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Article

Understanding Teachers' Preparedness for Climate Change and Sustainability Education: A Narrative Review (2015–2026)

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Abstract:

This narrative review examines teachers' preparedness for climate change and sustainability education between 2015 and 2026. Anchored in the ESD for 2030 Framework, Pedagogical Content Knowledge (PCK), Social Cognitive Theory, and Transformative Learning Theory, it conceptualises preparedness as a multidimensional construct encompassing climate and sustainability knowledge, pedagogical competence, self-efficacy, professional development, and institutional support. Across diverse contexts, teachers show strong support for sustainability and recognise the importance of climate change education, yet report limited climate literacy, uncertainty about pedagogical strategies, low instructional confidence, and inadequate access to sustained professional learning. Teacher education programmes often embed sustainability inconsistently, treating it as peripheral rather than integral. Structural barriers such as fragmented curricula, scarce resources, weak institutional leadership, and insufficient policy guidance further constrain implementation. Evidence highlights that sustained, collaborative, and practice-oriented professional development, including university–school partnerships and professional learning communities, significantly enhances teachers' confidence and competence. The review argues that improving preparedness requires coordinated efforts among teacher education institutions, schools, policymakers, and professional development providers. Systematic integration of climate change and sustainability into pre-service curricula, ongoing professional learning, and supportive policy and institutional frameworks are essential for enabling teachers to deliver transformative, action-oriented climate and sustainability education.

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1. INTRODUCTION

Climate change is widely recognized as one of the most pressing global challenges of the twenty-first century, affecting environmental, social, economic, and educational systems worldwide. Rising temperatures, extreme weather events, biodiversity loss, and increasing environmental uncertainties have intensified calls for educational responses that equip learners with the knowledge, skills, values, and competencies needed to address climate-related challenges. Consequently, climate change education (CCE) and sustainability education have emerged as critical components of contemporary educational agendas and are increasingly viewed as essential for promoting climate literacy, environmental responsibility, and sustainable development (Leve et al., 2023; Gleeson & Morrissey, 2024; UNESCO, 2020; United Nations, 2015). The growing emphasis on climate change education is consistent with the principles of Education for Sustainable Development (ESD), which advocate the integration of sustainability across all levels of education to prepare learners to address complex environmental and societal challenges (Hopkins & McKeown, 2002; Tilbury & Wortman, 2004; Mochizuki & Bryan, 2015;

Tilbury, 2011; UNESCO, 2017).

Education has been identified as a key mechanism for fostering informed and responsible citizens capable of understanding the causes and consequences of climate change and contributing to sustainable solutions. Within this context, Education for Sustainable Development (ESD) emphasizes the integration of environmental, social, and economic dimensions of sustainability into teaching and learning processes. ESD seeks not only to increase awareness of environmental issues but also to encourage critical thinking, systems thinking, problem-solving, and active participation in addressing sustainability challenges (Perwitasari et al., 2023; Sterling, 2004; UNESCO, 2020). Rather than focusing solely on environmental knowledge, ESD promotes transformative learning experiences that empower individuals to make informed decisions and participate actively in creating more sustainable societies while fostering key sustainability competencies essential for addressing global challenges (O'Sullivan, 2003; Sterling, 2011; Rieckmann, 2018; UNESCO, 2017).

Teachers occupy a central position in achieving the goals of climate change and sustainability education. As curriculum implementers, facilitators of learning, and agents of social change, teachers influence how environmental and climate-related issues are understood and addressed within educational settings. Effective climate change education depends largely on teachers' ability to interpret climate science, integrate sustainability concepts into their teaching practices, and engage students in meaningful discussions and actions related to environmental challenges. However, research suggests that many teachers experience difficulties in teaching climate change because of insufficient content knowledge, limited pedagogical preparation, inadequate institutional support, and a lack of professional development opportunities (Parry & Metzger, 2023; Leve et al., 2023; Competente, 2019; Corrochano et al., 2022). Teacher preparedness should therefore be understood as a continuous process of professional learning supported through sustained professional development, collaborative learning, reflective practice, and institutional commitment rather than isolated training initiatives (Burns, 2011; Clarke & Hollingsworth, 2002; Darling-Hammond et al., 2017; Inwood & Kennedy, 2020; Korthagen, 2016).

Recent studies have further highlighted concerns regarding teachers' preparedness to address climate change in educational contexts. Teacher preparedness extends beyond factual knowledge and includes attitudes, beliefs, pedagogical competencies, confidence, and the capacity to translate complex climate issues into age-appropriate learning experiences. Evidence from different countries indicates considerable variation in teachers' readiness to teach climate-related topics, with many educators reporting uncertainty regarding climate science and effective instructional approaches (Moshou & Drinia, 2023; Hanke & Schmalor, 2025; Uitto & Saloranta, 2017; Danaher et al., 2021; Albion et al., 2025). Preparing teachers for sustainability therefore requires not only strengthening climate literacy but also developing reflective practice, interdisciplinary perspectives, sustainability competencies, and transformative pedagogies that enable educators to respond effectively to emerging environmental challenges (Brundiers et al., 2010; Evans et al., 2017; Rahardjanto et al., 2025; Rieckmann, 2018).

Despite increasing scholarly attention to climate change education and Education for Sustainable Development (ESD), the existing literature remains fragmented, with studies examining different dimensions of teacher preparedness across diverse educational contexts. While previous research has explored teachers' climate literacy, environmental attitudes, sustainability competencies, and professional development, there remains a need to synthesize these findings to provide a comprehensive understanding of how teachers are being prepared to integrate climate change and sustainability into educational practice. A narrative synthesis of the available literature can help identify common themes, emerging trends, persistent challenges, and areas requiring further investigation. Furthermore, synthesizing evidence from different educational contexts can contribute to the development of comprehensive teacher education programmes, whole-school sustainability initiatives, and policy frameworks that support sustainability education (Lotz-Sisitka et al., 2015; Vare & Scott, 2007; Henderson & Tilbury, 2005; Tilbury, 2011).

Accordingly, this review aims to examine the existing literature on teachers' preparedness for climate change and sustainability education published between 2015 and 2026. Specifically, the review seeks to: (i) examine teachers' knowledge, attitudes, and pedagogical competencies related to climate change and sustainability education; (ii) identify the major barriers influencing teachers' preparedness; (iii) explore the role of teacher education and professional development in strengthening preparedness; and (iv) discuss implications for educational policy, classroom practice, and future research. By synthesizing evidence from diverse educational contexts, this review contributes to a broader understanding of how teacher preparedness can support the effective implementation of climate change and sustainability education.

Unlike previous reviews that have primarily focused on specific aspects of climate change education or Education for Sustainable Development, this review brings together evidence on teachers' preparedness by examining climate literacy, pedagogical competence, professional development, institutional support, and implementation challenges within a single integrated framework. By synthesizing recent literature across diverse educational contexts, the review identifies emerging trends, persistent gaps, and implications for teacher education, educational policy, and future research. The review also responds to the increasing international emphasis on preparing teachers as key agents of sustainable development and environmental transformation within formal education systems and aligns with global calls for strengthening teachers' professional capacities to implement Education for Sustainable Development (Tilbury, 2011; UNESCO, 2017; UNESCO, 2020; United Nations, 2015).

2. THEORETICAL FRAMEWORK

This narrative review is anchored in the Education for Sustainable Development (ESD) for 2030 Framework and supported by complementary theoretical perspectives that explain teachers' preparedness for Climate Change and Sustainability Education (CCSE). The ESD for 2030 Framework positions teachers as central agents in achieving sustainable development by equipping learners with the knowledge, skills, values, and attitudes required to address climate change and sustainability challenges through transformative, learner-centred, participatory, and action-oriented education (UNESCO, 2020). The framework emphasizes that teachers are not merely transmitters of knowledge but facilitators of critical thinking, responsible decision-making, and sustainable action. This perspective aligns with earlier foundational work on Education for Sustainable Development, which advocates integrating sustainability principles across educational systems to foster transformative learning and societal change (Hopkins & McKeown, 2002; Tilbury & Wortman, 2004; Sterling, 2004). Accordingly, the ESD for 2030 Framework provides the overarching lens for examining teachers' preparedness in the present review.

The review is further informed by Shulman's (1987) Pedagogical Content Knowledge (PCK) Theory, which proposes that effective teaching requires the integration of subject matter knowledge with appropriate pedagogical strategies. Within the context of climate change and sustainability education, teachers require not only a sound understanding of climate science, environmental sustainability, and sustainable development but also the pedagogical competence to translate these complex concepts into meaningful, contextually relevant, and age-appropriate learning experiences. This perspective highlights the importance of teacher education programmes that simultaneously develop disciplinary knowledge and pedagogical expertise (Loughran, 2006).

Bandura's (1997) Social Cognitive Theory, particularly the concept of teacher self-efficacy, provides an additional theoretical perspective for understanding teachers' preparedness. Self- efficacy refers to teachers' beliefs in their capability to organise and implement instructional practices that achieve desired learning outcomes. Teachers with higher levels of self-efficacy are more likely to adopt innovative teaching approaches, integrate sustainability concepts across the curriculum, and engage students in climate-related inquiry and action (Lohmann et al., 2021). Previous research also suggests that sustained professional development, institutional support, and collaborative learning opportunities contribute significantly to strengthening teachers' confidence and instructional effectiveness in sustainability education (Burns, 2011; Inwood & Kennedy, 2020).

The review is also informed by Mezirow's (1997) Transformative Learning Theory, which emphasizes the role of critical reflection, dialogue, and experiential learning in transforming individuals' perspectives and behaviours. Climate change and sustainability education extend beyond the transmission of scientific knowledge; they seek to encourage learners and educators to critically examine assumptions, reconsider values, and develop environmentally responsible behaviours. Similar arguments have been advanced within transformative sustainability education, which views education as a catalyst for personal, institutional, and societal transformation (O'Sullivan, 2003; Sterling, 2011).

Collectively, these theoretical perspectives provide a comprehensive conceptual foundation for understanding teachers' preparedness for climate change and sustainability education. They recognise that effective preparedness involves far more than acquiring factual knowledge; it encompasses pedagogical competence, professional identity, self-efficacy, reflective practice, sustainability competencies, and supportive institutional environments. Drawing on these complementary perspectives and the literature on educator competencies for sustainability (Corres et al., 2020; Wiek et al., 2011; Rieckmann, 2012), this review conceptualises teachers' preparedness as a multidimensional construct comprising climate and sustainability knowledge, pedagogical competence, attitudes and self-efficacy, professional development, and institutional support. These interconnected dimensions provide the analytical framework for synthesising and interpreting the literature reviewed in this study.

3. PURPOSE OF THE REVIEW

The growing recognition of climate change as one of the defining global challenges of the twenty- first century has intensified calls for educational systems to equip learners with the knowledge, skills, values, and competencies needed to contribute to a more sustainable future. Within this context, teachers occupy a pivotal role in translating climate-related concepts into meaningful learning experiences, fostering environmental awareness, and promoting responsible action among learners. Consequently, the effectiveness of climate change and sustainability education depends largely on the extent to which teachers possess the knowledge, pedagogical competence, confidence, and institutional support necessary to teach these complex issues effectively (UNESCO, 2020; United Nations, 2015).

Although research on climate change and sustainability education has expanded considerably during the past decade, existing evidence concerning teachers' preparedness remains dispersed across different educational settings, geographical regions, and methodological traditions. Previous studies have examined diverse dimensions of preparedness, including teachers' climate literacy, environmental attitudes, sustainability competencies, pedagogical content knowledge, self-efficacy, and professional development experiences (Competente, 2019; Corrochano et al., 2022; Danaher et al., 2021; Uitto & Saloranta, 2017). However, these findings have rarely been synthesised within a single framework capable of providing a

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comprehensive understanding of the factors influencing teachers' readiness to implement climate change and sustainability education.

The present narrative review seeks to address this gap by synthesising research published between 2015 and 2026 on teachers' preparedness for climate change and sustainability education. Specifically, the review examines how preparedness has been conceptualised and investigated across studies, identifies the key factors influencing teachers' readiness, and explores the challenges and opportunities associated with teaching climate-related issues. By integrating evidence from diverse educational contexts, the review develops a coherent understanding of teacher preparedness while identifying common patterns, emerging trends, persistent barriers, and implications for future research.

Given the increasing prominence of climate action and sustainable development within national and international educational agendas, a comprehensive synthesis of contemporary evidence is both timely and necessary. The findings of this review are expected to contribute to the growing body of scholarship on climate change and sustainability education while providing evidence-informed recommendations for teacher education, professional development, curriculum development, institutional leadership, and educational policy. Ultimately, the review seeks to support the preparation of teachers as key contributors to achieving the objectives of Education for Sustainable Development and the Sustainable Development Goals (Hopkins & McKeown, 2002; UNESCO, 2020; United Nations, 2015).

4. RESEARCH QUESTIONS

The review is guided by the following research questions:

RQ1. What are the major characteristics and trends of research on teachers' preparedness for climate change and sustainability education published between 2015 and 2026?

RQ2. How is teachers' preparedness conceptualized and measured in the existing literature?

RQ3. What evidence exists regarding teachers' climate-related knowledge, attitudes, competencies, and pedagogical practices?

RQ4. What barriers and challenges influence teachers' preparedness to teach climate change and sustainability-related topics?

RQ5. What recommendations have been proposed to enhance teacher preparedness through teacher education, professional development, and policy interventions?

5. METHODOLOGY

5.1. Research Design

This study employed a narrative review design to examine the existing literature on teachers' preparedness for climate change and sustainability education. A narrative review was considered appropriate because it enables the synthesis of evidence from diverse research designs and provides a comprehensive understanding of emerging concepts, trends, and challenges within a developing field (Green et al., 2006). Unlike systematic reviews, narrative reviews emphasize critical interpretation and thematic integration of the literature rather than exhaustive study identification or quantitative synthesis The review sought to explore how teachers' preparedness has been conceptualized in recent literature, identify recurring themes, examine challenges affecting preparedness, and discuss implications for teacher education, educational policy, and future research.

5.2. Literature Search Strategy

Relevant literature was identified through searches of major education and multidisciplinary databases, including ERIC and Google Scholar. Additional articles were located through reference list searches of relevant publications to ensure broader coverage of the topic. Searches were conducted using combinations of keywords such as 'climate change education', 'sustainability education', 'education for sustainable development', 'teacher preparedness', 'teacher readiness', 'teacher competence', 'teacher competency', 'pre-service teachers', 'in-service teachers', and 'professional development'. The review primarily considered publications published between 2015 and 2026 to capture recent developments in climate change and sustainability education. Foundational theoretical literature was also consulted where necessary to provide conceptual background.

5.3. Literature Selection

The literature was selected based on its relevance to the objectives of the review. Priority was given to peer-reviewed journal articles, scholarly books, book chapters, and reports published by recognized international organizations addressing teacher preparedness, climate change education, sustainability education, and Education for Sustainable Development (ESD).

Studies focusing specifically on teacher knowledge, attitudes, pedagogical competencies, professional development, and institutional support were examined in greater detail. Publications that were unrelated to teacher education or did not substantially contribute to the review objectives were not included in the narrative synthesis.

5.4. Data Analysis

The selected literature was analysed using a thematic approach. Each publication was examined to identify recurring concepts, patterns, and key findings related to teachers' preparedness for climate change and sustainability education. Similar ideas emerging across studies were grouped into broader thematic categories, enabling comparison of findings across different educational contexts. The analysis resulted in five major themes: (i) teachers' knowledge and climate literacy, (ii) attitudes and beliefs towards sustainability education, (iii) pedagogical competencies, (iv) barriers and challenges, and (v) professional development needs. These themes provided the basis for interpreting the literature and discussing implications for teacher education, educational practice, and policy.

6. FINDINGS

The analysis of the reviewed literature revealed five interrelated themes that explain teachers' preparedness for climate change and sustainability education. These themes encompass teachers' climate literacy, attitudes and beliefs, pedagogical competencies, barriers to implementation, and professional development needs.

6.1. Teachers' Knowledge and Climate Literacy

A recurring finding across the reviewed literature was that teachers generally recognized the importance of climate change and sustainability education but frequently reported insufficient content knowledge and conceptual understanding. Studies involving pre-service teachers in Australia, Spain, South Africa, and Indonesia revealed considerable variation in sustainability literacy, climate knowledge, and preparedness to teach sustainability-related concepts (Danaher et al., 2021; Corrochano et al., 2022; Rahardjanto et al., 2025; Jita & Thaanyane, 2026). Similar observations have been reported in earlier research, which argues that teachers require not only scientific understanding but also sustainability competencies that enable them to address complex environmental issues in educational settings (Hopkins & McKeown, 2002; Sterling, 2004). Research examining sustainability competencies among prospective teachers further indicated that teacher education programmes do not consistently prepare future educators for climate-related instruction (Rahardjanto et al., 2025). The findings therefore suggest that strengthening climate literacy should be regarded as a central objective of both pre-service and in-service teacher education, consistent with the goals of Education for Sustainable Development (UNESCO, 2020).

6.2. Teachers' Attitudes and Beliefs

The literature consistently indicates that teachers generally demonstrate positive attitudes towards sustainability, although these positive dispositions are not always accompanied by adequate knowledge, pedagogical competence, or confidence (Uitto & Saloranta, 2017; Competente, 2019; Corrochano et al., 2022). Teachers widely acknowledged environmental issues as important educational concerns and expressed strong support for integrating sustainability concepts across school curricula (Uitto & Saloranta, 2017; Horak et al., 2025; Albion et al., 2025). Similar findings were reported in studies conducted in Serbia, Australia, and South Africa, where teachers viewed sustainability education as essential for preparing future generations to address environmental challenges (Horak et al., 2025; Jita & Thaanyane, 2026). Despite these encouraging attitudes, the literature consistently identified a gap between teachers' commitment to sustainability education and their perceived readiness to implement it effectively. Several studies reported that teachers remained uncertain about selecting appropriate pedagogical strategies and translating sustainability concepts into classroom practice (Competente, 2019; Danaher et al., 2021). These findings reinforce earlier arguments that positive environmental attitudes alone are insufficient unless supported by professional competence and institutional support (Burns, 2011; Vare & Scott, 2007).

6.3. Pedagogical Competencies

The literature increasingly conceptualizes teacher preparedness as extending beyond content knowledge to include pedagogical competence. Effective climate change and sustainability education requires teachers to facilitate critical thinking, systems thinking, interdisciplinary learning, problem-solving, and action-oriented educational approaches (Sims & Falkenberg, 2013; Corrochano et al., 2022; Sterling, 2011). Several studies highlighted the effectiveness of inquiry-based learning, educational gardens, arts- based approaches, experiential learning, and community engagement in promoting sustainability learning (Corrochano et al., 2022; Jones et al., 2022). However, research on initial teacher education programmes consistently revealed that many teachers felt inadequately prepared to implement these innovative pedagogical approaches despite recognising their educational value (Jita & Thaanyane, 2026). These findings suggest that teacher education programmes should move beyond theoretical instruction towards practice-oriented experiences that strengthen pedagogical content knowledge and reflective teaching practice (Shulman, 1987; Loughran, 2006).

6.4. Barriers and Challenges

Multiple barriers to effective climate change and sustainability education were identified across the reviewed studies. The most frequently reported challenge involved insufficient preparation within teacher education programmes (Competente,

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2019; Danaher et al., 2021). Sustainability-related content was often incorporated inconsistently or treated as an optional component rather than an integral element of teacher preparation (Sims & Falkenberg, 2013; Hopkins & McKeown, 2002). Additional barriers included limited curriculum guidance, inadequate teaching resources, insufficient institutional leadership, limited collaboration, and inadequate professional development opportunities (Inwood & Kennedy, 2020; Madden, 2025). Studies conducted in developing educational contexts further highlighted financial constraints, resource limitations, and policy implementation challenges that restricted teachers' ability to integrate sustainability concepts effectively (Chen & Das, 2025; Rahardjanto et al., 2025). Collectively, these findings indicate that improving teachers' preparedness requires systemic support extending beyond individual teacher capacity to include curriculum reform, institutional commitment, and supportive educational policies (Tilbury & Wortman, 2004).

6.5. Professional Development Needs

Professional development emerged as one of the strongest determinants of teachers' preparedness for climate change and sustainability education. Across the reviewed studies, researchers consistently emphasized the importance of sustained, collaborative, and practice-oriented professional learning rather than isolated workshops or short-term training initiatives (Inwood & Kennedy, 2020; Madden, 2025). University-school partnerships, mentoring initiatives, professional learning communities, and collaborative networks were identified as particularly effective mechanisms for strengthening teachers' preparedness (Inwood & Kennedy, 2020). Evidence further suggested that teachers who participated in sustained professional development demonstrated greater confidence, stronger sustainability competencies, and increased willingness to implement climate-related learning activities within their classrooms (Madden, 2025; Jita & Thaanyane, 2026). These findings support previous scholarship emphasizing that continuous professional learning is fundamental to achieving the objectives of Education for Sustainable Development (Burns, 2011; Henderson & Tilbury, 2005).

7. SYNTHESIS OF FINDINGS

Overall, the reviewed literature demonstrates that teachers generally possess positive attitudes toward climate change and sustainability education but frequently lack the knowledge, pedagogical competencies, self-efficacy, and professional support necessary for effective implementation (Uitto & Saloranta, 2017; Corrochano et al., 2022; Horak et al., 2025). Across diverse educational contexts, teacher preparedness emerged as a multidimensional construct comprising climate literacy, sustainability values, pedagogical content knowledge, self-efficacy, professional development, and institutional support (Sims & Falkenberg, 2013; Rahardjanto et al., 2025; Corres et al., 2020).

A notable pattern emerging from the literature is that positive attitudes towards sustainability do not automatically translate into effective classroom practice. Rather, preparedness develops through the interaction of knowledge, pedagogical competence, reflective practice, institutional support, and continuous professional learning (Bandura, 1997; Burns, 2011; Sterling, 2011). Furthermore, the reviewed studies consistently suggest that fragmented curriculum integration and limited professional development remain significant obstacles to the effective implementation of climate change and sustainability education.

Collectively, these findings reinforce the principles of Education for Sustainable Development, which advocate a transformative approach to teacher education that integrates sustainability competencies throughout initial teacher preparation and lifelong professional learning (UNESCO, 2020; Hopkins & McKeown, 2002; Vare & Scott, 2007). The evidence therefore suggests that strengthening teachers' preparedness requires coordinated efforts involving teacher education institutions, schools, policymakers, and professional development providers to create supportive educational environments capable of preparing learners for an increasingly complex and climate- affected world.

8. DISCUSSION

The purpose of this ''narrative review" was to synthesize existing evidence on teachers' preparedness for climate change and sustainability education. The findings indicate that although teachers generally demonstrate positive attitudes toward sustainability and environmental responsibility, significant challenges remain regarding climate literacy, pedagogical competence, and professional preparedness. These findings reinforce growing concerns within the literature that educational systems have not yet adequately equipped teachers to address the complex environmental challenges of the twenty-first century. Similar concerns have long been emphasized within the Education for Sustainable Development (ESD) literature, which argues that sustainability education requires transformative changes in teacher education rather than the addition of environmental content alone (Hopkins & McKeown, 2002; Sterling, 2004).

One of the most significant findings of this review concerns the gap between teachers' positive attitudes and their instructional readiness. Consistent with previous research, teachers across diverse contexts expressed strong support for sustainability education and recognized the importance of preparing students for environmental challenges (Uitto & Saloranta, 2017; Horak et al., 2025). However, many teachers simultaneously reported limited confidence in their ability to teach climate-related topics effectively (Competente, 2019; Danaher et al., 2021). This finding suggests that motivation alone is insufficient for successful implementation and highlights the importance of strengthening teacher preparation programmes. Earlier studies similarly argue that teachers require sustained professional learning opportunities to translate

positive environmental attitudes into effective classroom practice (Burns, 2011; Henderson & Tilbury, 2005).

The review further revealed persistent concerns regarding teachers' climate-related knowledge and sustainability literacy. Studies involving pre-service teachers indicated considerable variation in conceptual understanding and climate literacy levels (Corrochano et al., 2022; Rahardjanto et al., 2025). Similar concerns have been identified in international climate change education research, where inadequate content knowledge frequently limits teachers' ability to address climate science accurately and confidently (Hopkins & McKeown, 2002; Sterling, 2004). Given the interdisciplinary nature of climate change, teachers require not only scientific knowledge but also an understanding of the social, economic, ethical, and political dimensions of sustainability. These findings support the argument that climate literacy should be embedded systematically within both pre-service and in-service teacher education programmes.

Another important finding relates to pedagogical competence. Effective climate change education requires approaches that encourage critical thinking, systems thinking, problem-solving, interdisciplinary learning, and active engagement with real-world environmental issues. The reviewed studies emphasized inquiry-based learning, project-based learning, educational gardens, community engagement, and arts-based approaches as promising strategies for sustainability education (Jones et al., 2022; Corrochano et al., 2022). Nevertheless, many teachers reported limited opportunities to develop these competencies during their pre-service preparation. This finding suggests that teacher education institutions should move beyond traditional content-focused approaches and prioritize transformative pedagogies that support sustainability learning and reflective practice (Shulman, 1987; O'Sullivan, 2003; Sterling, 2011).

The review also identified several structural barriers affecting teacher preparedness. Insufficient curriculum guidance, limited instructional resources, competing curricular priorities, and inadequate institutional support were among the most frequently reported challenges (Inwood & Kennedy, 2020; Madden, 2025). These barriers indicate that teacher preparedness should not be viewed solely as an individual responsibility. Rather, effective climate change education requires supportive educational environments, coherent policy frameworks, institutional leadership, and whole-school approaches to sustainability (Tilbury & Wortman, 2004; Lotz-Sisitka et al., 2015).

Professional development emerged as a particularly important factor influencing teacher preparedness. Studies consistently demonstrated that teachers who participated in sustained professional learning opportunities reported higher levels of confidence and instructional competence (Inwood & Kennedy, 2020; Madden, 2025). This finding supports the argument that professional development should be regarded as a continuous process rather than a one-time intervention. Ongoing opportunities for collaboration, reflection, mentoring, and practical application appear essential for strengthening teachers' capacity to implement climate change education effectively (Burns, 2011; Henderson & Tilbury, 2005).

Collectively, the findings suggest that teacher preparedness is a multidimensional construct encompassing knowledge, attitudes, pedagogical competence, self-efficacy, and professional learning opportunities. The evidence further indicates that current teacher education systems often emphasize environmental awareness while providing insufficient support for the development of practical teaching competencies. Addressing this imbalance is likely to be critical for improving the quality and effectiveness of climate change and sustainability education. These findings reinforce the principles of transformative sustainability education, which advocate integrating sustainability competencies throughout teacher preparation and lifelong professional learning (Sterling, 2011; Vare & Scott, 2007).

The findings of this review also have important implications for educational policy. As governments increasingly incorporate sustainability and climate literacy into national curricula, greater attention must be given to preparing teachers for these responsibilities. Without adequate teacher preparation, curriculum reforms may have limited impact on classroom practice. Consequently, policymakers should prioritize investments in teacher education, professional development, curriculum resources, institutional support mechanisms, and collaborative partnerships that facilitate the integration of climate change and sustainability education across educational settings. Such efforts are essential for achieving the broader objectives of Education for Sustainable Development and the Sustainable Development Goals (UNESCO, 2020; United Nations, 2015; Hopkins & McKeown, 2002).

9. IMPLICATIONS FOR TEACHER EDUCATION, POLICY AND PRACTICE

9.1. Implications for Teacher Education

The findings of this review suggest that teacher education programmes play a critical role in preparing future educators to address climate change and sustainability challenges. Although many pre-service teachers demonstrate positive attitudes toward sustainability, the evidence indicates that teacher preparation programmes do not consistently provide sufficient opportunities to develop climate literacy, sustainability competencies, and pedagogical skills required for effective classroom implementation (Corrochano et al., 2022; Danaher et al., 2021; Rahardjanto et al., 2025). These findings reinforce earlier scholarship, which argues that sustainability should be embedded throughout teacher education rather than treated as an isolated topic or elective component (Hopkins & McKeown, 2002; Sterling, 2004).

Teacher education institutions should therefore integrate climate change and sustainability education more systematically

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across curricula by combining scientific understanding with pedagogical content knowledge and sustainability competencies. Opportunities for experiential learning, interdisciplinary collaboration, community engagement, inquiry-based learning, and reflective practice should be embedded throughout teacher preparation programmes. Such approaches are likely to strengthen teachers' confidence, pedagogical competence, and capacity to facilitate meaningful sustainability learning experiences (Shulman, 1987; Loughran, 2006; Sterling, 2011).

9.2. Implications for Professional Development

The review highlights the importance of continuous professional learning in strengthening teachers' preparedness for climate change and sustainability education. Many practising teachers reported limited formal preparation and expressed a need for additional support, training, mentoring, and instructional resources (Inwood & Kennedy, 2020; Madden, 2025). These findings indicate that teacher preparedness should be viewed as a lifelong professional learning process rather than a competency acquired during initial teacher education alone. Educational authorities should therefore develop long-term professional development initiatives that promote collaboration, reflection, mentoring, classroom application, and continuous knowledge updating. Professional learning communities, university-school partnerships, interdisciplinary workshops, and peer-learning networks may provide effective mechanisms for supporting teachers as they integrate climate-related topics into their instructional practice (Burns, 2011; Henderson & Tilbury, 2005). Sustained professional development is also likely to enhance teachers' self-efficacy, instructional confidence, and willingness to adopt innovative pedagogical approaches (Bandura, 1997; Lohmann et al., 2021).

9.3. Implications for Educational Policy

The findings indicate that educational policy plays a significant role in shaping teachers' preparedness. Although sustainability and climate literacy are increasingly incorporated into curriculum frameworks worldwide, implementation often remains inconsistent because of insufficient policy guidance, limited institutional support, and inadequate professional learning opportunities. Similar concerns have been highlighted in international literature on Education for Sustainable Development, which emphasizes that curriculum reform alone cannot achieve meaningful educational change without corresponding investments in teacher capacity and institutional commitment (Tilbury & Wortman, 2004; Lotz-Sisitka et al., 2015). Policymakers should therefore ensure that climate change and sustainability education is accompanied by clear curriculum expectations, appropriate teaching resources, sustained funding, and targeted teacher education initiatives. Greater alignment between curriculum reform, teacher preparation, professional development, and institutional leadership is likely to improve the effectiveness of sustainability education while contributing to the broader objectives of the Sustainable Development Goals and the UNESCO Education for Sustainable Development 2030 Framework (UNESCO, 2020; United Nations, 2015).

9.4. Implications for Classroom Practice

The review suggests that effective climate change and sustainability education requires teaching approaches that extend beyond the transmission of factual information. Teachers should be encouraged to adopt learner-centred pedagogies that promote critical thinking, systems thinking, problem-solving, collaboration, and active participation in addressing sustainability-related issues. Such approaches are consistent with transformative learning perspectives, which encourage learners to critically examine assumptions and develop responsible environmental behaviours (Mezirow, 1997; O'Sullivan, 2003). Inquiry-based learning, project-based learning, outdoor education, educational gardens, community engagement activities, interdisciplinary teaching, and arts-based approaches may help students develop deeper understanding of climate change and sustainability challenges (Jones et al., 2022; Corrochano et al., 2022). These pedagogical approaches can also strengthen learners' environmental responsibility, climate literacy, and civic engagement while preparing them to become active contributors to sustainable development. Consequently, classroom practice should move beyond knowledge transmission towards empowering learners to participate in creating more sustainable communities (Vare & Scott, 2007; Sterling, 2011).

10. CONCLUSION

Climate change and sustainability education have become increasingly important components of contemporary educational agendas as societies seek to respond to complex environmental, social, and economic challenges. As key facilitators of learning, teachers play a pivotal role in promoting climate literacy, environmental responsibility, and sustainable development among future generations. Consequently, understanding teachers' preparedness for climate change and sustainability education is essential for strengthening educational responses to global environmental challenges and achieving the objectives of Education for Sustainable Development (UNESCO, 2020; United Nations, 2015).

This narrative review synthesized research published between 2015 and 2026 on teachers' preparedness for climate change and sustainability education. The findings revealed that although teachers generally demonstrate positive attitudes toward sustainability and recognise the importance of climate-related learning, significant challenges remain regarding climate literacy, pedagogical competence, instructional confidence, institutional support, and access to sustained professional learning opportunities. Across diverse educational contexts, teachers expressed a willingness to

integrate sustainability into their teaching; however, many reported insufficient preparation to translate this commitment into effective classroom practice (Competente, 2019; Corrochano et al., 2022; Jita & Thaanyane, 2026).

The review further demonstrated that teacher preparedness is a multidimensional construct encompassing climate and sustainability knowledge, pedagogical competence, attitudes, self- efficacy, professional development, and supportive institutional environments. These findings reinforce the view that effective climate change education requires more than curriculum reform or increased environmental awareness. Rather, it depends upon comprehensive teacher preparation that develops sustainability competencies, reflective practice, and the capacity to facilitate transformative learning experiences (Hopkins & McKeown, 2002; Sterling, 2011; Burns, 2011).

Overall, the evidence suggests that strengthening climate change and sustainability education requires coordinated action across teacher education institutions, schools, policymakers, and professional development providers. Greater investment in pre-service teacher education, continuous professional learning, curriculum development, institutional leadership, and educational policy will be essential for preparing teachers to address increasingly complex sustainability challenges (Henderson & Tilbury, 2005; Lotz-Sisitka et al., 2015).

This review contributes to the growing body of literature by providing an integrated synthesis of recent evidence on teachers' preparedness for climate change and sustainability education across diverse educational contexts. The review also highlights the need for future research to evaluate the long-term effectiveness of teacher education programmes, examine innovative models of professional learning, and explore context-specific strategies for strengthening teachers' preparedness in different educational systems. By investing in teacher preparedness, educational systems can enhance their capacity to equip learners with the knowledge, skills, values, and competencies required to contribute meaningfully to a more sustainable and climate-resilient future (Vare & Scott, 2007; UNESCO, 2020).

DECLARATIONS

Author(s) Contribution

Dr. Noor Alam conceptualized the study, developed the methodology, performed the investigation, analyzed the data, and wrote the original draft. The author has read and agreed to the published version of the manuscript.

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AI was used for language structuring and drafting support during manuscript preparation. All content was reviewed, verified against cited sources, and edited by the authors.

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Availability of Data and Materials

This study is based entirely on publicly available documents, institutional reports, and published literature. No new datasets were generated or analysed during the current study.

Competing Interests

The authors declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this study.

Clinical Trial Registration (if applicable)

Not Applicable

Human Ethics and Consent to Participate

The study did not involve any clinical interventions or experiments requiring formal ethical approval, as it is based solely on the analysis of publicly available documents and published literaturel.

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