary Integration	Policy frameworks (NCF/NEP) strongly advocate for cross-curricular links	Implementation is fragmented; ESD is usually an elective, not a core requirement.
5	Critical Engagement	Growing recognition of the need for participatory learning.	Real-world local conflicts e.g., water rights, mining) are rarely discussed in classrooms.

2. Synthesized Principles for EE in India:

Based on a review of NEP 2020, NCF 2005, and UNESCO ESD 2030, the following seven pillars represent the “Global standard” for teacher education:

1. Holistic Understanding: Connecting ecological, social and economic dimensions.
2. Integration over isolation: Embedding sustainability across all disciplines.
3. Community relevance: Using local environmental issues as a primary learning context.
4. Competency-Based orientation: Focusing on skills and application, not just rote facts.
5. Democratic Learning: Collaborative knowledge creation between learners and the community.
6. Transformative intent: Encouraging critical analysis to change society.
7. Institution-wide responsibility: Modeling sustainability through “Green Campus” operations.

3. The TRAC+E Framework: A Diagnostic View:

The TRAC+E model (Teaching, Resources, Assessment, Curricula, and Environment) reveals where the “Bottlenecks” exist in teacher training programs.

T-Teaching (Pedagogy)

Status: Predominantly lecture-based.

Barrier: Lack of professional development for teacher educators.

Success Factors: Programs using eco-clubs and project-based learning show higher impact.

R-Resources:

Status: Most institutions lack specialized tools.

Barrier: Limited access to GIS tools, digital simulations, or environmental labs.

Success Factors: TEIs with “Green Campus” initiatives provide better applied learning.

A-Assessment:

Status: The weakest link.

Barrier: Current systems do not evaluate competencies like creativity or collaboration.

Required: Transition to portfolios, reflective journals and community audits.

C-Curriculum:

Status: Theory-heavy.

Barrier: Sustainability is often “Pushed” into elective courses.

Required: Inclusion of sustainability-focused activities in mandatory practicum.

E-Environment (Institutional Culture)

Status: Inconsistent leadership.

Barrier: Lack of incentives for institutions to adopt sustainable operations.

Success Factors: Institutions that model eco-friendly operations create a “hidden curriculum” of sustainability

VI. CONCLUSION FROM TRAC+E ANALYSIS

The analysis reveals that while India possesses a robust Policy Roadmap, the application within Teacher Education Institutions remains Isolated and theoretical. To achieve genuine impact, TEIs must move Beyond “Teaching About” the environment to “modeling” sustainability through every of their teaching, resources, and institutional culture.

Strategic Roadmap for Education for Sustainable Development (ESD):

The integration of ESD into the Indian teacher education framework requires a multi-layered approach involving policy shifts, institutional restructuring and research-driven innovation.

1. Policy & Regulatory Reforms:

To create systematic change, the NCTE and SCERTs must move beyond recommendations toward mandatory standards.

Accreditation Standards: Integrate ESD competencies as a requirement for institutional accreditation.

Mandatory Practicum: Require student-teachers to complete field projects addressing local environmental issues.

Strategies Funding: Allocate dedicated budgets for:

Transitioning institutions into Eco-campus.

Developing open-access digital repositories for sustainability resources.

2. Transforming Teacher Education Institutions (TEIs)

TEIs should serve as “Living laboratories” for sustainability by adopting a Whole-Institution Approach.

Eco-Management: Implement green operations (Solar power, waste management, water harvesting)

Curriculum Redesign: Shift from soloed subjects to an interdisciplinary model where sustainability is woven into every discipline.

Community synergy: Establish formal partnerships with local NGOs and environmental groups to bridge the gap between theory and practice.

3. Capacity Building for Teacher Educators:

Training must shift from “One-off” seminars to continuous professional growth.

From workshops to PLCs: Foster Professional Learning Communities (PLCs) and Action Research to encourage long-term mentoring.

Core Pedagogical Training: Educators must master specialized teaching tools:

Inquiry-Based Learning: Encouraging students to ask “Why”? And “How”?

Place-Based Education: Using the local community and landscape as the primary classrooms.

Competency Assessment: Developing methods to measure values and behaviors, not just rote facts.

4. Future Research Agenda:

Evidence-Based research is crucial to validate the impact of ESD and identify what works in the Indian context.

Sl No.	Research Area	Focus Objectives
1	Longitudinal Studies	Tracking how ESD training changes long-term classroom behavior
2	Tool Development	Creating validated rubrics to measure “Sustainability Competencies”.
3	Comparative Analysis	Mapping ESD success across different Indian States to find replicable models.
4	Barrier Identification	Pinning region-specific challenges (Cultural, economic or logistical).

VII. LIMITATIONS:

This review is subject to several limitations:

1. Scope of sources while major databases such as Scopus and Google scholar were consulted, some region-specific or unpublished institutional studies may not have been included.
2. Dependence on available Research Quality Much of the existing literature is based on self-reported data, small samples and cross-sectional designs, necessitating cautions interpretation of the findings.
3. Limited Access to institutional Practices Implementation varies widely across TEIs in India, and available studies may not adequately or under-resourced institutions.
4. Variation in Terminology The use of differing terms-such as ESD, environmental education (EE), and sustainability education-complicates the synthesis of findings into consistent categories.
5. Incomplete Documentation of the Policy-Practice Gap while policies are well-recorded, detailed assessments of how TEIs interpret and execute them remain scarce.

VIII. CONCLUSION

Policy momentum from initiatives such as the National Education Policy 2020 and UNESCO Education for Sustainable Development frameworks presents a significant opportunity to integrate environmental responsibility into Indian teacher

education. However, the transition from policy to sustained implementation has been inconsistent. Research identifies several viable, evidence-based strategies-including competency-focused curricula, hands-on practicum experiences, professional development for educators and interdisciplinary collaboration-yet there is a scarcity of empirical data regarding their long-term effects. To fully harness teacher education as a catalyst for environmental responsibility, coordinated efforts must be directed toward curriculum development, faculty enhancement, assessment mechanisms and research investment. Longitudinal studies and standardized competency indicators will be essential to inform and scale effective reforms.

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