

MSc Global Healthcare Leadership Dissertation

Global Analysis of Climate Adaptation Policies for Promoting Environmentally Sustainable, Decarbonised Health Systems: A Scoping Review

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DEDICATION

To my son, the future.

To my late grandparents, the past, who birthed the future.

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LAY SUMMARY

As a medical doctor committed to doing no harm, I have observed how health systems - already stretched by changing patterns of infectious diseases and the effects of the COVID-19 pandemic - also contribute to environmental damage through emissions. This creates a double burden.

Consequently, I began considering how we can reduce the health sector's environmental impact and what role international gatherings like the annual Conference of Parties might play in fostering better policies that support sustainable health systems. This is especially relevant as climate adaptation gains recognition as an essential complement to climate mitigation in helping countries meet global targets. However, little is known about how governments are actually implementing climate adaptation policies or what factors assist them in doing so.

This gap became particularly evident after I hosted a roundtable in November 2024, where it was clear that many countries discuss strategies and plans on climate adaptation. Still, few understand how to implement them effectively, nor what lessons can be learned from those making progress - especially in lower-income settings.

To explore this further, I conducted a global scoping review using two well-established frameworks: the WHO's operational framework on building climate-resilient health systems and the Ottawa Charter on Health Promotion. I reviewed 26 publications to understand existing climate adaptation policies and the support systems that enable them. I found that most studies originated from high-income countries, and only a few addressed all of the WHO's critical areas. Policies related to leadership and governance were frequently mentioned in all 26 studies. In contrast, key policy areas focusing on air quality and waste management (i.e., environmental determinants of health) were mentioned sparingly. This has implications for the totality and

effectiveness of existing climate adaptation policies across countries. The crucial role of communities as an enabler, particularly in vulnerable regions, was also frequently overlooked. Furthermore, studies from lower-middle-income countries were grossly lacking.

Based on the findings, I recommended that policymakers strengthen governance structures, incorporate climate adaptation into domestic budgets, engage the private sector, and promote innovations that reflect the needs of local communities and health workers. I also suggested that countries begin with small, affordable, eco-friendly practices in primary care and expand using national guidelines that blend leadership at the top with local community participation. This would need to be informed by each country's vulnerability assessments.

Moreover, I called for more research on the real-world implementation of climate policies within health systems, particularly in low- and middle-income countries, using tools to evaluate their effectiveness, costs, and long-term impacts. I also proposed that future studies explore how communities, traditional knowledge, and emerging technologies, such as AI, can support adaptation, alongside economic analyses, to identify the most cost-effective actions for transforming health systems into more sustainable entities.

Overall, this thesis highlights critical policy gaps and practical opportunities to improve climate adaptation in health systems, providing a pathway for countries to adopt more informed and locally relevant actions as they confront the increasing health impacts of climate change.

ABSTRACT

Background - Climate change threatens human health and strains health systems, which must cut GHG emissions and boost resilience. While progress occurs in HICs, LMICs lack similar initiatives, limiting comparative analysis. There is little empirical evidence on climate adaptation (CA) policies and enablers, especially in LMICs. This thesis aims to address this gap by reviewing literature on global CA policies and enablers for sustainable, decarbonised health systems.

Method - A scoping review of peer-reviewed and grey literature from 2005 to 2025 was conducted, following the guidelines of Arksey and O'Malley, Levac *et al.*, and JBI. Six databases (PubMed, Web of Science, Scopus, JBI database, Overton, and WHO Global Index Medicus) were searched with relevant keywords. A deductive framework analysis mapped CA policies against the WHO's Operational Framework and their enablers to the Ottawa Charter for Health Promotion. The protocol was registered on Open Science Framework. PRISMA-ScR and scoping review guidelines were adhered to.

Results - Out of 2,632 studies, 26 studies met the inclusion criteria. 80% were published between 2023 and 2025, 42% from HICs, and 39% were original research. All 26 studies discussed 'leadership and governance', the most addressed component. Only 12% discussed 'managing environmental determinants of health'. The most common enabler addressed, related to the Ottawa Charter, was 'building healthy public policy', and the least was 'strengthening community action'. No studies from Nigeria or on the evaluation or implementation costs of CA policies.

Conclusion - This review highlights gaps in CA policy evidence for sustainable, decarbonised health systems, stressing the need for more research across geopolitical contexts, sharing lessons, and real-world experiences. This will help shift from fragmented efforts to comprehensive strategies that build resilience and support decarbonisation and transformative health system change.

Keywords – *Climate adaptation, resilience, health systems, health promotion, net zero, Nigeria, Ottawa charter, Building blocks*

1 INTRODUCTION

1.1 OVERVIEW OF CLIMATE ADAPTATION POLICIES IN HEALTH SYSTEMS

Climate change poses an unprecedented challenge to public health, with devastating consequences globally. ¹⁻⁶ The WHO has called climate change “the greatest threat to global health” of the 21st century. ⁵

Paradoxically, the healthcare sector, responsible for public health, significantly contributes to greenhouse gas (GHG) emissions and environmental harm. ^{7,8} This tension underscores the pressing need for health systems to adapt to climate change and evolve into environmentally sustainable, decarbonised entities. They must implement and advance climate adaptation (CA) policies to achieve decarbonisation.

CA policies in health systems involve strategies that bolster resilience to climate impacts, such as integrating climate risks into planning, building resilient infrastructure, and enhancing disease surveillance. ⁵ These are complemented by climate mitigation (CM) efforts to decarbonise health care, addressing both climate shocks and reducing the sector's climate footprint.

WHO's *Operational Framework for Climate-Resilient and Low-Carbon Health Systems* ⁹ emphasises transformative action to ensure health facilities can provide safe care in a changing climate while cutting emissions and resource use. This aligns with the fact that the global healthcare sector contributes approximately 4–5% of worldwide GHG emissions. ^{8,10,11} Thus, “climate-smart” health policies address both adaptation (building capacity to manage climate risks) and mitigation (pursuing sustainable, low-carbon operations) as interlinked goals.

Countries are adopting common policy strategies such as assessing climate-related health risks, creating Health National Adaptation Plans (H-NAPs) that align with broader National Adaptation Plans (NAPs), and setting standards for resilient health infrastructure and supply chains.¹² These include setting goals for achieving net-zero emissions in hospitals, enhancing energy efficiency, and transitioning to renewable energy sources within health facilities.^{13,14} Overall, the landscape of CA policies in health systems is evolving, driven by growing evidence of climate change's health impacts and global commitments to sustainable development (e.g., SDG 13 on Climate Action). However, a critical review shows that, despite having documented policies, their implementation remains inconsistent and often delayed.⁵

Key definitions of terms are in the thesis protocol on Open Science Framework (OSF), aligned with the United Nations Framework Convention on Climate Change (UNFCCC), WHO, and others.¹⁵⁻²³

1.2 THE RATIONALE FOR CLIMATE ADAPTATION POLICIES IN HEALTH SYSTEMS

The case for actively promoting CA policies within health systems is compelling and multifaceted, outlined in five points.

Firstly, climate change is presently affecting health through increased frequency of heatwaves, extreme weather events, alterations in infectious disease patterns, food and water insecurity, and other stressors.²⁴⁻²⁶ These effects threaten to overwhelm healthcare services and compromise health outcomes, particularly for high-risk populations such as the impoverished, elderly, children, and individuals residing in climate-vulnerable regions. Therefore, enhancing the resilience of health systems via CA policies is imperative to safeguard human lives and well-

being amid climate-related shocks.^{5,27} Consequently, a climate-resilient health system is an essential prerequisite for protecting public health in the context of climate change.⁵

Secondly, while CM and CA policies support SDG 13, CM efforts primarily focus on reversing climate change impacts on health, often neglecting CA efforts despite attempts to merge them at the 8th Conference of the Parties (COP 8) in 2002, through the Delhi Declaration.^{28,29} Therefore, advancing environmentally sustainable and decarbonised health systems requires developing well-designed CA policies and implementing nuanced practices.

Thirdly, there is an ethical and economic need to decarbonise health systems as part of CA policies. The healthcare sector is a major GHG emitter.^{8,10,11,30} This undermines the health sector's mission ("first, do no harm") and worsens climate-related health risks. The health sector can lead by example by reducing its carbon footprint and gaining significant co-benefits.^{31,32} These co-benefits strengthen the case for robust climate policies that improve care quality, reduce costs, and optimise health outcomes.

Authors have advocated for the addition of environmental sustainability as a sixth goal to health system performance, highlighting the need to address planetary needs while providing equitable, high-value care.³³ WHO emphasises that climate-resilient, low-carbon health systems are essential for universal health coverage (UHC) and SDGs, making climate action in health synergistic with strengthening health systems.⁹

Fourthly, the healthcare sector exhibits many features of a complex system, involving interactions amongst people, infrastructure, institutions, regulations, and financial expenditure. Adopting a systems thinking approach to CA policies can only benefit countries. However, this requires a holistic approach supported by research, evidence, alliances, cultural change,

contextual policies, and legislation.^{31,34} This is essential for change management and identifying health system levers to achieve a net-zero, sustainable future across high-income countries (HICs), upper-middle-income countries (UMICs), and lower-middle-income countries³⁵ (LMICs e.g., Nigeria).

Fifthly, promoting CA in health systems is crucial for achieving equity in public health, particularly as climate change disproportionately affects LMICs and vulnerable communities, often with already strained health systems.³⁶⁻³⁸ Investing in adaptation, like climate-proofing clinics and training health workers, helps prevent crises and economic losses. Failing to adapt worsens health disparities, especially in low-resource settings affected by climate-related issues disasters. CA is an upstream, preventive approach³⁹ aligned with public health principles and frameworks like the Ottawa Charter,⁴⁰ which emphasises enabling, mediating, and advocating for healthier environments. Health leaders must advocate for climate action, support communities, and coordinate efforts to protect health from climate-related threats. Leadership in developing equity-focused policies is crucial due to unequal GHG contributions across country income groups.^{7,41,42} Ignoring these issues may hinder progress toward resilient, decarbonised health systems and global CA goals.

1.3 GLOBAL INITIATIVES AND THE ROLE OF COP IN ADVANCING CLIMATE-RESILIENT, LOW-CARBON HEALTH SYSTEMS

The urgency to shift climate-health discourse has grown. Globally, efforts now focus on embedding CA into health systems, with UN climate conferences, such as the COP, serving as key venues for agenda-setting and tracking progress. Initially, health played a peripheral role in climate talks, but since the 2015 Paris Agreement, the climate-health link has gained

prominence. COP26 in 2021 marked a milestone, launching the COP Health Programme¹² led by the WHO and its partners. This initiative prompted 50 countries to pledge climate resilience and 45 to commit to low-carbon health systems, with some aiming for net-zero emissions by 2050. At COP27 in 2022, health had an even stronger presence, including the creation of the ATACH coalition.^{13,43,44}

By 2023, over 90 countries had committed to developing climate-resilient health systems, aligning their strategies with vulnerability assessments and climate funding efforts. International health actors, such as the WHO and the World Bank (WB), as well as civil society, actively promote these goals, with thousands of health workers advocating for the adoption of climate policies.^{9,12,38,45–48}

1.4 LEADERSHIP, GOVERNANCE AND ENABLERS FOR CLIMATE ADAPTATION IN DECARBONISING HEALTH SYSTEMS

Achieving resilient, low-carbon health systems that provide excellent clinical care requires large-scale change, shared decision-making, and effective governance. Designing policies is just one step; implementing and maintaining them demands strong governance models with political commitment, clear roles, collaboration, and accountability.^{38,49–52}

Traditional 'green' actions, such as recycling, are insufficient to achieve the necessary scale of decarbonisation; holistic initiatives with clear metrics are crucial to prevent greenwashing and align health and climate objectives.^{53,54} Neglecting these key components amid worsening health disparities poses a threat to UHC and global health goals.

Leadership and collaboration across sectors are fundamental, as climate impacts span many domains, requiring whole-of-society efforts. Governance models enabling intersectoral cooperation, community engagement, and supportive policies foster resilience.^{40,41,55–59} Equity considerations are crucial, especially in LMICs with resource constraints.⁶⁰

Countries making progress often establish dedicated climate units within health, form multisectoral climate-health groups, or enact laws requiring climate resilience in health infrastructure and services.^{61–66} Resources and capacity, including funding, workforce, data, and infrastructure, are vital enablers and barriers when neglected.^{5,55,67–73}

The Ottawa Charter emphasises⁵⁴ the importance of “healthy public policy” and “creating supportive environments. As such, governments need to develop policies that promote CA and foster resilience.^{40,41} Strengthening community action, a key strategic area outlined in the Charter, is vital - well-informed and involved communities can significantly enhance policy effectiveness.⁵⁹ Empowered communities^{55,56} hold authorities accountable and ensure adaptation measures are culturally and contextually appropriate,⁷⁴ enabling sustained change.

Equity and justice are vital in governing climate-adapted, low-carbon health systems. LMICs face challenges like funding shortages, workforce gaps, and unclear priorities. Adaptation and decarbonisation need tailored support, including international aid, technology transfer, and South–South knowledge exchange. Wealthier nations should reduce health sector emissions and share knowledge to support poorer countries, thereby strengthening global health equity.⁶⁰

Reducing emissions in high-income health systems mitigates climate impacts and supports LMICs' health access expansion. Strong global governance, including honouring climate finance

commitments, is fundamental, especially for complex federal systems ^{75,76} such as Nigeria's. Without this support, policies may exist but fail to be implemented where needed most.

1.5 STUDY RATIONALE

Health systems face mounting climate pressure, but evidence for adaptation and decarbonisation is fragmented and incomplete. Many countries' Nationally Determined Contributions (NDCs) and strategies are often underfunded and misaligned with the health sector's needs and priorities. ^{19,48,77,78}

Fossil fuel subsidies continue to surpass investments in climate-health, and adaptation policies frequently lack sustainable financing mechanisms, clear governance structures, and robust evaluation. ^{13,48}

Most reviews of CA in health systems have concentrated on HICs, leaving gaps in understanding for LMICs, where vulnerabilities are most significant. ^{67,79–82} Frameworks such as the WHO Operational Framework for Climate-Resilient Health Systems, ⁹ and the Ottawa Charter ⁴⁰ for Health Promotion are rarely applied to guide or assess adaptation policies in these contexts. This limits opportunities for comparative analysis, knowledge exchange, and the identification of transferable practices. ^{5,83–85} Weak policy harmonisation and poor data systems further prevent countries such as Nigeria from accessing climate finance, undermining efforts to build resilient and decarbonised health systems. ^{19,86,87}

This scoping review addresses these gaps by mapping global CA policies in health systems across income groups ³⁵. It applies established frameworks to highlight policy gaps, offering insights to guide reforms and strengthen resilience. ^{40,88–90}

These practical frameworks explore complex links between CA, health systems, and sustainability, guiding LMICs like Nigeria to revise strategies for net-zero health goals and resilience.⁵⁶ This sets the review apart from similar analyses.^{5,19}

1.6 AIM AND OBJECTIVES

This scoping review aims to map key CA policies that promote environmentally sustainable, decarbonised health systems and the factors that enable them.

Objectives include: (1) identifying and mapping global CA policies and enablers to decarbonise health systems using the WHO Framework and the Ottawa Charter, respectively. (2) describing study characteristics; identifying policies and interventions within health systems in HICs, UMICs, and LMICs; and (3) identifying gaps to guide future research.

1.7 THESIS OVERVIEW

Two frameworks guided the review. The WHO Operational Framework outlines how health systems prepare for climate shocks using ten components as a policy lens. The Ottawa Charter offers a socio-ecological perspective, emphasising health prerequisites, supportive environments, and policies that aid in mapping enablers for CA and decarbonisation as highlighted in the introduction.

Following this, Chapter 2 covers methodology, search strategy, inclusion/exclusion criteria, and data charting. Chapter 3 presents findings with a narrative synthesis of study characteristics, highlighting themes aligned with the WHO Framework and Ottawa Charter. Chapter 4

summarises findings, strengths, limitations, and future research directions. Chapter 5 concludes the thesis and proffers recommendations, and Chapter 6 reflects on the dissertation process.

2 METHODS

This scoping review followed the methodological framework outlined by Arksey and O'Malley⁹¹, Levac *et. al*⁹², and the Joanna Briggs Institute (JBI) guidance⁹³ for scoping reviews to ensure methodological rigour. Its suitability was confirmed by an interactive web tool⁹⁴ (available at <https://whatreviewisrightforyou.knowledgetranslation.net/>). The review complied with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews⁹⁵ (PRISMA-ScR) (Appendix B), and a protocol was published, a priori, on OSF in April 2025 (Appendix A - osf.io/a62ky).

2.1 STAGE 1: IDENTIFYING THE RESEARCH QUESTION

A preliminary literature search revealed a gap in CA policies regarding the promotion of sustainable, decarbonised health systems, particularly in LMICs.¹⁹ This led to the research questions guiding this scoping review –

1. What CA policies are in place to promote environmentally sustainable and decarbonised health systems in HICs, UMICs, and LMICs?
 - a. What are the enablers being deployed by countries for domesticating, applying, and translating these policies into action within health systems?
 - b. What might this mean for the promotion of environmentally sustainable and decarbonised health systems in LMICs (e.g. Nigeria)?

Enablers are factors, conditions, and mechanisms that facilitate the translation of CA policies into actionable health system strategies.

The Population, Concept, and Context (PCC) framework was used to formulate the research questions for this scoping review, as indicated in Table 1 below.

In articulating the purpose for undertaking this scoping review, ⁹² the review maps CA policies and enablers promoting sustainable, decarbonised health systems across income groups to guide future research and policy decisions within the climate-health ecosystem. It aligns with objectives (section 1.6).

Table 1 PCC criteria for the research questions and inclusion criteria

PCC element	Description	Inclusion criteria
<i>Population</i>	Countries with existing climate adaptation policies	Studies involving countries with climate adaptation policies
<i>Concept</i>	Environmentally sustainable, decarbonised health systems	Studies on environmentally sustainable, decarbonised health systems
<i>Context</i>	Health systems in HICs, UMICs, and LMICs	Studies from HICs, UMICs and LMICs

2.2 STAGE 2: IDENTIFYING RELEVANT STUDIES

Following JBI guidelines, ^{93,96,97} the initial step was a limited search of two online databases – PubMed and Web of Science. This was followed by analysing titles, abstracts, and index terms in the retrieved papers.

A second comprehensive search used key concepts, keywords, and index terms across six databases: PubMed, Web of Science, Scopus, JBI database, Overton, and WHO Global Index Medicus to find relevant literature (Appendix C). These databases, selected for their comprehensive coverage of CA policy, included peer-reviewed and grey literature. References

from reports and articles were also reviewed. Conducted from February to May 2025, the search utilised Boolean operators, keywords, and MeSH terms, following consultation with NR, a Senior Outreach Librarian at Oxford. The final search was on 10 May 2025.

Studies included in the review (Table 1) must be published in English from 2004 onward, in peer-reviewed journals or grey literature, such as opinion pieces, editorials, and commentaries on CA policies. Implementation in health systems of HICs, UMICs, and LMICs was included. The 2004 cutoff reflects CA's evolution, influenced by COP meetings. Language limitation was due to resource constraints.

Excluded studies were those published before 2004, not written in English, not related to CA policies, did not encompass health system domains, focused solely on CM, or did not differentiate between CA and CM policies.

2.3 STAGE 3: SELECTING RECORDS

Records found were exported to Covidence (www.covidence.org) and duplicates removed.

Covidence allows team members to blind their reviews from each other.⁹⁸⁻¹⁰⁰

The selection process involved title/abstract screening, followed by full-text review, which was conducted independently by two reviewers (DC and me) in accordance with standard practice.¹⁰¹

DC screened 10% of search outputs, 15% of evidence from title/abstract, and 20% from full-text, guided by literature.^{96,97} Cohen's kappa = 0.45 (moderate agreement) after title/abstract

screening; disagreements were resolved by discussion. Both reviewed all full texts to finalise inclusion, and citations of included articles were checked for additional relevant articles. The research flow, including record numbers at each step, is shown in Figure 1. Citations were

managed using Mendeley and included only those that met the criteria. Methodological quality and bias assessments were not part of this review. ^{91,102,103}

2.4 STAGE 4: DATA EXTRACTION

Data from studies, articles, and reports were manually extracted and verified with ChatGPT-5, ¹⁰⁴ then charted into a purpose-designed Microsoft Excel™ spreadsheet (Appendix D). This process reviewed publications with multiple CA policies and enablers to obtain all relevant details.

Selected studies were uploaded to ChatGPT-5 for data extraction based on frameworks used in this thesis. Discrepancies between the author's extraction and GenAI output were resolved by the author, who made the final decision.

During data extraction, additional fields beyond those specified in the protocol were included in the tool to detail key findings. Descriptive data collected encompassed Author, Title, Year, Country, WB income classification ³⁵ (HIC, UMIC, LMIC), Journal, Study Design, Methodology, Study Aim, and findings/themes aligned with CA policies mapped to the WHO's Operational Framework for Building Climate Resilient and Low-Carbon Health Systems.

Enablers were mapped to the Ottawa Charter's five action areas. These are summarised in Tables 2 and 3, section 3.2.

2.5 STAGE 5: COLLATING, SUMMARISING AND REPORTING RESULTS

After compiling data from the records, the presentation utilised tables and charts, including frequencies and proportions. Mapping to framework components and action areas showed CA policy areas and enablers with a doughnut pie chart (Figure 3). The focus was on policy

categories and contextual enablers, guided by the guidelines for conducting scoping reviews.

^{93,102} The analysis addressed each research question using descriptive overview, deductive framework analysis, ¹⁰⁵ and narrative summaries. All charts were made with Think-Cell (www.think-cell.com/en).

The WHO Operational Framework's ten components and the Ottawa Charter's five action areas were mapped to CA policies and enablers, supporting a structured narration of the results and discussions section for research questions “1” and “1a” (section 2.1).

The response to research question “1b” (section 2.1) used Table 4 to summarise implications for Nigeria, an LMIC, based on findings from four Canadian publications (a HIC reference). ^{106–109}

Both countries have federal systems, with unique challenges and implications for CA policies.

^{75,76,110}

3 RESULTS

The search identified 2,132 records from database searches and 500 records from grey literature searches. The PRISMA ¹¹¹ flow diagram is shown in Figure 1.

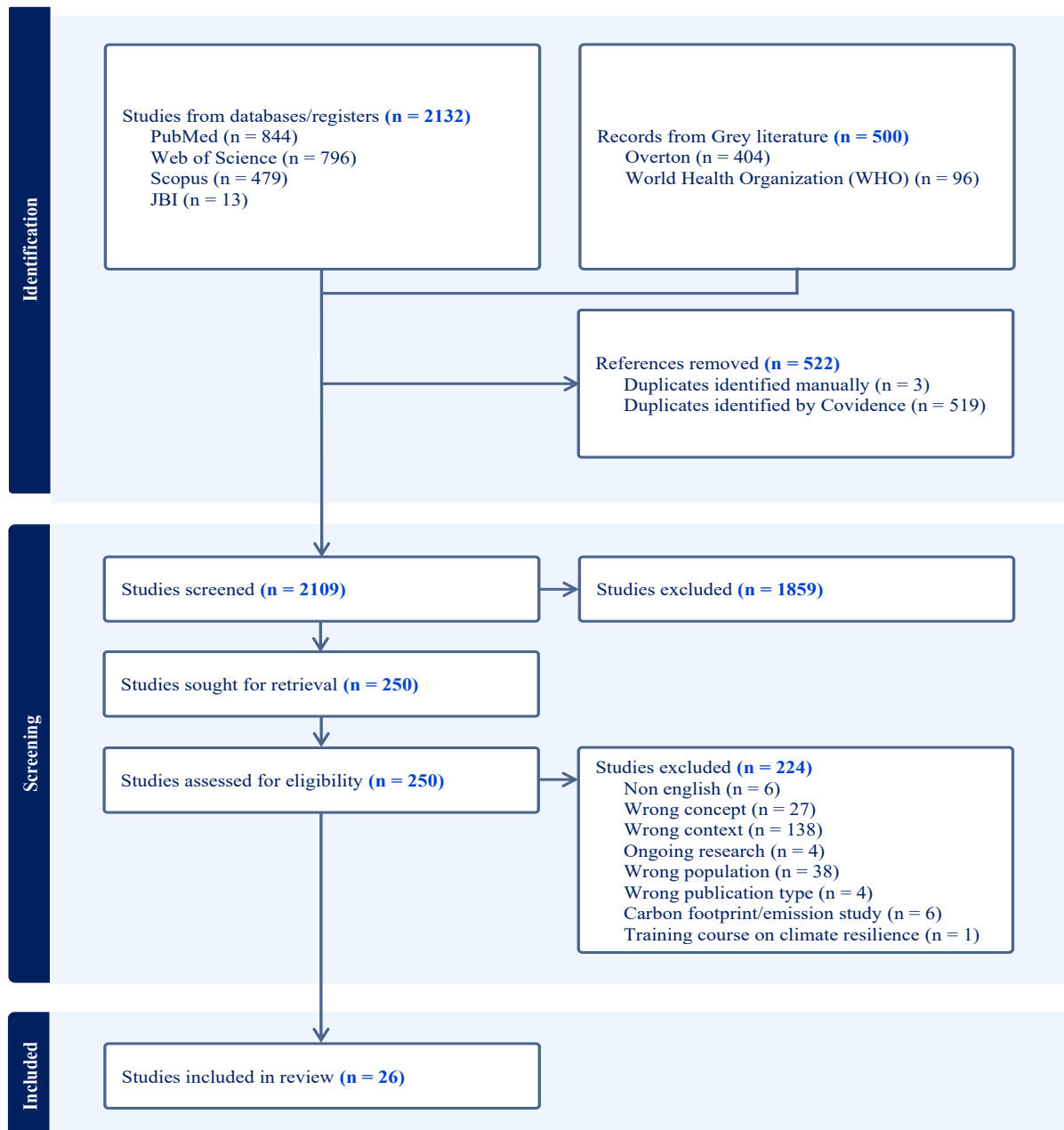


Figure 1 PRISMA flowchart detailing the articles included in the scoping review across phases

After removing 522 duplicates, publications were screened for relevance based on their titles and abstracts, resulting in the exclusion of an additional 1,869 records. Subsequently, 250 records were assessed for full-text eligibility, and 224 were excluded. In total, 26 records were deemed relevant and included in this review (Appendix E).

3.1 CHARACTERISTICS OF INCLUDED RESULTS

All 26 studies ^{19,22,23,41,106–109,112–129} were published between 2020 and 2025 (Figure 2A). 21 (80%) were published between 2023 and 2025. Of these, about half (n = 10) were published in 2024 alone ^{19,23,107,112,113,117,120–122,126}.

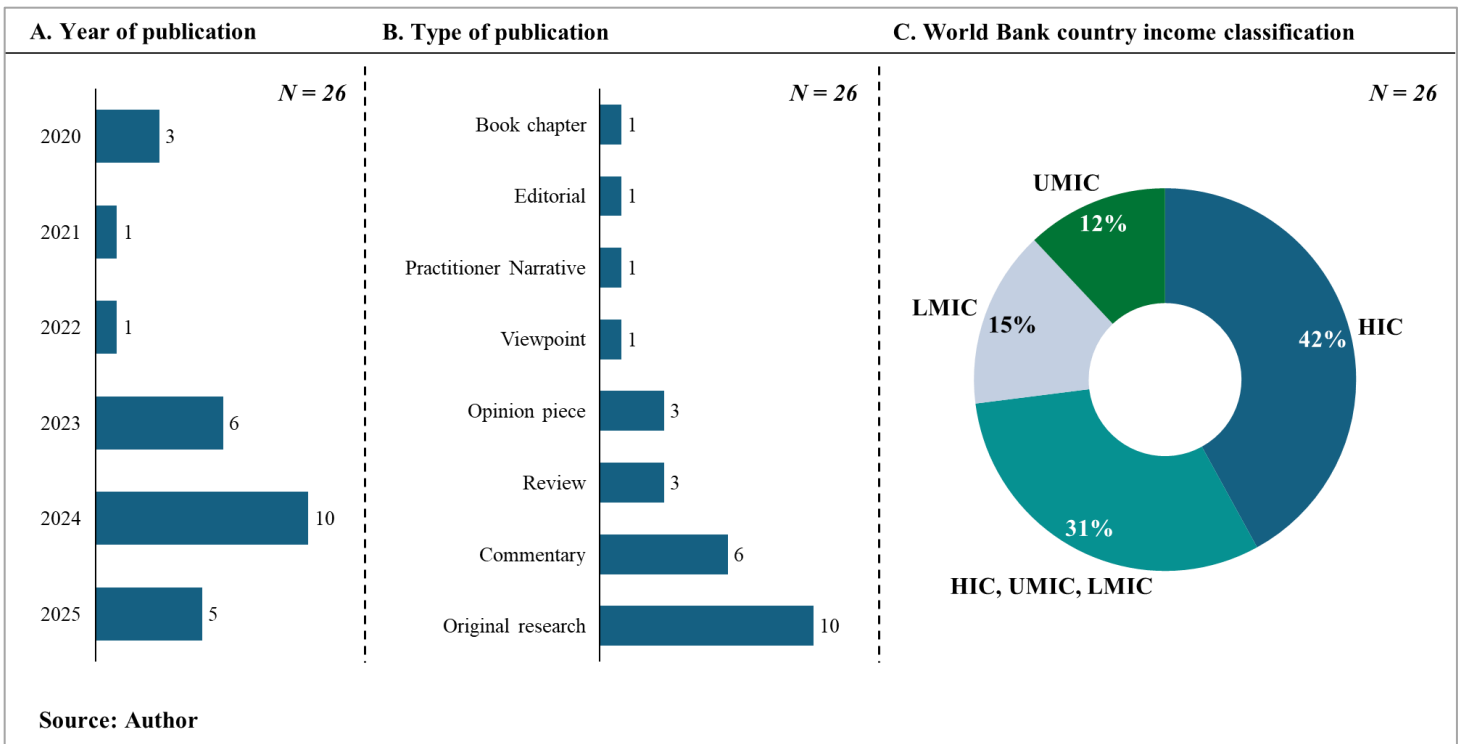


Figure 2 Characteristics of included studies. 2A - Year of Publication; 2B – Type of publication; 2C – Studies by World Bank country income classification

The distribution of the studies by publication type and study design is shown in Figure 2B. Out of the 26 studies (Figure 2B), 10 (39%) were original research.^{106–109,112,117,119,123,127,130} Six (23%) were commentaries,^{41,116,120,126,128,129} three (12%) were reviews,^{19,22,23} three (12%) were opinion pieces,^{114,124,125} and one study (4%) each was a book chapter,¹¹³ an editorial,¹²¹ a practitioner narrative,¹¹⁸ and a viewpoint.¹²² All original research was conducted in 2023 (n = 3),^{106,119,123} 2024 (n = 3),^{107,112,117} and 2025 (n = 4).^{108,109,127,130} About half of the original research (n = 5) consisted of evidence syntheses/scoping reviews (n = 2),^{112,119} qualitative studies (n = 2),^{107,127} and one mixed methods study.¹¹⁷ One of the six commentaries was a case study.¹²⁹

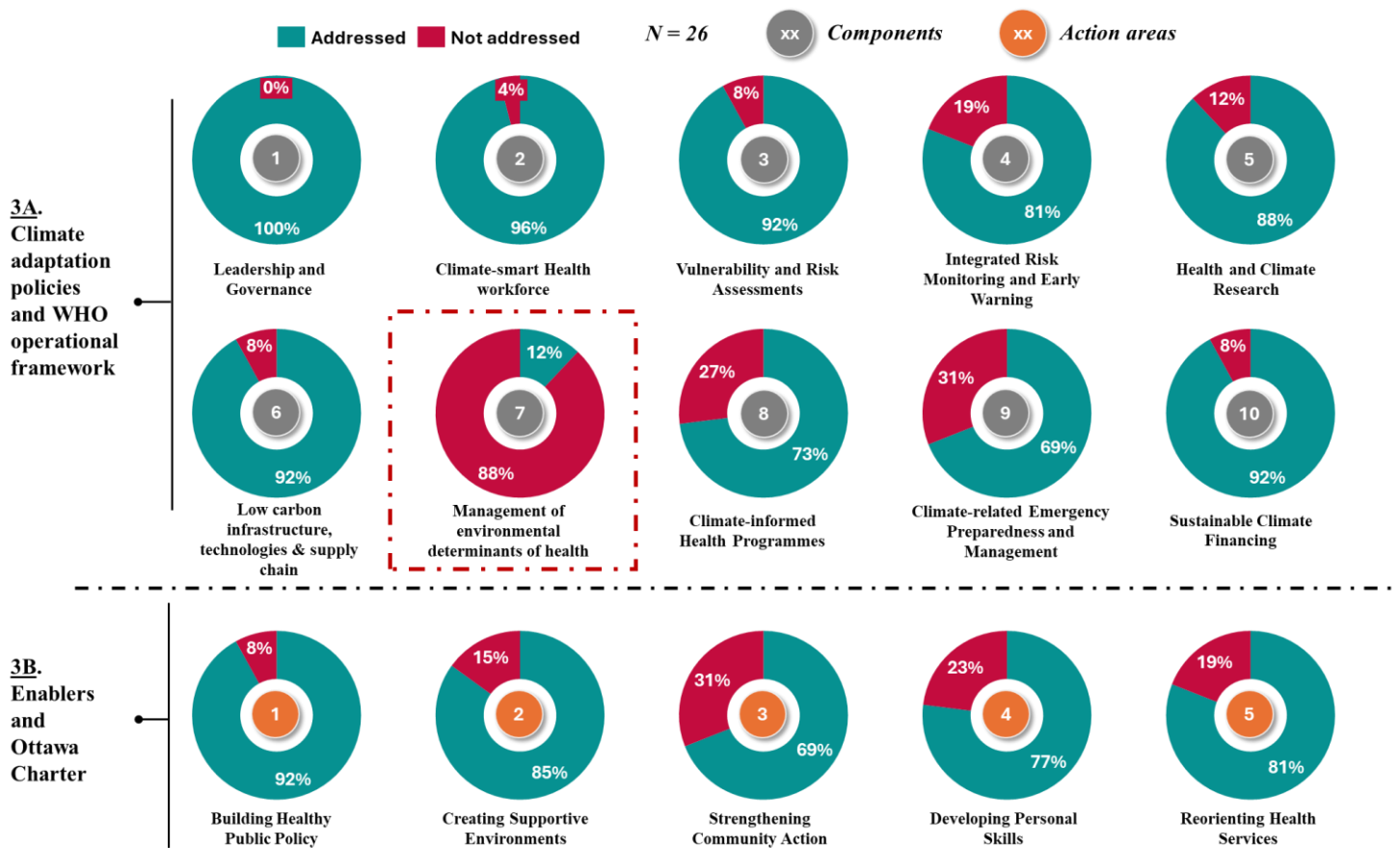
Using the WB income classification categories (Figure 2C, Tables 2 and 3), eleven (42%) of the studies were conducted in HICs - Australia (n = 1), Canada (n = 4), the US (n = 3), England (n = 1), the Netherlands & Bahamas (n = 1), and Italy (n = 1).^{106–109,113,114,122,124,125,128,130} Three studies (12%) were from UMICs - South Africa, Peru and Ecuador.^{117,123,126} Four studies (15%) were from LMICs - Kenya, India, Pakistan, and the least developed countries.^{118,120,121,127} Eight studies (31%) included combined analysis from all three categories (HIC, UMIC, and LMIC).^{19,22,23,41,112,116,119,129} No studies were identified from Nigeria, nor were there any studies evaluating CA policies.

3.2 FRAMEWORK ANALYSIS

Framework analysis, using a deductive approach,¹⁰⁵ was employed to map studies to the WHO Operational Framework and the Ottawa Charter. Figure 3, Tables 2 and 3 summarise findings for both frameworks.

3.2.1 CLIMATE ADAPTATION POLICIES IN HICs, UMICs, AND LMICs

CA policies aim to promote sustainable, decarbonised health systems in various income countries, mapped to the WHO Operational Framework's ten components. Figure 3A shows the proportion of studies for each component. Only 'leadership and governance' was addressed in all 26 studies. Other components were addressed in 12% to 96% of the studies (Figure 3A).



Source: Author

Figure 3 Output of deductive framework analysis and mapping of included studies. 3A - Climate Adaptation Policies mapped to the WHO Operational Framework. 3B – Enablers mapped to the Ottawa Charter action areas

3.2.1.1 Leadership and Governance

All 26 studies (100%) had this component addressed (Figure 3A). There are no unified governance structures or standardised accountability mechanisms,^{23,107} and in some cases, there is a complete lack of strategic policies (or plans) (e.g., Pakistan¹¹⁷) across countries. Governance structures for implementing CA policies vary, with approaches ranging from centralised and decentralised systems to community-led strategies.^{108,117,122,128}

Australia¹⁹, Canada (at the provincial level¹⁰⁹), and Norway¹⁹ - examples of HICs - have developed health and climate strategies, created roadmaps, or integrated climate considerations across multiple ministries (e.g., Netherlands¹¹³) into broader health sector planning or NDC¹¹⁶ (e.g. Peru¹¹⁷), including commitment to integrate health in all policies (HiAP).¹²² However, gaps remain, with only 8% of Canadian health authorities currently acknowledging climate change in strategic plans,¹⁰⁸ and progress remains fragmented across territories and provinces.¹⁰⁷ England has set long-term net-zero targets,^{114,125} incorporated into legislation⁴¹ including establishing a centralised Sustainable Development Unit (SDU)¹¹⁴ - now the Greener NHS National Programme - within the NHS. Spain, Belgium, the US, Western Cape Government in South Africa, the Victoria Department of Health in Australia, and Switzerland's largest private hospital have made similar long-term commitments to environmental sustainability in health systems.⁴¹

In Kenya,¹²⁷ CA leadership and governance are being aided by the Climate Change Act (2016), NAPs (2016), and a dedicated Climate Change and Health Strategic Working Group established in 2017. India has developed a comprehensive multilevel response to climate-health risks.¹²¹

Across other LMICs, NAPs and H-NAPs¹¹⁶ are being aligned within government structures and health systems, and integrated into climate planning for primary healthcare (PHC) management

through leadership, accountability mechanisms, and intersectoral collaboration.¹²³ A scoping review by Mosadeghrad *et al.*¹¹⁹ proposes the introduction of crisis leadership models across countries.

A major driver of these national-level CA agendas has been the COP, especially COP26; ATACH,^{19,108,127} participation at WHO-led climate-health policy dialogues,²² alignment with frameworks such as the One Health approach,^{41,118} and other sustainability frameworks.^{109,112}

3.2.1.2 Climate-smart Health Workforce

Figure 3A shows that 96% of reviewed studies addressed the climate-smart health workforce component. Policies in this component included formal support for clinicians to acquire new skills, voluntary or “hybrid” roles to lead sustainability initiatives^{19,119,131} or roles promoting behavioural change.⁴¹ Reports also note instances where no institutional training is provided.^{107,117} Although workforce planning indicators developed by the WHO exist, there are no “meaningful” data²³ or available data sources.

In HICs, national-level guidance and educational reforms on climate resilience and sustainability are either being advocated for or have already been incorporated into medical and nursing curricula. These initiatives have supported the adoption of clinical competencies and accreditation standards for climate-related training.^{19,106,109,112,116,119} In Australia, CA policies to upskill workers are aligned with a long-term human resources (HR) policy¹²² that addresses the evolving needs of health systems. Such needs include those in humanitarian settings.¹²⁹

In India, workforce initiatives include training programmes coordinated by national and state governments, as well as curricula tailored to different cadres of frontline health workers and

vulnerable occupational groups.¹²¹ In Peru (a UMIC), a lack of preparedness in health workforce training on climate-related risks has been reported.¹¹⁷

Across all income levels, greater awareness^{112,113,118,127,129} of ongoing implementation of CA policies is needed.

3.2.1.3 Vulnerability and risk assessments

This component was addressed in 92% of the studies reviewed (Figure 3A). Climate- and health-related vulnerability and risk assessments (VRAs) are being promoted in several HICs through frameworks such as the U.S. Building Resilience Against Climate Effects (BRACE) initiative.^{128,132} In the Netherlands, vulnerability and risk modelling are applied,¹¹³ and in Australia, vulnerability indices for climate-health risks are used.¹²² A structured, nationwide assessment does not exist in Canada,^{107,108} or Peru,¹¹⁷ and no health-specific VRAs are referenced in Italy.¹²⁴ According to a review by Blom *et al.*, only 25 (30%) of 82 countries committed to the COP26 Health Programme have conducted a vulnerability and adaptation assessment.²³

Kenya¹²⁷ (a LMIC) and Ecuador¹²⁶ (a UMIC) both recognise health system vulnerability in their respective national CA and surgical care strategies. Other LMICs, such as Colombia and Fiji, also conduct these assessments, which are linked to the NAPs.¹⁹

3.2.1.4 Integrated risk monitoring and early warning

National CA policy frameworks supporting climate-health surveillance and early warning systems - such as alert programs for wildfire smoke or integrated air quality monitoring - have been introduced,¹³⁰ and are being proposed or advocated for in several HICs and humanitarian settings.^{126,128-130} As seen in Figure 3A, 81% of the reviewed studies addressed this component.

In Italy, a monitoring framework exists theoretically.¹²⁴ In Peru, disease surveillance is siloed and basic, with no integration into climate-health early warning systems,¹¹⁷ whereas India has developed integrated systems to track climate-sensitive conditions¹²¹. A scoping review by Blom *et al.* found that only 5% of countries reported meteorological and health surveillance.²³

In Small Island Developing States (SIDS) in the western Pacific, there is reliance on regional or donor-supported disaster monitoring systems that operate independently of routine health data flows.²²

Proposed features for integrated early warning systems include the ability to track progress against sustainability targets;⁴¹ embed climate risk monitoring into decision-making and learning cycles;¹⁰⁶ integrate climate indicators into routine health surveillance systems;¹¹⁸ use multi-indicator systems;¹¹⁹ and foster the development of localised, climate-informed data systems¹²³ for anticipatory planning based on climate risk.¹¹³

3.2.1.5 Health and climate research

As in Figure 3A, 88% of studies addressed this component. Studies suggest that attention to supporting climate and health research is increasing.¹²⁵ Most climate and health research policies remain fragmented, are not part of a coherent national research strategy focused on health adaptation, and lack research-related indicators or coordinated global metrics.²³

In the US, innovative funding mechanisms and federal grants¹³⁰ support research, while the Netherlands uses environmental and health data to anticipate disease outbreaks.¹¹³ In Canada, despite hosting promising academic laboratories,¹⁰⁷ research uptake remains inconsistent. In Australia, inadequate funding and gaps in research prioritisation limit progress,¹²² and in India,

similar challenges in implementation and evidence translation have been reported.¹²¹ Peru lacks a national climate and health research agenda.¹¹⁷

There are calls to embed research into climate-resilient health planning at all levels,²² supported by advocacy for applied research and knowledge translation;¹¹⁹ investment in interdisciplinary implementation science for adaptation;¹¹⁸ fostering collaboration;⁴¹ ensuring dedicated funding;¹²⁴ and increasing engagement of the humanitarian sector in research on climate and health risks.

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3.2.1.6 Low-carbon infrastructure, technologies and supply chain

Under this component, 92% of the reviewed studies addressed low-carbon infrastructure, technologies, and supply chains (Figure 3A). HICs have established policies that incentivise infrastructure retrofits and emissions reduction in health facilities, often linked to broader climate legislation e.g., the U.S. Inflation Reduction Act¹³⁰ or Australia’s hospital energy efficiency programmes. These policies support renewable energy integration,¹⁹ green building standards,¹⁰⁷ climate-resilient facility,^{117,122} energy audits,¹⁹ building emission tracking²³ and circular health system models (Netherlands).¹¹³ However, such measures are often voluntary and inconsistently enforced (e.g., in Canada),¹⁰⁷ despite concerns about sustainability regarding the existing healthcare infrastructure.

UMICs and LMICs frequently rely on renewable energy sources¹²⁰ - such as solar power^{19,123,127} (Kenya, Singapore, and South Africa) - low-carbon sustainable buildings,^{19,127} infrastructure upgrades,¹²⁰ supply chains (including humanitarian supply chains) and transport,^{123,129} and technology applications (e.g., digital health records, telemedicine) in Ecuador¹²⁶ with long-term co-benefits such as reducing fragmentation within health systems.¹²⁶ India has issued

“Guidelines for Green and Climate-Resilient Healthcare Facilities,” which outline energy efficiency, water conservation, and waste management practices.¹²¹ In contrast, Peru has yet to incorporate climate-resilient infrastructure guidelines into its building codes or health facility design norms.¹¹⁷ In Pakistan, there is recognition of the potential role of private sector actors in investing in resilient infrastructure and supporting renewable energy for rural health systems.¹²⁰

3.2.1.7 Management of environmental determinants of health

Only 12% of studies (n = 2)^{117,121} addressed this component (Figure 3A). In Peru, environmental determinants are inconsistently integrated into disease programmes (e.g., dengue, diarrhoea)¹¹⁷ In contrast, India is experiencing a growing emphasis on heat-related illnesses, nutrition, and air pollution in its health campaigns and training.¹²¹

3.2.1.8 Climate-informed health programmes

Over 70% of reviewed studies addressed this component (Figure 3A). At the global level, WHO supports the mainstreaming of climate-health considerations into vertical programmes (e.g. dengue, nutrition).²² Some HICs have begun integrating climate considerations into disease surveillance and public health interventions, such as vector control and the management of chronic diseases. Few programmes are specifically tailored to CA, with a greater emphasis placed on carbon reduction than on adaptive service delivery.¹⁹ In the Netherlands, efforts target prevention, personalisation, and appropriate care, particularly through home-based service delivery.¹¹³

Long-term recommendations and policy directions include embedding climate considerations into UHC and essential service packages;¹¹² rethinking care delivery (e.g. telemedicine, reduced

operating room use during off-peak hours);⁴¹ and aligning clinical services with sustainability initiatives (e.g., Choosing Wisely, evidence-based low-carbon care).¹⁰⁹

3.2.1.9 Climate-related emergency preparedness and management

About 70% of reviewed studies addressed this component (Figure 3A). Across most settings, climate-specific emergency planning policies in the health sector are rare,¹⁹ underdeveloped, not specific, not comprehensive (e.g., Pacific region countries, Peru).^{22,117} They often exclude humanitarian settings,¹²⁹ and tend to be reactive (e.g., Canada).¹⁰⁷ Blom *et al.* reported that only 13 of 26 countries scored the maximum on the NDC health sector action category²³ which incorporates climate-related emergency preparedness. In Ecuador, the surgical health system emphasises interfacility coordination and stakeholder communication as central features¹²⁶ of existing climate-related emergency preparedness plans.

In the Bahamas, there is an emphasis on climate-resilient emergency response infrastructure,¹¹³ while in India, a relatively robust disaster management architecture exists alongside an institute that provides climate-health response training.¹²¹

3.2.1.10 Sustainable climate financing

More than 90% of reviewed studies addressed this component (Figure 3). Domestic fiscal space for adaptation is limited,¹²⁰ insufficient,¹²¹ and voluntary.¹⁰⁸ Analysis by Blom *et al.*²³ found that in most countries, government-financed health expenditure accounted for less than 50%, with many relying on private or external funds.²³

In HICs, fiscal instruments such as subsidies, tax credits¹³⁰, "green loans"¹²⁸ or grant programs support facility-level adaptation or decarbonisation efforts (e.g. in the U.S. and Australia). In

Canada, funding is constrained by short-term political cycles and the absence of earmarked climate-health budgets. ¹⁰⁷

LMICs are highly dependent on international climate funds such as the GCF and the WHO's Special Initiative on Climate and Health ²² or on innovation grants. ¹⁹ Kenya is exploring carbon credits and incentives; ¹²⁷ the Bahamas has mobilised GCF and other donor resources for adaptation planning; ¹¹³ budgetary allocations in India are insufficient; ¹²¹ and in Peru, the climate budget lacks detailed allocations to the health sector. ¹¹⁷

Table 2 Mapping of climate adaptation policies to components of the WHO Operational Framework for climate-resilient and low-carbon health systems

Included studies	Country/ WB income group	WHO Operational Framework for Climate-Resilient and low Low-Carbon Health Systems Components									
		Governance and Leadership	Health workforce	Vulnerability and Risk Assessments	Integrated Risk Monitoring and Early Warning	Health and Climate Research	Climate-resilient Technologies and Infrastructure	Management of environmental determinants of health	Climate-informed Health Programmes	Emergency Preparedness and Management	Climate and Health Financing
Armocida et al. (2022) ¹²⁴	Italy/HIC	Italy's National Prevention Plan recognises healthcare's role in climate mitigation, but healthcare is not explicitly addressed in broader national climate policies or the National Recovery and Resilience Plan (NRRP).	NRRP highlights the need for professional development around community-oriented and digital healthcare skills.	NRRP supports resilience-building and ecological transition but does not explicitly reference healthcare-specific vulnerability assessments.	Reference to monitoring frameworks (Ministerial Decree 77) exists theoretically.	Recommends dedicated investments in research on healthcare decarbonisation impacts.	NRRP promotes infrastructure improvements and energy efficiency at the regional level, but healthcare-specific actions are limited.	Not addressed.	Recognises importance of primary healthcare and telemedicine for reducing emissions indirectly.	Not addressed.	NRRP provides substantial funding for climate objectives but explicitly overlooks healthcare sector decarbonisation.
Smith (2023) ¹²⁵	England/HIC	NHS England has committed to reaching carbon net zero by 2040 for its direct operations and	Recommends formal support and hybrid roles, where clinicians have paid time allocated to	The publication implies that clinical practices must evolve in response to	Not addressed.	Highlights the critical role of research in driving innovation towards net zero.	General recommendations for sustainable capital investment to	Not addressed.	Advocates changing clinical practices to reduce carbon footprints	Not addressed.	Suggests financial investment and emphasises that carbon savings generally align with cost savings.

		by 2045 for its procurement and consumption.	sustainability initiatives.	climate risks, although explicit vulnerability assessments are not detailed.			facilitate net zero goals.		significantly.		
Smith et al. (2024) ¹²²	Australia/HIC	Australia's National Health and Climate Strategy outlining roles for clinicians, policymakers, and health departments including policy commitments to integrating health in all policies (HiAP).	Australia's current workforce policy (Medical Workforce 2021–2031).	The strategy's proposes frameworks and vulnerability indices for climate health risks.	Not addressed.	Recognition of inadequate targeted research funding compared to other countries (policy-level gap in research prioritisation).	Policy intentions to upgrade healthcare infrastructure for climate resilience.	Not addressed.	Not addressed.	Recognition in policy of disaster preparedness planning and workforce surge capacity as critical.	General recognition in policy of the need to finance climate adaptation efforts in healthcare.
Salas et al. (2020) ¹²⁸	US/HIC	Advocates integrating a climate lens into US health policy decision-making, emphasising national strategic climate preparedness plans.	Calls for the development of a climate-ready health care workforce through training and adaptive strategies.	Proposes conducting local vulnerability assessments to climate hazards in health care infrastructure planning.	Advocates establishing real-time national surveillance for climate-related health risks.	Emphasises enhanced funding and coordinated research, notably through institutions like National Institute of Environmental Health Sciences (NIEHS) and CDC.	Suggests decarbonisation measures (e.g., net-zero buildings) and resilience improvements (e.g., infrastructure reinforcement, energy diversification).	Not addressed.	Encourages developing standardised climate-informed clinical protocols (e.g., addressing medication impacts during heat waves).	Recommend strengthening hospital preparedness and infrastructure resilience planning against climate-sensitive extreme events.	Proposes "green loans" through Medicare and financial incentives to support decarbonisation investments.
Schwerdtle et	Global/HIC	Proposes climate-aware	Emphasises the need for a	Encourages climate-	Calls for improved	Recommends increased	Advocates for sustainable	Not addressed.	Urges integration	Highlights the need for	Recommends humanitarian

al. (2020) ¹²⁹	,UMI C,LM IC	leadership and governance, urging humanitarian organisations to integrate climate risks into strategic planning.	climate-informed humanitarian health workforce, advocating for targeted training and capacity building.	informed humanitarian needs assessments integrating climate vulnerability data.	integration of climate data into humanitarian early-warning systems (EWS).	humanitarian engagement in research on climate and health risks.	humanitarian supply chains and infrastructure.		of climate risk into humanitarian health programmes.	climate-resilient humanitarian emergency preparedness and capacity to pre-position relief materials.	organisations improve access to climate finance through targeted accreditations and funding models.
Hensher and McGain (2020) ¹¹⁴	US/HIC	Advocates explicitly embedding sustainability metrics into health systems governance frameworks and strategic goals.	Emphasises the need to build workforce capacity for sustainability through training and integration with quality improvement frameworks.	Suggests integration of sustainability risk assessments within performance frameworks, linking them with financial disclosures (e.g., Task Force on Climate-related Financial Disclosures).	Not addressed.	Recognises significant growth in research on healthcare's carbon footprint and environmental impact but emphasises the need for broader environmental metrics.	Urges hospitals and health systems to invest in low-carbon infrastructure and energy-efficient technologies.	Not addressed.	Proposes integrating sustainability measures explicitly into broader healthcare performance and quality measurement frameworks.	Suggests integrating sustainability into overall health care quality and safety measurement frameworks, indirectly related to preparedness.	Recommends financial transparency and alignment of climate disclosure with financial reporting practices.
Quintana et al. (2021) ¹¹⁶	Global/HIC, UMI C,LM IC	Urges strong governance for health system resilience by integrating climate risks explicitly into health policies, strategic plans (NAPs, H-	Recognises the need for building the resilience of health workforce as part of health system resilience.	Advocates explicit integration of health systems research on climate-related vulnerabilities into decision-making and national plans.	Encourages global collaboration and accountability mechanisms, indirectly suggesting the need for integrated risk monitoring.	Strong emphasis on the need for Health Policy and Systems Research (HPSR) to provide evidence on climate-resilient health systems.	Not addressed.	Not addressed.	Urges inclusion of climate considerations into H-NAPs.	Critiques humanitarian responses, advocating for the integration of local governance structures into emergency preparedness.	Calls for COP policy negotiations to explicitly ensure climate financing supports health systems research and interventions.

		NAPs, and NDCs).									
Kluge et al. (2023) ⁴¹	Multiple countries/ HIC, UMIC, LMIC	Urges the operationalisation of the One Health approach, aligning environmental sustainability with health systems governance. Calls for legally binding targets (e.g. NHS England's net-zero targets).	Advocates engagement of healthcare workers in sustainability through behaviour change, clinical decisions, and operational efficiency.	Highlights the need for baseline carbon footprint assessments to guide evidence-based targets.	Implicit need for monitoring systems to track progress against sustainability targets.	Stresses evidence-based target-setting and climate-health research collaboration.	Advocates transition to energy-efficient infrastructure and equipment across the sector.	Not addressed.	Suggests rethinking care delivery (e.g. telemedicine, reduced operations room use during off-peak hours).	Not addressed.	Emphasises long-term financial and political commitment to achieve environmental health system goals.
Martins et al. (2024) ¹¹²	Global/ HIC, UMIC, LMIC	Emphasises the need for coherent climate and health governance at national and global levels. Argues for the alignment of health systems with climate targets under frameworks such as the Paris Agreement and SDGs.	Calls for improving climate literacy and integrating climate-health competencies in workforce planning.	Points to the importance of data and assessments to identify climate-related vulnerabilities in health systems.	Suggests that early warning systems can improve anticipatory action in health systems.	Advocates investing in health systems research that includes climate change impacts, adaptation strategies, and co-benefits.	Highlights importance of transitioning to low-emission and resilient health infrastructure.	Not addressed.	Recommends embedding climate considerations into Universal Health Coverage and essential service packages.	Points to climate-driven disasters increasing health emergencies.	Argues for aligning financial flows with climate and health goals.
Thomson et al.	Canada/ HIC	Emphasises the need for health leaders	Advocates for increased carbon literacy	Encourages the use of tools like the	Suggests embedding climate risk	Promotes data-driven planning and learning	Suggests low-carbon and resilient	Not addressed.	Proposes aligning health	Acknowledges that health systems	Stresses the need for resource allocation via

(2023) 106		to incorporate both mitigation and adaptation into strategic plans and explicitly outlines the need for institutional accountability frameworks.	and climate education within the workforce.	Climate Atlas of Canada and WHO indicators to guide site-specific vulnerability assessments.	monitoring into decision-making and learning cycles.	health systems to support evidence generation.	infrastructure as a strategic imperative.		service delivery with climate projections and risks.	need to plan for climate-related shocks (e.g. power outages)	long-term planning.
Teshome (2023) 118	Least Developed Countries/LMIC	Emphasises the need for coherence between health and climate strategies, leveraging frameworks such as H-NAPs and One Health approaches.	Advocates for workforce climate literacy and awareness as critical to implementing adaptation.	Supports integrated surveillance and risk assessment through multi-hazard early warning systems.	Suggests integrating climate indicators into routine health surveillance systems.	Encourages investment in interdisciplinary implementation science for adaptation.	Proposes infrastructure investments such as energy-efficient retrofits and fleet upgrades.	Not addressed.	Highlights the need to embed sustainability in health service delivery (e.g. reducing superfluous energy use).	Links climate adaptation with ex-ante planning for emergency health services.	Advocates access to GCF, LDCF, SCCF and increased allocation for health in adaptation funding.
Mosadeghrad et al. (2023) 119	Global/HIC, UMIC, LMIC	Development of national health and climate change adaptation plans. Engagement in inter-sectoral and international collaboration. Introduction of crisis	Integrating climate change education into university curricula. Strengthening workforce training and capacity development.	Conducting health vulnerability and adaptation assessments	Proposes multi-indicator systems (e.g. Linares et al.'s 4-phase early warning model).	Strong advocacy for applied research and knowledge translation.	Infrastructure adaptation and resource allocation for climate-proofed services.	Not addressed.	Recommends integration of climate resilience into existing service delivery frameworks.	Includes preparedness in national plans and emergency communication strategies.	Emphasises cost estimation of inaction, access to climate funds, and cost-recovery models.

		leadership models and regulatory refinement									
Lokotola (2023) ¹²³	South Africa/UMIC	Encourages integration of climate planning into PHC management through leadership, accountability mechanisms, and intersectoral collaboration.	Calls for embedding climate-health education in training programmes.	Recommends climate vulnerability mapping at the PHC and community level.	Supports the development of localised, climate-informed data systems.	Advocates collaborative research with NGOs and universities to build evidence for decision-making.	Recommends investing in temperature-regulated storage, transport systems, and solar codes.	Not addressed.	Integrate early warnings and climate data into programme design.	Emphasises proactive planning for extreme weather and migration surges.	Encourages climate budgeting and resource mobilisation within the health sector.
Braithwaite et al. (2024) ¹¹³	Netherlands and Bahamas/HIC	Netherlands - “Dutch Green Deal Agreement in Healthcare” coordinated across four ministries and numerous stakeholders. Bahamas - “Blueprint for Change” and H-NAPs guide climate-health policy.	Emphasis on raising awareness and training for healthcare workers in climate adaptation.	Netherlands - Climate modelling used to anticipate health threats like malaria and dengue from freshwater reservoirs.	Both countries recognise need for anticipatory planning based on climate risk.	Netherlands highlights use of environmental and health data to anticipate disease outbreaks.	Netherlands aims for carbon neutrality in healthcare by 2050; circular health system models proposed.	Not addressed.	Netherlands targets prevention, personalisation, and appropriate care, especially home-based.	Bahamas emphasises climate-resilient emergency response infrastructure.	Bahamas has mobilised Green Climate Fund (GCF) and other donor resources for adaptation planning.
Hough and Tanugi-carresse	Global/HIC, UMIC, LMIC	Many countries (e.g. Norway, Australia) are creating national	Some countries integrate climate content into training; Forté	LMICs like Colombia and Fiji conduct assessments; links with NAPs.	Referenced indirectly via climate-health NAPs and	Not addressed.	Strong focus. Examples include solar in Singapore, energy audits in Canada, and	Not addressed.	Few programs specifically tailored; focus is more on	Some mentions (e.g. drone delivery in Norway); hospital-	Financial enablers acknowledged (e.g. GCF, UK Aid). Some countries support innovation grants.

(2024) ¹⁹		roadmaps and voluntary pledges (e.g. ATACH, COP26 Health Programme).	Hospital (NZ) uses staff sustainability roles.		adaptation plans.		low-carbon buildings (NZ).		carbon reduction than adaptive service delivery.	level climate-resilience actions are rare.	
Blom et al. (2025) ¹²⁷	Kenya/LMIC	Kenya has developed a Climate Change Act (2016), NAPs (2016), and joined the UNFCCC COP26 Health Programme. A dedicated Climate Change and Health Strategic Working Group (2017) was also established.	Not addressed	Kenya recognises health system vulnerability in national strategies.	Not addressed	Highlights the need for data to guide policy.	Energy Transition Plan promotes solarisation; climate strategy encourages sustainable buildings.	Not addressed.	Not addressed.	Not addressed.	Kenya is exploring carbon credits and incentives.
Blom et al. (2024) ²³	Global/HIC, UMIC, LMIC	No unified governance structures or standardised accountability mechanisms across countries.	The WHO framework includes workforce indicators, but no meaningful data on workforce planning or training is reported.	About 30% of countries reported having completed climate and health vulnerability and adaptation assessments.	Only 5% of countries reported meteorological health surveillance integration.	WHO's indicator set includes climate-health research tracking, but study notes the absence of research-related indicators or coordinated global metrics.	Some HICs (e.g., UK, France) track Scope 3 emissions; others don't.	Not addressed.	Not addressed.	Despite resilience being declared an objective, only 13 countries scored maximum on the NDC health sector action category.	Most countries had <50% government-financed health expenditure, with many reliant on private or external funds.

Vidal-Cuellar et al. (2024) ¹¹⁷	Peru/ UMI C	Peru has a National Strategy for Climate Change (ENCC), and the health sector is part of the NDCs with climate-health links.	Overall lack of preparedness in health workforce training on climate-related risks.	Peru's climate strategy identifies health as vulnerable; no formalised national climate-health vulnerability assessment exists.	Peru has basic disaster surveillance, but no integrated climate-health early warning systems were mentioned.	Peru lacks a national climate and health research agenda.	Climate-resilient infrastructure is mentioned as a need but not embedded into building codes or health facility design norms.	Environmental determinants are inconsistently integrated into disease programmes (e.g., dengue, diarrhoea).		The government has an emergency health contingency framework.	Peru's climate budget does not include detailed allocations to the health sector.
Akhtar and Reid (2024) ¹²⁰	Pakistan/ LMI C	Pakistan does not currently have a national action plan specific to climate-resilient health systems.	Not addressed.	Not addressed.	Use of AI, satellite data, and digital tools to enhance flood risk prediction and early warning systems. Sehat Kahani, a telemedicine platform, is highlighted as a tool for maintaining care access during disasters.	Not addressed.	article urges investment in resilient infrastructure and suggests that private actors (e.g. K-Electric, Engro Corporation) could support renewable energy for rural health systems.	Not addressed.	Not addressed.	Not addressed.	Domestic fiscal space for adaptation is limited.
Kumar et al. (2024) ¹²¹	India/ LMI C	India has developed a comprehensive multilevel response to climate-health risks, starting	Workforce initiatives include training programmes coordinated by national and	Not addressed.	India has developed integrated systems such as the Health Management Information	Gaps in implementation and in translating evidence into action.	India has issued Guidelines for Green and Climate-Resilient Healthcare	There is growing inclusion of heat-related illness, nutrition, and air pollution in health campaigns and training.		India has a relatively robust disaster management architecture. The National	India has committed significant spending (USD 0.16 trillion in 2021–22), this accounts for only

		with the National Action Plan on Climate Change (NAPCC) and the dedicated National Action Plan on Climate Change and Human Health (NAPCCHH). Governance is further decentralised through State Action Plans (SAPCCHH) and District Action Plans (DAPCCH). A national expert group and designated nodal agencies provide institutional structure.	state governments. Curricula target medical officers, frontline health workers, and specific vulnerable occupational groups (e.g. traffic police, sanitation workers).		System (HMIS) and Integrated Health Information Platform (IHIP) to track climate-sensitive conditions.		Facilities (2023) outlining energy efficiency, water conservation, and waste management practices.			Institute of Disaster Management (NIDM) provides climate-health response training.	5.5% of GDP, and just 1.8% is allocated to public healthcare.
Barber et al. (2024) ¹⁰⁷	Canada/HIC	Lacks a unified national policy or accountability framework for climate-resilient and low-carbon health systems.	Health professionals demonstrate high interest in low-carbon practices, with 84% expressing willingness to champion such efforts.	No evidence of structured, nationwide climate-health vulnerability assessments.	Not addressed.	Canada hosts promising academic hubs like CASCADES and Planetary Healthcare Lab, which foster research and practitioner engagement.	Sustainability is acknowledged as a healthcare infrastructure concern, with LEED silver standards mentioned. However, these are	Not addressed.	Examples of operational adaptation are limited.	No evidence of a proactive, climate-specific emergency health plan.	Funding remains constrained by short-term political cycles and lack of earmarked climate-health budgets.

		<p>Health system governance is fragmented across provinces and territories, which complicates coordinated action.</p> <p>Awareness is growing on the need for CA among health leaders but has not translated into consistent national strategies.</p>	However, few have received formal training or guidance.			However, research uptake into policy and practice is inconsistent.	voluntary and inconsistently enforced				
Gerk et al. (2024) ¹²⁶	Ecuador/UMI C	Ecuador's National Surgical, Obstetric, and Anaesthesia Plan (NSOAP) or National Surgical Strengthening Plan (NSSP), is the first in Latin America to explicitly integrate CA. The NSSP is aligned with Ecuador's Decennial	Not addressed.	Risk assessment is listed as a strategic component in the NSSP. The plan aims to prepare for increased climate-related injuries, including trauma and obstetric emergencies exacerbated by extreme weather.	The NSSP proposes integrating information systems to improve emergency preparedness. While ENSO-related climate forecasts are part of national disaster plans, they are not yet	Not addressed.	NSSP proposes electronic health records (EHR) and trauma data registries to enhance coordination. The digital health agenda also aims to reduce fragmentation across Ecuador's healthcare system.	Not addressed.	Ecuador's NSSP acknowledges the carbon footprint of surgery and outlines mitigation strategies, including greener surgical practices and supply chain changes.	Climate-related disasters (e.g. floods, landslides) are core to the NSSP's emergency response strategy. Interfacility coordination and stakeholder communication are central features	Not addressed.

		Health Plan and the country's disaster preparedness framework for the El Niño Southern Oscillation (ENSO).			embedded in surgical care pathways.						
Thoms on et al. (2025) ¹⁰⁹	Canada/ HIC	Alberta Health Services (AHS) has developed the Climate-Resilient Acute Care Clinical Operations Framework, aligned with the WHO operational framework. It embeds climate resilience into service delivery through governance, QI, research, and sustainability goals.	AHS has embedded sustainability into staff education via internal platforms (e.g., MyLearningLink), including a dedicated climate-health course.	Not addressed.	Not addressed.	The framework promotes integration of environmental metrics into quality improvement (QI) efforts through the Sustainable QI (SusQI) model.	Not addressed.	Not addressed.	Not addressed.	Not addressed.	Not addressed.
Gohel and Turcotte	Canada/ HIC	Canada has committed internationally (e.g. COP26 Health	Not addressed.	Canada's NAPs exists but does not systematically include	Not addressed.	Not addressed.	Not addressed.	Not addressed.	Not addressed.	Not addressed.	Funding through HealthADAPT (\$43 million over 5 years) exists but

(2025) 108		Programme) to climate-resilient, low-carbon health systems. However, there is no national health-specific climate policy. Provincial governance leads to fragmentation. Only 8% of health authorities currently acknowledge climate change in strategic plans.		healthcare vulnerability mapping.							is voluntary and limited.
Hussain et al. (2025) 130	US/HIC	Highlights New York Academy of Medicine's 2024 convening and multisectoral collaboration as part of governance efforts.	Training health professionals on climate resilience (e.g. inclusion of "planetary health" in clinical competencies)	Encouragement for facilities to conduct facility-specific climate vulnerability assessments.	Reference to CDC's BRACE framework, linking real-time air quality to disease burden (e.g. British Columbia's wildfire-related systems).	Reference to funding via Inflation Reduction Act (IRA) and federal grants to support data-driven research and decarbonisation.	IRA funding incentives and NYSERDA cost-sharing for infrastructure upgrades.	Not addressed.	Not addressed.	Not addressed.	Exploiting tax credits (IRA), FEMA hazard mitigation grants, CMS's Team Decarbonisation initiative.
Schwerdtle et al.	Western Pacific	Pacific Islands have NAPs and participate in WHO-led	Emphasises need for culturally competent,	WHO supports vulnerability assessments;	Regional disaster and risk monitoring	Calls for embedding research into climate-resilient	Renewable energy integration into health	Not addressed.	WHO supports mainstreaming	National disaster frameworks incorporate	Pacific Island countries engage with the GCF and

(2025) 22	(Australia, Fiji, South Korea, Laos, Mongolia, and Viet Nam) / HIC, UMIC, LMIC	climate-health policy dialogues.	climate-aware training.	SIDS recognised as priority regions.	tools promoted by WHO and Pacific institutions.	health planning across all levels.	centres promoted via regional organisations and donors.		climate-health in vertical programmes (e.g. dengue, nutrition).	health but not always climate specificity.	WHO's Special Initiative.
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3.2.2 ENABLERS OF CLIMATE ADAPTATION POLICIES IN HEALTH SYSTEMS

Countries implement CA policies in health systems using key enablers mapped to the five Ottawa Charter action areas. Figure 3B shows the proportion of studies per area. Three enablers – building healthy public policy (92%), creating supportive environments (85%), and reorienting health services (81%) – were addressed by over 80% of studies. The least addressed was strengthening community action (69%), while the most was building healthy public policy.

3.2.2.1 Building public health policy

Examples of public health policy enablers include the establishment of health-inclusive climate policies,¹²² strategies,¹¹⁷ and adaptation plans; high-level commitment across multiple ministries and sectors (e.g., the Netherlands and the Bahamas);^{23,113} strategic support from key stakeholders and funders;^{22,130} and participation in international climate-health alliances.¹²² These were addressed in 92% of the studies reviewed (Figure 3B). Other examples include policies anchored on dedicated national targets such as the NHS net-zero ambition,¹²⁵ Australia’s National Health and Climate Strategy and Climate Change Act,^{108,122} and health sector integration within the U.S. Inflation Reduction Act.¹³⁰ Additional measures involve integrating health into national climate policies, adopting a One Health approach, and promoting HiAPs¹¹⁹ within national and subnational adaptation plans,¹²³ led by competent bodies (e.g., a national secretariat to align federal and provincial policy).¹⁰⁸

In Kenya and Pakistan, the development of Health National Adaptation Plans (H-NAPs) or climate-health components within national climate strategies serves a similar function. Kenya also demonstrates strong participation in international agreements and national climate

frameworks.¹²⁷ In India, a layered framework of national, state, and district action plans reflects a robust public policy foundation.¹²¹

3.2.2.2 Creating supportive environments

Creating environments that enable climate action in health systems depends on infrastructure improvements or retrofitting,^{22,23,109,120,130} technological advancements,^{109,121,126} and regulatory instruments.¹²² Eighty-five per cent of reviewed studies addressed this component (Figure 3B).

In HICs, supportive environments include creating green hospitals (e.g., New Zealand, Singapore); sustainable transport plans (e.g., New Zealand’s Go Well Initiative);¹⁹ NHS England’s Greener NHS programme; green procurement practices (Canada),¹⁰⁹ electronic medical record (EMR) integration (Canada),¹⁰⁹ digital and telehealth services,¹³⁰ and infrastructure redesign (e.g. flood-proofing the Ruth Bader Ginsburg Hospital, USA).¹³⁰

In UMIC and LMICs, enablers include support for “green PHC” environments (e.g. four-star rated facilities in South Africa),¹²³ deployment of green hospital guidelines;¹²¹ and digital health services in India¹²¹ and Ecuador.¹²⁶

Other enablers include the private sector’s role in Pakistan in promoting renewable energy and climate-proofing health infrastructure,¹²⁰ as well as the use of traditional housing designs and community-based risk maps in Western Pacific countries.²²

3.2.2.3 Strengthening community action

Just under 70% of studies reviewed addressed this component (Figure 3B). Community-based structures¹²⁴ and participatory governance approaches^{118,122,125} serve as key enablers in

translating climate-health policies into practice, grounded in global and local partnerships and declarations (e.g. the WHO Budapest Declaration).^{41,133}

In both HICs and LMICs, local actors such as community health workers, traditional leaders, and civil society groups play critical roles in promoting awareness,¹¹⁹ facilitating risk communication,¹⁰⁶ and applying local knowledge¹¹² to coordinate responses to climate events. Case studies from the Bahamas,¹¹³ Chile,¹⁹ and SIDS²² highlight the value of community ownership in emergency response and adaptive service delivery, including the use of climate-health ambassador networks.¹¹³

In HICs, co-governance models and community advisory boards¹³⁰ have enabled bottom-up engagement in hospital sustainability initiatives. Other enablers include patient-led initiatives such as the “Bring Your Own Bag” programme (Canada).¹⁰⁹

3.2.2.4 Developing personal skills

Health worker education, raising awareness,^{113,114} and capacity-building initiatives to equip health workers with climate knowledge¹¹⁶ and sustainability skills¹¹² are recognised as crucial enablers. About 80% of reviewed studies addressed this component. These also include creating dedicated roles for sustainability;¹²⁵ leading advocacy to train health professionals in understanding climate risks and appropriate clinical responses;¹²⁸ promoting behaviour change among health professionals;⁴¹ and ensuring climate literacy among health sector leaders.^{19,118}

Across country profiles, there is a mix of formal and informal efforts to develop competencies in climate action, such as embedding climate and sustainability competencies in medical and nursing curricula (e.g. curriculum reforms in Australia and the U.S., WHO-supported clinical toolkits), and targeted training for hospital managers.^{19,118} India has developed multiple training

modules for frontline workers and occupational risk groups.¹²¹ Canada has implemented education platforms with climate-health modules, and quality improvement (QI) training incorporates environmental metrics¹⁰⁹ – embedding data components for accountability and integrating them into routine QI activities within healthcare delivery settings. Informal training and knowledge transfer also occur through community-based sessions, workshops and regional exchanges, with community leaders acting as knowledge holders.²²

3.2.2.5 Reorienting health services

Reorienting health services to CA policies for environmental sustainability is both a policy goal and an enabler, with 81% of studies addressing this (Figure 3B).

Care pathways are being redesigned^{41,106,112} to reduce emissions through greener surgical practices¹²⁶ and to promote clinical transformation (e.g., reducing over-treatment, telemedicine, circular economies)¹⁹ The Netherlands promotes a decentralised, home-based care to reduce system strain and emissions¹¹³. In Canada, initiatives such as virtual home hospital and climate-conscious surgical care demonstrate progress in redesigning care delivery models.¹⁰⁹

Sustainability metrics and performance measurement complement these efforts.^{114,123} Other examples include sustainability-linked healthcare certification, reuse programs (e.g., gowns), and initiatives supporting the mental well-being of healthcare staff,¹³⁰ and the expansion of telemedicine and community-based services—particularly relevant in the aftermath of COVID-19.¹²⁸

Reorientation efforts also encourage the integration of traditional medicine and climate-responsive service models,²² promoting preventive services, implementing low-emission care models, and disaster contingency planning.¹¹⁸ Telemedicine is increasingly used to maintain

service access during climate disasters,^{120,128} while climate considerations are being incorporated into PHC and broader service reforms.¹¹⁹

Table 3 Mapping of enablers to the Ottawa Charter action areas

Included studies	Country/WB income group	Ottawa Charter action areas				
		Building Healthy Public Policy	Creating Supportive Environments	Strengthening Community Action	Developing Personal Skills	Reorienting Health Services
Armocida et al. (2022) ¹²⁴	Italy/HIC	EU-level strategies (e.g., European Green Deal, Pharmaceutical Strategy, Farm to Fork) mentioned.	NRRP advocates energy efficiency and digital health services, potentially supportive for healthcare decarbonisation.	Community-based healthcare is promoted generally through NRRP.	NRRP identifies skill development in digital healthcare as essential.	NRRP encourages transition toward primary healthcare and telemedicine as climate-friendly options.
Smith (2023) ¹²⁵	England/HIC	NHS net-zero targets serve as overarching strategic policies.	General recognition of the need to enhance relationships among healthcare providers, patients, and communities.	Explicit recommendation for increased community involvement.	Acknowledgement of the need for training and dedicated roles for sustainability.	Recognition that health service delivery models must shift significantly toward sustainable care.
Smith et al. (2024) ¹²²	Australia/HIC	Recent federal policies: Climate Change Act 2022, joining international climate-health alliances.	Strategic emphasis on policies promoting active transport and supportive environments for climate-informed health choices.	Broad policy-level mention of community involvement.	General policy-level identification of education and awareness as necessary.	Broad policy-level statements on shifting healthcare towards sustainable, climate-responsive models.
Salas et al. (2020) ¹²⁸	US/HIC	Emphasises integrating climate considerations systematically across health policies (e.g., Medicare incentives).	Recommends creating supportive environments through energy-efficient healthcare buildings and reliable energy access.	Not addressed.	Advocates for training health professionals to understand climate risks and appropriate clinical responses.	Encourages healthcare reorientation towards telemedicine and community-based services, particularly relevant after COVID-19.
Schwerdtle et al. (2020) ¹²⁹	Global/HIC, UMIC, LMIC	Encourages policy mainstreaming of climate resilience within	Advocates sustainable environmental	Emphasises community involvement in	Highlights the importance of training	Advocates reorientation of humanitarian

		humanitarian organizations and partnerships.	management as part of humanitarian response.	planning and implementing humanitarian climate responses.	humanitarian workers in climate-health resilience.	services to integrate climate adaptation strategies and predictive analytics.
Hensher and McGain (2020) ¹¹⁴	US/HIC	Strong emphasis on integrating sustainability as a formal metric within national and global health system policy frameworks.	Encourages the development of low-carbon healthcare infrastructure and environmental sustainability in healthcare environments.	Not addressed.	Briefly acknowledges workforce awareness as necessary but offers minimal detail on skill development strategies.	Advocates integration of sustainability metrics into mainstream quality and performance measurement in healthcare.
Quintana et al. (2021) ¹¹⁶	Global/ HIC, UMIC, LMIC	Strong emphasis on integrating health system resilience into COP policy negotiations, national adaptation plans, and strategic frameworks.	Recommends governance structures that support local and equitable partnerships in health systems.	Advocates for equity, justice, and inclusion of local voices in decision-making processes during health crises	Recognises implicitly the need to equip health workers with climate knowledge but provides minimal explicit detail.	Encourages shifting humanitarian and crisis response frameworks to better integrate local governance and sustainability considerations
Kluge et al. (2023) ⁴¹	Multiple countries/ HIC, UMIC, LMIC	Strong calls for cross-sector policy action linking health and environmental agendas.	Encourages embedding sustainability into infrastructure and supply chains.	Advocates local engagement through cross-country partnerships and declarations (e.g. WHO Budapest declaration).	Points to behaviour change among health professionals as crucial.	Advocates redesigning healthcare services around sustainability principles.
Martins et al. (2024) ¹¹²	Global/ HIC, UMIC, LMIC	Advocates health-in-all-policies and coherence between climate and health national action plans.	Recommends environmentally friendly facilities and service redesign.	Emphasises the role of community resilience and the value of local knowledge.	Argues for equipping healthcare workers with climate literacy and sustainability skills.	Calls for redesigning services and embedding sustainability in health planning.

Thomson et al. (2023) ¹⁰⁶	Canada/ HIC	Strong advocacy for integrated climate-health policy at organisational and provincial levels.	Encourages green design in infrastructure and resilient operations.	Emphasises engagement with local communities, especially in understanding regional climate vulnerabilities.	Emphasises climate literacy for leaders and staff.	Suggests redesign of health services for resilience and sustainability.
Teshome (2023) ¹¹⁸	Least Developed Countries/LMIC	Advocates for policy coherence between health and climate at all levels of governance.	Supports sustainable infrastructure and service delivery.	Suggests devolved decision-making and community engagement.	Emphasises awareness and climate-health literacy among professionals.	Encourages preventive services, low-emission care models, and disaster-contingency planning.
Mosadeghrad et al. (2023) ¹¹⁹	Global/ HIC, UMIC, LMIC	Integration of health in national climate policies, One Health, and HiAPs.	Proposes resilient hospital design, safe energy use, and improved building codes.	Advocates engaging communities through education and awareness.	Strong support for climate-health literacy.	Suggests embedding climate considerations in PHC and service reform.
Lokotola (2023) ¹²³	South Africa/UMIC	Champions PHC integration into national and subnational adaptation plans.	Supports “emerging” environments (e.g. 4-star rated facilities).	Urges community-oriented PHC (COPC) to address climate-related risks	Prioritises equipping the workforce with emergency and environmental health response capabilities.	Seeks restructured services that embed climate indicators and resilience principles.
Braithwaite et al. (2024) ¹¹³	Netherlands and Bahamas/HIC	High-level commitment across multiple ministries and sectors in the Netherlands and Bahamas.	Policies to reduce environmental impact of hospitals and pharmaceuticals.	Bahamas proposes creating a network of climate-health ambassadors.	Both countries support increasing awareness among healthcare workers and patients.	Netherlands promotes decentralised, home-based care to reduce system strain and emissions.
Hough and Tanugi-carresse (2024) ¹⁹	Global/ HIC, UMIC, LMIC	Countries developed health-linked climate strategies (e.g. Australia’s Health & Climate Strategy).	Green hospitals (NZ, Singapore) and sustainable transport plans (NZ Go Well Initiative).	Chile’s Valdivia Public Health Network established orchards and local carbon literacy.	Staff training and sustainability leadership encouraged in certain hospitals.	Clinical transformation (e.g., reducing over-treatment, telemedicine,

						circular economies).
Blom et al. (2025) ¹²⁷	Kenya/LMIC	Kenya's participation in international agreements and national climate frameworks is strong.	Not addressed.	Not addressed.	Not addressed.	Not addressed.
Blom et al. (2024) ²³	Global/ HIC, UMIC, LMIC	83 nations have signed onto high-level climate-health goals; however, implementation is patchy , with only a minority producing HNAPs or GHG assessments.	Some HICs (e.g., UK, New Zealand) report investment in clean energy and facility retrofits.	No substantial indicators track community engagement or local-level adaptation actions.	Not addressed.	Not addressed.
Vidal-Cuellar et al. (2024) ¹¹⁷	Peru/UMIC	Climate change is identified in Peru's national health strategy and development plans.	Not addressed.	Not addressed.	Climate-health education is not mainstreamed into national campaigns or health promotion curricula.	Not addressed.
Akthar and Reid (2024) ¹²⁰	Pakistan/ LMIC	Not addressed.	Private-sector actors are proposed as key partners in promoting renewable energy and climate-proofing health infrastructure.	Not addressed.	Not addressed.	Telemedicine (e.g. Sehat Kahani) is presented as a valuable tool for maintaining service access during climate disasters.
Kumar et al. (2024) ¹²¹	India/ LMIC	India's layered framework of national, state, and district action plans reflects a strong public policy foundation.	Initiatives like green hospital guidelines and digital health services (e.g. telemedicine) are emerging.	Not addressed.	India has developed multiple training modules targeting frontline workers and occupational risk groups.	Policy frameworks exist to guide service delivery transformation, including heatwave response and pollution-related care.
Barber et al. (2024) ¹⁰⁷	Canada/ HIC	Not addressed.	Not addressed.	Not addressed.	Not addressed.	Not addressed.
Gerk et al. (2024) ¹²⁶	Ecuador/ UMIC	Ecuador's NSSP is an innovative policy move that aligns surgical system	Digital transformation and coordinated trauma data systems are	Not addressed.	Not addressed.	The NSSP calls for improved emergency

		strengthening with climate resilience	promoted to enhance efficiency.			coordination and greener surgical practices
Thomson et al. (2025) ¹⁰⁹	Canada/ HIC	The framework and affiliated strategies advocate for embedding sustainability in operational and clinical decision-making.	Infrastructure improvements, EMR integration, and green procurement practices are underway in several sites.	Patient initiatives like the “Bring Your Own Bag” programme demonstrate support for hospital-level waste reduction.	Education platforms now include climate-health modules, and QI training incorporates environmental metrics.	Initiatives like virtual home hospital and climate-conscious surgical care show progress in redesigning care delivery models.
Gohel and Turcotte (2025) ¹⁰⁸	Canada/ HIC	Authors propose a national secretariat to align federal and provincial policy. Health is still not embedded into Canada’s National Adaptation Strategy.	Not addressed.	Not addressed.	Not addressed.	Not addressed.
Hussain et al. (2025) ¹³⁰	US/ HIC	IRA, NYSERDA support for clean energy in hospitals, CMS Team Decarbonization & Resilience Initiative	Infrastructure redesign (e.g. flood-proofing Ruth Bader Ginsburg Hospital), access to green infrastructure, telehealth access during climate crises.	Emphasis on co-governance and community advisory boards to co-design resilience strategies.	WHO toolkit for health professionals, clinical education incorporating planetary health, climate-health communication tools.	Sustainability-linked healthcare certification, reuse programs (e.g. gowns), emphasis on mental wellbeing of healthcare staff.
Schwerdtle et al. (2025) ²²	Western pacific (Australia, Fiji, South Korea, Laos, Mongolia, and Viet Nam)/ HIC, UMIC, LMIC	Regional frameworks from WHO and SPREP advocate integrated policy approaches.	Examples include traditional housing designs and community-based risk maps.	SIDS rely heavily on local governance and community networks to coordinate response.	Informal training via workshops and regional exchanges; community elders often act as knowledge holders.	Some guidance encourages integrating traditional medicine and climate-responsive service models.

4 DISCUSSION

4.1 SUMMARY OF FINDINGS

The studies show ongoing efforts to develop CA policies aimed at creating sustainable, decarbonised health systems worldwide across income levels. The review highlights growing evidence of these policies and countries' initiatives, despite limited data on their impact.

Findings, based on global analysis and 26 English publications, focus on promoting sustainable health systems.

4.2 NOVELTY OF THE STUDY

This is the first scoping review to employ a health systems and socio-ecological framework in mapping existing research across health systems and income groups in this emerging field. It fills a research gap and paves the way for future studies.

4.3 TYPE AND SOURCE OF RECORDS

Results show an increase in publications since 2020, with a notable surge between 2024 and 2025 (Figure 2A). A surge may relate to a renewed focus on resilience following the COVID-19 pandemic.¹³⁴

The review encompassed various publication types, including research articles, commentaries, reviews, opinion pieces, a book chapter, editorials, practitioner narratives, and viewpoints (Figure 2B). It revealed a lack of studies, especially in LMICs, which represent only a third of

publications from HICs (Figure 2C). HIC publications mainly came from North America (Canada and the US) and Australia. Due to policy development processes and bureaucratic red tape, especially with grey literature, some relevant policy documents might not have been publicly accessible.

4.4 WHO OPERATIONAL FRAMEWORK

While the studies reviewed aligned with the ten components of WHO's Operational Framework (Figure 3A), gaps were evident. The most frequently addressed component was 'leadership and governance' – addressed by all studies (100%). This highlights the importance of leadership and governance in shaping the discourse on CA, regardless of a country's income level. The 'management of environmental determinants of health' component was the least addressed, by only 12% of the reviewed studies. The review found that this component was often nested within the 'climate-informed health programmes' component (Table 2) rather than as a separate entity. As a result, evidence in this CA policy area was largely missing, with no clarity on how countries are responding to this component policy-wise. Only two studies, one from Peru¹¹⁷, a UMIC, and another from India¹²¹, a LMIC, addressed this component in their publications. This may likely reflect the significant climate change impacts these countries are experiencing, which could justify the focus on this critical area. As suggested by Hough *et al*, and in the case of India, LMICs focus more on adaptation due to higher vulnerability and lower emissions.¹⁹ Per WHO's Operational Framework, the 'management of environmental determinants of health' component aims to increase efforts to address environmental risks through enhanced monitoring and management, regulatory frameworks, and coordinated intersectoral action for air quality; water quality and quantity; food and nutrition security; housing; and waste management.⁹

In LMICs, including those in sub-Saharan Africa and the Pacific, VRAs are often facilitated through the WHO or other international actors. They are not typically mandated for routine use or localisation, despite such assessments being recognised as a strategic starting point for CA policies. There is a noticeable absence of binding policies requiring periodic, system-wide VRAs in most countries, regardless of income level. Resource constraints, such as limited finances and a shortage of a capable workforce, may be reasons for the limited engagement in this component.

For the components of the WHO framework addressed in less than 80% of the studies (Figure 3A) - including integrated risk monitoring and early warning, climate-informed health programmes, and climate-related emergency preparedness and management - further work is needed to optimise these CA policies and achieve comprehensive coverage within country policies.

There is a global policy gap in integrating CA into health systems, with limited progress in embedding climate competencies, mandating VRAs, linking early-warning systems to emergency preparedness, or establishing research frameworks. Despite the importance of climate finance, few countries have predictable domestic funding, causing fragmented and unsustainable adaptation efforts. The effectiveness of policies depends on the capacities, governance, and resources available.

4.5 OTTAWA CHARTER STRATEGIC ACTION AREAS: ENABLERS OF CLIMATE ADAPTATION POLICIES

Countries have generally enabled the promotion of environmentally sustainable, decentralised health systems through all five strategic areas of the Ottawa Charter (Figure 3B). The most

addressed was the building of healthy public policy (92% of reviewed studies), while the least addressed was strengthening community action (69% of reviewed studies) (Figure 3B).

Although it is acknowledged that communities bear the brunt of Climate change's consequences and frequently lack access to health systems, often located far from the regions with the highest emissions,¹⁹ the strengthening of community action was addressed in only 69% of the reviewed studies (Figure 3B). Despite their proven effectiveness, formal policy recognition and inclusion of community-led CA remain limited and subpar in reviewed studies. Without institutional backing and the deliberate engagement of communities and their institutions, the reach and sustainability of community action to support climate goals remain vulnerable to shifts in political and financial support.

Studies have revealed communities demonstrating innovation in community engagement and the integration of local knowledge, particularly in reorienting services and fostering community action.¹¹⁷ However, these enablers are not always formalised or sustained through national systems, as shown by this review.

Across studies, CA remains weakly institutionalised with fragmented implementation. Countries acknowledge the need for these policies and have enacted legislation or signed up to agreements,^{108,117,121–123,125,127} as enablers, but intentional actions are required, primarily through a multisectoral approach.

Supportive environments use innovative green initiatives for infrastructure, service delivery, or technology, tailored to countries' capacities within a strong policy framework. They incorporate community participation, climate-health literacy, professional training, and embed accountability metrics.^{109,121}

Many enablers are being piloted, but they remain reactive with limited integration into routine care, education accreditation, and health services. Stronger institutional capacity, regulation, and financing would help countries incorporate climate considerations into health policies, boost community action, train staff, and enhance service delivery by reorienting health services.

4.6 PROMOTING ENVIRONMENTALLY SUSTAINABLE AND DECARBONISED HEALTH SYSTEMS IN LMICs (E.G., NIGERIA)

This section addresses research question “1b”: “What might this mean for the promotion of environmentally sustainable and decarbonised health systems in LMICs (e.g., Nigeria)?”. As described in section 2.5, the details are summarised below and in Table 4, acknowledging the need for comparative policy learning.¹⁰⁸

Canadian research shows high awareness of CA policies but reveals limited coordination, fragmented governance, and poor funding hinder health system transformation.^{106–109} Efforts across provinces are disjointed due to lack of shared responsibility, standard metrics, and clear goals, risking lives and system viability. Canada's case illustrates the challenge of translating intent into systemic policy change in high-income, decentralised settings.¹⁰⁷

Canada faces increasing seasonal wildfires, especially in Alberta and British Columbia, which is raising awareness. Nigeria rarely has wildfires but frequently floods, leading to economic losses, disease outbreaks, and healthcare issues. Nigeria is among the top ten for zoonotic outbreaks driven by climate change.¹³⁵ An integrated risk monitoring and early warning system will aid health surveillance, countermeasures, and planning for vulnerable communities.

Nigeria, a signatory to the WHO-led COP 26 Health Program,¹² is committed to implementing policy-driven CA activities to achieve SDG 13. The country passed the Climate Act, established the Nigeria Council on Climate Change (NCCC) for multisectoral coordination, and has a dedicated desk within the Federal Ministry of Health to integrate climate discussions into health, similar to approaches in Australia.¹⁹ This is crucial for addressing challenges highlighted by Blom *et al.*, where policy reports and indicators varied across ministries.²³

The WHO Operational Framework's leadership and governance component is vital for implementing these strategies. While central coordinating entities exist, leading health change needs research-based decisions.^{23,107} Despite 88% of studies addressing this component, the research agenda remains fragmented. In Nigeria, ministries' research departments lack capacity in HR and are often underfunded. Climate research leadership needs rapid upskilling, akin to building a climate-smart workforce with essential tools.^{109,136}

Given Nigeria's governance system, empowering the workforce with the necessary skills at both national and subnational levels is crucial, regardless of cadre.¹²¹ This differs from Canada's current fragmented approach. Implementing this in Nigeria will require more than just staff passion for environmental sustainability.¹³⁷ It must also consider human resource shortages, staff turnover,¹³⁷ data gaps,²³ and be integrated into long-term HR policies like Australia's,¹²² while raising awareness and addressing special contexts such as humanitarian crises. Since 2009, insurgencies in North East Nigeria¹³⁸ have caused ongoing humanitarian crises, making a comprehensive CA response essential in these settings.

Different departments in the Federal Ministry oversee Nigeria's health service delivery, with subnational entities managing PHCs. Developing shared guidelines across ministries, outside the

MoH's mandate, can ensure immediate and long-term health system benefits, including enhancing private sector roles.¹¹⁷ As Nigeria aims for UHC by revitalising PHCs, initiatives promoting low-carbon sustainable building, transport, supply chains, infrastructure upgrades with green standards, digitising health records, and telemedicine in new projects are especially valuable.

Nigeria has separate meteorological and disease control agencies with siloed data, which are underutilised for health surveillance. Blom *et al.*²³ found only 5% of countries report meteorological and health data.

Nigeria has yet to conduct a country-led VRA; actual emissions from its health system remain unknown, though plans are underway as health becomes part of Nigeria's NDC. Only 30% of 82 countries in the COP26 Health Programme have conducted such assessments.²³ Community-based participatory approaches could improve this, aligning with the WHO Budapest declaration.

Table 4 Comparison between Canada and Nigeria based on the WHO Operational Framework and the Ottawa Charter enablers

S/N	Canada ¹⁰⁶⁻¹⁰⁹ (HIC focal country) - WHO Operation Framework components and Enablers	Nigeria (LMIC focal country) - what might this mean for Nigeria?
1	<p><u>Leadership and Governance</u> – Strategic plans and road maps created at the provincial level (e.g., Alberta). Fragmentation across territories results from the absence of a unified national strategy. Highlights the need for health leaders to include mitigation, adaptation in plans, and establish accountability frameworks.</p> <p><i>Enabler</i> – COP26 health programme. Advocating for integrated climate-health policy at the organisation and provincial levels, emphasising climate literacy for leaders and staff and pushing for sustainability in decision-making. Authors suggest a national secretariat to align federal and provincial policy, noting that health remains not embedded in Canada’s National Adaptation Strategy.</p>	<p>CA policies should strengthen coordination across governance levels, embed climate-health mandates into health institutions, and leverage COP commitments for accountability and funding. The 2022-inaugurated National Council on Climate Change (NCCC) and its new leadership (as of xxx) serve as the Nationally Designated Authority and Focal Point to address the impact of climate change in Nigeria. Policies should be reinforced by embedding climate-health into enforceable laws, using COP commitments to ensure political accountability.</p> <p>Community engagement should be institutionalised in climate-health decision-making, utilising structures like Ward Development Committees for co-designing adaptation strategies.</p>
2	<p><u>Climate-smart Health workforce</u> - Health professionals show strong interest in low-carbon practices and are willing to promote them. However, few have received formal training guidance. Alberta Health Service integrates sustainability into staff education with a climate-health course. Authors advocate for more carbon literacy and climate education among workers.</p> <p><i>Enabler</i> - Climate literacy for leaders and staff. Education platforms now include climate-health modules, and QI training incorporates environmental metrics.</p>	<p>Embed climate-health modules into health worker training and continuous professional development (CPD) curriculum, aligning professional councils with sustainability standards.</p> <p>Incorporate the learning modules into medical, nursing, and public health curricula and establish CPD requirements through the Nigerian Universities Commission (NUC) and regulatory councils or professional bodies.</p>
3	<p><u>Vulnerability and risk assessments</u> - Canada’s NAPs exist but lack systematic healthcare vulnerability mapping or nationwide assessments. Authors promote tools like the Climate Atlas of Canada and WHO indicators for site-specific vulnerability guidance assessments.</p>	<p>Conduct the first-ever VRA and institutionalise them within state/federal health planning cycles, making them a prerequisite for investment, public or donor-funded projects.</p> <p>Engage communities, consult and utilise structures like Ward Development Committees during VRAs.</p>

	<p>Enabler - Focus on engaging local communities to understand regional climate vulnerabilities is suggested.</p>	
4	<p><u>Integrated risk monitoring and early warning</u> - Proposes integrating climate risk monitoring into decision-making and learning processes.</p> <p>Enabler – None</p>	<p>Expand Integrated Disease Surveillance and Response (IDSR) to include climate-sensitive indicators and link to the Nigerian Meteorological Agency (NiMET).</p> <p>Support efforts with nuanced public health policies and create the necessary supportive environment (e.g., regulation or MoU) for a collaborative multi-stakeholder engagement.</p>
5	<p><u>Health and climate research</u> - Canada hosts research hubs like CASCADES and Planetary Healthcare Lab that foster research and practitioner engagement, but research uptake into policy and practice remains inconsistent. The Sustainable QI (SusQI) model promotes integrating environmental metrics into quality improvement efforts, while data-driven planning and learning health systems support evidence generation.</p> <p>Enabler - None</p>	<p>Incentivise local research through national grants (e.g., through the Tertiary Education Trust Fund, TETFUND), foster academic–policy partnerships, and ensure evidence feeds into health sector strategies.</p>
6	<p><u>Low-carbon infrastructure, technologies and supply chain</u> - Sustainability is a healthcare infrastructure concern, with voluntary LEED silver standards that are inconsistently enforced. It advocates low-carbon, resilient infrastructure as a strategic approach imperative.</p> <p>Enabler - Encourages green infrastructure and resilient operations, suggesting redesign of health services for sustainability through infrastructure improvements, EMR integration, and green procurement at several sites. Initiatives such as virtual home hospitals and climate-conscious surgical care indicate progress in redesigning care models.</p>	<p>Commission and scale solar-powered PHC facilities with GCF funding and develop cost-appropriate green building guidelines that prioritise energy-efficient PHCs, and scale through public–private partnerships.</p> <p>Develop national standards for sustainable health infrastructure, scaling affordable technologies (such as solar and water efficiency) through public–private partnerships and donor leverage.</p> <p>Mainstream low-carbon practices into national service delivery guidelines and pilot scalable models in PHCs, ensuring sustainability is tied to service quality and equity goals.</p>

7	<p><u>Management of environmental determinants of health</u> – Not addressed <i>Enabler - None</i></p>	<p>Joint planning and strategic development of CA policies should involve all relevant stakeholders, including environmental, meteorological, health, and disease control services. They need to utilise existing data while addressing key factors such as air pollution, waste management, planning, design, heat-related illnesses, nutrition, and air pollution in health campaigns and training. These considerations should be consistently integrated into disease programmes.</p>
8	<p><u>Climate-informed health programmes</u> - Proposes aligning health service delivery with climate projections and risks. <i>Enabler - None</i></p>	<p>Mainstream climate considerations into vertical programmes (malaria, maternal health), piloting low-carbon care models in PHCs.</p>
9	<p><u>Climate-related emergency preparedness and management</u> - There is no evidence of a proactive, climate-specific emergency health plan, although it acknowledges that health systems need to prepare for climate-related shocks (e.g., power outages). <i>Enabler - None</i></p>	<p>Develop state-level climate-sensitive preparedness plans, integrate with the National Emergency Management Agency (NEMA), and align with health sector contingency plans.</p>
10	<p><u>Sustainable climate financing</u> - Funding remains limited due to short-term political cycles and the absence of dedicated climate-health budgets. While funding through HealthADAPT (\$43 million over five years) is available, it is voluntary and capped. Stresses the need for resource allocation via long-term planning. <i>Enabler - None</i></p>	<p>Create a climate-health budget line within FMoH, earmark funds for PHC adaptation, and leverage international finance through strong proposals.</p>

4.7 STRENGTHS

This review's strength lies in its transparent methods for mapping CA policies using the WHO Operational Framework and the Ottawa Charter, particularly on an evolving topic, while balancing practicality and resources. The deductive socio-ecological data extraction grounds the thesis in established frameworks. It is the first to use both frameworks on this emerging issue, offering insights into how countries develop policies to mainstream CA in health systems and highlighting what they omit or advocate.

This thesis reviewed six bibliographic databases, including the minimum recommended two¹⁴⁰ - PubMed and Web of Science - for thorough literature coverage in scoping reviews, with four additional relevant databases (Scopus, JBI, Overton, and WHO Global Index Medicus). An experienced librarian (NR) validated search terms and strategy. A protocol was developed and published beforehand, with a second reviewer involved, following scoping review guidelines and the PRISMA-ScR checklist.

Using Covidence allowed a blinded review, a key strength. An updated search on May 10, 2025, covered a 20-year period to avoid missing records. The study method was validated using an interactive web tool, and its rigour was strengthened by following Levac *et al.*'s recommendations. Mendeley was used to manage citations.

Despite limited evidence on policy impact across WHO and Ottawa Charter components, the review highlighted growing evidence on CA amid renewed urgency to complement CM policies. It showed an increase in scientific output on CA and health systems over time, particularly between 2023 and 2025, compared to earlier years.

4.8 LIMITATIONS

This review has limitations. Firstly, the search included multiple databases for peer-reviewed and grey literature; however, English language restrictions may have biased the results, as they focused on CA in health systems and utilised only English terms. It might not have found all relevant literature, despite attempts at comprehensiveness. Using no language restrictions could have increased records but mainly affected non-English-speaking countries. However, some studies from non-English-speaking countries, such as Peru and Ecuador, were included.

Secondly, the protocol and search strategy aligned with CA policies and the WHO Framework, focusing on key concepts. Excluding other relevant terms likely reduced the search yield, leading to some missed studies. While the criteria were clear and screening consistent, study heterogeneity may have led to omissions. The review only counted how CA policies matched the WHO Framework and Ottawa Charter themes without weighting, allowing for more qualitative research.

Thirdly, due to time, resources, and limited access to knowledge users and experts, the sixth step by Arksey and O'Malley ⁹¹, later emphasised by Levac *et al.* ⁹², was not performed. Critical documents might have been overlooked, especially since countries develop policies differently and may be stored in local databases, personal devices, or other private IT resources. As a result, the review may not fully capture all perspectives within the country's diverse health system.

Fourthly, publication bias towards HIC settings may limit the applicability of findings to LMICs; however, this is not exclusive to scoping reviews, which help identify research gaps and emerging concepts. ¹⁰² This limits generalisation to LMICs. The characterisation and interpretation of reviews may have been influenced by reviewer bias, despite the process being

blinded and led by two independent reviewers. Cohen's kappa of 0.45 indicates moderate agreement after screening. The review's temporal scope also limits findings and may not reflect ongoing changes to CA policies.

Fifthly, the review did not include quality assessment, as it aimed to map evidence rather than critically appraise studies. Without a bias risk assessment, recommendations cannot be graded based on the findings.¹⁰²

Sixthly, using a deductive approach in a scoping review offers efficiency and clarity. Still, it also risks forcing data into preset categories, restricting themes, and limiting insight, especially when dealing with diverse or new literature. A hybrid approach combining deductive and inductive methods can overcome this.

4.9 FURTHER RESEARCH

This review found isolated CA initiatives lack evidence of scalability, replication, or adoption. Some promote CA policies, but the impact is limited without wider dissemination across health systems. Research should support moving from isolated projects to systemic change, enabling widespread practical implementations. Comparative studies should document effective strategies in low-resource settings, especially LMICs, where evidence is limited. There is a limited understanding of how policies are translated into practice in LMICs. Focus should be on implementation science to evaluate adaptation and scale-up strategies.

Despite studies on CA policies supporting sustainable health systems, they highlight the need for future reviews – process, impact, or economic – of these policies. Future research should incorporate both qualitative and quantitative insights, such as economic evaluations, to facilitate

detailed effectiveness assessments. Studies should also examine the long-term effects on health systems, including their funding, governance, and environmental factors. More evidence is needed on the role of enablers in the implementation process.

Each WHO framework component examines CA in health systems through global, national, or regional research, providing evidence for policy analysis and accountability frameworks that promote potential North-South and South-South knowledge exchange. More evidence is needed on how federal systems, political incentives, and institutions influence the success or failure of adaptation policies. Nigeria, with its federal system, is an ideal location for these studies, especially since no research has been conducted there yet. Exploring this in Nigeria and other LMICs is valuable. A hybrid approach combining deductive frameworks with open exploration of new themes is recommended.

With more deidentified patient data, meteorological data, and VRA outputs, researching AI's role in advancing CA policies warrants further exploration.

No studies reported implementation costs of policies, making it hard to identify the most cost-effective interventions that provide the greatest CA benefits. More studies with cost-benefit analysis, beyond environmental savings, are needed for future guidance.

Climate change impacts communities, so their role warrants further exploration. Communities help seek and develop partnerships for CA policies, ensuring ownership and accountability. Research is often top-down and technical, but LMIC communities already adapt to climate issues, such as local disaster preparedness and informal health services. Incorporating local and indigenous knowledge into research can offer context-specific solutions.

4.10 DEVIATIONS FROM PROTOCOL

Deviations were minor, with few parameter changes from the published protocol, and did not affect the review's results. They actually improved quality through iterative scoping.

Firstly, the WHO Operational Framework mapped CA policies and highlighted gaps, while the WB income classification grouped countries by income for synthesis and description. These inputs enhanced the extraction tool and results.

Secondly, including studies from UMICs alongside those from HICs and LMICs expanded the evidence base. UMIC studies met the criteria, spanned multiple countries, and increased relevance. The protocol followed Arksey and O'Malley, JBI, and Levac *et al.* for rigour. GenAI-verified data extraction enabled detailed mapping to the frameworks.

Thirdly, due to time constraints, the second reviewer (DC) reviewed 10%, 15%, and 20% of the initial findings, title and abstract, and full-text articles. All included articles were read and discussed by both me and DC. Since DC did not review all articles at every stage, this is a limitation of the review.

One grey literature database (Open Grey) was proposed but discontinued.¹⁴¹ The preidentified databases offered alternatives to find sources and avoid bias.

4.11 ETHICAL CONSIDERATIONS

Secondary data sources were utilised; therefore, no ethical approval was required.

5 CONCLUSION AND RECOMMENDATIONS

This review offers a comprehensive overview of CA policies and factors that promote sustainable, decarbonised health systems. It highlights research gaps, particularly regarding CA policies that address the management of environmental determinants of health within the WHO Framework, aligned with the Ottawa Charter. The review also highlights the limited research in LMICs and identifies key areas for future investigation.

This offers insights for policymakers, practitioners, and stakeholders involved in CA initiatives. Future policies across income groups should align with existing frameworks to cover key areas. More research, especially in LMICs, is needed within the WHO framework. WHO and Member States can support this by aligning policies with these frameworks, as differences hinder implementation and knowledge sharing. Additional recommendations are in section 5.1.

5.1 RECOMMENDATIONS TO POLICYMAKERS

Provisional recommendations are proposed but limited by earlier-discussed scoping review limitations.

1. This review offers a method for comparative CA analysis. It calls for mainstreaming health into CA programmes, improving governance, establishing sustainable financial mechanisms, and developing climate-health budgets, as well as domestic resources and capacity for external funds. Engaging the private sector can enhance infrastructure investment, ensuring service continuity and climate resilience.

2. Countries should develop cohesive policies with oversight and decision-making systems to translate global goals into domestic actions. Indicators need to be aligned with frameworks, and accountability must be shared and transparent to avoid greenwashing.
3. Countries new to sustainable health planning should prioritise planning and baseline data collection. They can reduce entry barriers by adopting frugal, local CA innovations. This approach should be community-driven, primarily bottom-up, guided by the insights of VRAs.
4. Reorganising health services and promoting community engagement and workforce participation are essential. Policies should avoid solely top-down methods. Engaging communities and building health workforce skills in CA ensure sustainability. Regulatory bodies need to co-create and share adaptation practices. Guideline-driven reforms accelerate change. Pilot low-carbon models in primary care and expand through national standards when feasible.
5. Policymakers, leaders, and health system managers should base decisions on evidence to improve CA policies' effectiveness and cost-efficiency. Policies should aim for co-benefits, such as improvements in mental and physical health, and generate social and economic gains. Cultural adaptation is essential when applying evidence-based programmes from different countries or communities, especially when the target populations differ from those where the programmes were initially developed and tested.

6 REFLECTIONS

This dissertation marks a full-circle moment for me, as it concludes a rewarding journey in the MSc in Global Healthcare Leadership programme.

The climate and health agenda presents a challenge, with polarised, poorly evidence-based discussions, but undeniable impacts. Policies often shift with politics and lack rigour, risking vulnerable populations. I had intended to attend the last COP in Baku to gain insights into climate and health policymaking and agenda-setting, but scheduling conflicts prevented me from doing so.

This dissertation provided me with clearer insights into ongoing global and regional gaps in CA policies, such as limited community engagement, underexplored private sector roles, misaligned global metrics with country data, and the need for early-stage focus on VRA in CA policy development by countries. This has complemented the policy discussions I facilitated during a roundtable I organised in Module 6, further deepening my knowledge in this evolving topic. The thesis further highlights the importance of evidence-based approaches for CA in health systems, which will shape my leadership approaches moving forward.

Furthermore, the programme has demonstrated that leadership requires both courage and skill. Systems thinking, evidence generation, scenario planning, and self-leadership are not abstract ideas; they are essential tools for navigating uncertainty and achieving meaningful outcomes. Completing the modules and dissertation has equipped me with the knowledge and tools to address pressing global challenges.

Finally, this work connects to my leadership role in Nigeria and the broader LMIC context. It has provided me with the resources to inform policy briefs, engage as a thought leader, and advocate

for resilient and sustainable health systems. It has also shown me the potential of new tools, such as GenAI, in research, if used responsibly. Above all, the dissertation reflects the programme's purpose: to prepare leaders who can confront complex problems with clarity, evidence, and vision.

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8 CONFLICTS OF INTEREST

None declared.

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APPENDIX A – PROTOCOL

Global Analysis of Climate Adaptation Policies for Promoting Environmentally Sustainable, Decarbonised Health Systems: A Scoping Review Protocol.

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Abstract

Introduction: Climate change is a serious threat to public health. The healthcare sector contributes 5% of global greenhouse gas (GHG) emissions. Strategic, policy-led discussions on the approaches to decarbonise health systems are only gaining momentum – especially in LMICs compared to HICs. Limited data on healthcare emissions from LMICs complicates cross-country comparisons against set targets. Furthermore, Nationally Determined Contributions (NDCs) for reducing GHG emissions are also incomplete — illustrated by Nigeria’s NDC and 2024 National Vulnerability and Adaptation Assessment Report omitting health sector decarbonisation targets. This scoping review aims to systematically review global climate adaptation policies for promoting environmentally sustainable, decarbonised health systems. Policies, practices and concepts in this domain will be mapped, and key characteristics, and enabling factors related to the mainstreaming of climate adaptation in promoting environmentally sustainable, decarbonised health systems will be identified.

Methods and analysis: This scoping review will follow the Arksey and O’Malley methodological framework (2005) as well as the Joanna Briggs Institute Reviewer’s manual. Relevant publications will be searched on Pubmed/MEDLINE, SCOPUS, JBI Evidence Synthesis, Web of Science, and the following grey literature sources: World Health Organisation’s Global Index Medicus, OpenGrey and Overton. Literature published between January 2004 and March 2025 will be reviewed. Publications in English Language related to Climate Adaptation Policies that promote environmentally sustainable, decarbonised health systems will be included. Records in other languages may be missed. A first search will be conducted with keywords to identify relevant articles. Subsequently, a two-part study selection process will be systematically applied by two reviewers. In line with best practice and JBI guidelines, data will be extracted, collated and charted to summarise all the relevant methods, outcomes and key findings in the reviewed publications.

Ethics and dissemination: This scoping review will undertake a secondary analysis of data already collected and does not require ethical approval. Results will form part of the requirement for obtaining a Master of Global Healthcare Leadership degree at the University of Oxford. Findings will also be disseminated in peer-reviewed journals.

Keywords: Climate change; Developed countries; Developing countries; Health policy; Net zero

Introduction

Climate change poses a serious threat to public health. It is a defining challenge of the 21st century, leading to devastating consequences globally (Parry, 2007; Rosenthal, 2007; Solomon, 2007; Romanello *et al.*, 2022). The impact of climate change on healthcare, and human health, is evidenced by increasing healthcare needs due to recurring infectious disease outbreaks, thermal stress, natural disasters, and the propagation of insect-borne diseases (Flahault, de Castaneda and Bolon, 2016; Semenza *et al.*, 2022). Greenhouse gas (GHG) emissions are a primary driver of these changes (Parry, 2007; Filonchik *et al.*, 2024).

The healthcare sector contributes 5% of these GHG emissions worldwide, from direct and indirect sources, with increases expected given the demands of health systems (Pichler *et al.*, 2019; Or and Seppänen, 2024). Therefore, it has a role in reducing global warming by prioritising efforts to limit GHG emissions through deliberate, intentional, policies, and practices that ensure business continuity and delivery of equitable universal healthcare, globally, within environmentally sustainable, and decarbonised health systems.

Developing and implementing climate mitigation (CM) and climate adaptation (CA) practices and policies are key levers to accelerate such efforts – specifically towards the attainment of Sustainable Development Goal (SDG) 13 on Climate Action. CM efforts have been the mainstay of response to reversing the impact of climate change on health and have occurred at the expense of essential and complementary CA efforts (Costello *et al.*, 2011). Promoting environmentally sustainable, decarbonised health systems will benefit from the implementation of nuanced CA policies and practices.

According to the United Nations Framework Convention on Climate Change (UNFCCC), CA refers to “changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change” (UNFCCC, 2022). These are required by countries and communities to respond to current and future climate change impacts. They are unique with no ‘one-size-fits-all-solution’. *Health policies* refer to “decisions, plans, and actions undertaken to achieve specific healthcare goals within a society” (Hunter, 2003; WHO, 2011). An *environmentally-friendly* health system is “a health system that improves, maintains or restores health, while minimising negative impacts on the environment and leveraging opportunities to restore and improve it, to the benefit of the health and well-being of current and future generations” (WHO, 2017). An environmentally *sustainable healthcare system* “delivers high-quality care and improved public health without exhausting natural resources or causing severe ecological damage” (Fineberg, 2012). *Decarbonising health systems* involves a set of

actions aimed at reducing or eliminating carbon dioxide emissions across healthcare systems (Hough and Cohen Tanugi-Carresse, 2024). According to the WHO, the *Health System* is defined as “all the organisations, people and actions whose primary purpose is to promote, restore or maintain health” (WHO, 2000).

Achieving better environmental sustainability in health systems requires changes (e.g., organisations, people and actions directly or indirectly contributing to GHG emissions) at multiple systemic and individual levels, supported by research, evidence, alliances, cultural change, contextual policies and legislations (Jamieson, Wicks and Boulding, 2015).

Study rationale

Global efforts to promote and deliver healthcare within environmentally sustainable, and decarbonised health systems have remained limited particularly in LMICs compared to HICs. While countries in other geographies (e.g. HICs) have developed overarching National Adaptation Plans (NAP) and established long-term targets or established specific programs, and incentivised practices to decarbonise healthcare, these have not been holistic and sector-wide, especially in lower-middle-income African countries like Nigeria (NHS, 2020; Waters, 2022; Hough and Cohen Tanugi-Carresse, 2024). There is also varied practice across the tiers of healthcare delivery – primary, secondary and tertiary.

Furthermore, where national commitments exist, as contained in the Nationally Determined Contributions (NDC) to reducing GHG emissions, the content of such has been incomplete (Hough and Cohen Tanugi-Carresse, 2024). For example, within Nigeria’s NDC and the 2024 National Vulnerability and Adaptation Assessment Report, there is no reference to achieving net-zero/decarbonisation within the health sector (FMOH&SW, 2024; Hough and Cohen Tanugi-Carresse, 2024). Data on GHG emissions within healthcare and by extension health systems are not readily available limiting cross-country comparison against targets. A direct implication of such missed opportunity includes failure to achieve outcomes such as enhanced health system resilience, lower energy and operational costs, and improved overall public health outcomes by reducing pollution-related risks. Additionally, opportunities to benefit from financial incentives such as grants, low-interest loans, and funding opportunities from mechanisms like the Green Climate Fund, the Global Environment Facility, and various bilateral or multilateral agreements that support clean energy transitions and climate resilience initiatives could be lost. This lack of data further compounds our understanding of barriers and factors limiting the implementation of CA policies, harmonising such policies within national and sub-national strategic plans, and communicating and socialising the same with contributions from key stakeholders and communities (Ansah *et al.*, 2024).

There is also a compelling argument for equitable development and implementation of these policies given the lopsided contribution of GHG emissions and the impact in high-income countries vs. low-income countries (Or and Seppänen, 2024). Failure to address these multiple factors may impede progress toward global climate adaptation objectives and goals towards resilient and decarbonised health systems.

Evidence is required to map the key concepts in this domain, and identify key characteristics, policies, and enabling factors related to climate action in promoting decarbonised health systems. This aligns with target 13.2 (*integrate climate change measures into national policies, strategies, and planning*) of SDG 13. Such evidence could inform the effective translation of existing policies and practices in Nigeria thereby signifying a commitment to collective efforts to accelerate the achievement of SDG 13 by 2030 and enabling the harnessing of the benefits and opportunities associated with climate action (Roca-Barceló *et al.*, 2024).

A scoping review will therefore be undertaken to review and map the existing evidence as countries navigate and develop a roadmap for environmentally sustainable, decarbonised health Systems by; i) assessing the extent of peer-reviewed and grey literature, available in the public domain, that has documented CA policies promoting environmentally sustainable, and decarbonised healthcare systems in HICs and LMICs; ii) gathering and organising data that has informed the development of and translation of these global policies into action within health systems; and iii) identifying key enablers to domesticating these policies within health systems in LMICs.

This scoping review can identify the CA policies promoting sustainable and decarbonised healthcare systems including where there has been a plethora of CA research and policy implementation that may warrant future systematic reviews or economic evaluations. Areas within climate and health research with policy gaps or where coherent evidence-based policies are scarce can become evident, highlighting topics or focus areas for future study.

Methods and analysis

The proposed scoping review will follow the framework introduced by Arksey and O'Malley for conducting scoping reviews, and the methodology manual published by the Joanna Briggs Institute for scoping reviews. The present protocol and future corresponding scoping review will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (Arksey and O'Malley, 2005; Tricco *et al.*, 2018; Peters *et al.*, 2024).

Thus, this review will follow five of these six stages: (1) identification of the research question; (2) identification of relevant studies; (3) selection of eligible studies; (4) charting the data; and (5) collating,

summarising and reporting of the results. There is an optional stage 6 (consultation with stakeholders) to identify additional references about potential studies to include and to collect feedback about the findings uncovered by the review. This may be considered should time permit and willing stakeholders be promptly sourced and available.

Stage 1: identifying the research question

A preliminary literature search identified a gap related to the variations in the Climate Adaptation Policies for promoting environmentally sustainable, decarbonised health systems, especially in LMICs (Hough and Cohen Tanugi-Carresse, 2024). This led to the development of the research questions that will guide this scoping review –

2. What climate adaptation policies are in place to promote environmentally sustainable, and decarbonised health systems in HIC and LMICs?
3. What might this mean for the promotion of environmentally sustainable, and decarbonised health systems in LMICs (e.g. Nigeria)?
4. What are the enablers being deployed by countries for domesticating, applying, and translating these policies into action within health systems?

Enablers refer to the factors, conditions, and mechanisms that facilitate and promote the application, and translation of climate adaptation policies into actionable strategies within health systems. For example, leadership, political and institutional commitment; governance frameworks; financial resources and funding mechanisms; capacity building and technical expertise; stakeholder engagement and multisectoral collaboration; data, technology, and information systems; and knowledge transfer and communication networks.

Stage 2: Identifying relevant studies

A preliminary search of PubMed, MEDLINE, and JBI Evidence Synthesis was undertaken, and no current or in-progress scoping reviews on this topic were identified. This scoping review adopts the Population, Concept, Context (PCC) framework as recommended by the Joanna Briggs Institute (Peters *et al.*, 2024). The research question is defined as follows:

Table 5 PCC framework of the scoping review

PCC element	Example
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<i>Population</i>	Countries with existing climate adaptation policies
<i>Concept</i>	Climate adaptation policies promoting environmentally sustainable, decarbonised health systems.
<i>Context</i>	Health systems in HICs, LMICs

A search strategy will be developed in consultation with an academic librarian to retrieve both published and unpublished studies. A three-step search approach will be employed: (1) **Initial limited search** - a limited search of MEDLINE (PubMed) was conducted to identify relevant articles. Text words from the titles and abstracts, as well as the index terms of these articles, were extracted to inform the development of a comprehensive search strategy; (2) **Development of the full search strategy** - using the identified keywords and Medical Subject Headings (MeSH) terms—screened and sorted by pertinence and frequency—a refined search strategy will be crafted. Keywords will be searched within titles, abstracts and subject headings on PubMed, and as topics on Overton and the World Health Organisation’s Global Index Medicus; (3) **Comprehensive search** - full search strategy will then be adapted for each of the chosen databases and information sources. These include PubMed, SCOPUS, JBI Evidence Synthesis and grey literature sources such as the World Health Organisation’s Global Index Medicus, OpenGrey and Overton. The databases were chosen for their international coverage of health sciences literature, interdisciplinarity and complementarity to the concept. A 20-year timeframe (January 2004 to March 2025) has been selected to capture sufficient information on the evolution of this topic since the early 2000s, taking into account the influential role of the annual Conference of the Parties (COP) meetings in advancing these discussions. Due to time and resource limitations, only studies published in English will be included. The reference lists and bibliographies of all included studies will be screened to identify other relevant articles.

A pilot search strategy, including the identified keywords and index terms, is detailed in supplemental Appendix A. This pilot search will help refine and finalise the full search strategy before conducting the comprehensive search across all selected databases and grey literature sources.

Stage 3: Selection of eligible studies

Following the search, all identified citations will be collated and uploaded into Covidence review software (available at www.covidence.org) and duplicates removed.

A two-step screening will be subsequently performed. The first part consists of screening titles and abstracts, thanks to the research strategy, to define the eligibility of each article while ensuring that no article is prematurely excluded at this stage. Screening will be done by two independent reviewers for

assessment against the inclusion criteria for the review. Publications with titles or abstracts not meeting the eligibility criteria (Table 1) will be excluded.

During the second part, the full texts having passed the first step will be screened and only relevant articles will be kept. The remaining ones will get full text screened.

The full text of selected citations will be assessed in detail against the inclusion criteria and consistency checks will be performed. In case of inconsistency, Covidence will display the rating differences and prompt each reviewer to review the article a second time. Reasons for exclusion will be recorded and reported in the scoping review. Any disagreements that arise between the reviewers at each stage of the selection process will be resolved through discussion. Unresolved conflicts will be resolved by a third reviewer. Co-reviewer(s) will be sourced from within the Global Healthcare Leadership executive cohort.

The search results and the study inclusion process will be reported in full in the final scoping review and presented in a PRISMA flow diagram.

Citation management will be done using Mendeley desktop (Mendeley Ltd., Elsevier, Netherlands) and will contain only citations of publications already reviewed and met the inclusion criteria.

Stage 4: Charting the data

Data will be extracted from papers included in the scoping review by two independent reviewers using a data extraction tool developed by the author. As endorsed by the methodology manual published by the Joanna Briggs Institute for scoping reviews, the data extraction form will be tested on a small sample of studies to ensure that all relevant data are extracted (Peters *et al.*, 2024). As this review follows an iterative approach, the data extraction form will be cumulatively filtered and regularly updated.

Modifications will be detailed in the scoping review report. Any disagreements that arise between the reviewers will be resolved through discussion. A third reviewer may be required where disagreements occur. As appropriate, authors of papers will be contacted to request missing or additional data, where required.

The data extraction table will include at least the following key elements with specific details about the concept, context, methods and key findings relevant to the research question/s. Additional details will consist of information about the authors, year of publication, study location, study population characteristics, and outcomes of interest to this scoping review (Table 2).

Table 6 Key elements for data extraction

1. <i>Author(s).</i>
2. <i>Year of publication.</i>
3. <i>Origin/country of origin.</i>
4. <i>Aims/purpose.</i>
5. <i>Methodology/methods.</i>
6. <i>Type of study</i>
7. <i>Type of publication (journal article, book chapter, grey literature)</i>
8. <i>Scoping review PCC – Population, Concept (interventions/programmes and outcomes assessed), Context</i>
9. <i>Key findings that relate to the scoping review questions (e.g., climate adaptation policies, practices, enablers, opportunities, domestication and approach to implementation).</i>
10. <i>Emergent themes (does the paper/publication report on any further issues not related to the above that might be of interest to this review?)</i>

Step 5: Collating, summarising and reporting results

Data presentation will initially be in tabular format. Due to the iterative process of scoping reviews, the decision on further presentation styles, such as graphs and figures, will be decided once data extraction has been undertaken. A narrative summary will be presented, together with visual data to create a richer description of the findings. The five principles outlined in the Ottawa Charter will help categorise outcomes and use its strategies to define the policies, practices, and enablers for CA policies (WHO, 1986).

Ethics approval and dissemination

The manuscript outlines a protocol for a scoping review that will undertake a secondary analysis of data already collected and does not require ethical approval. Data will be extracted from published articles in the public domain. Once the scoping review is complete, an MSc thesis and manuscripts for publication will be written to convey the findings of this review. The thesis will be submitted as part of the requirements for the degree of Master of Science in Global Healthcare Leadership at the University of Oxford - a program co-developed and jointly delivered by the Saïd Business School and Nuffield

Department of Primary Care Health Sciences. The author will subsequently submit versions of this thesis for publication in a peer-reviewed journal. It is anticipated that the results of this review will map out the various CA policies that will inform the promotion of environmentally sustainable, decarbonised health systems in LMICs. Specifically, this scoping review will identify areas of potential saturation or lopsidedness of existing CA policies within health systems, identify opportunities for future systematic reviews, policy implementation evaluations, primary research studies requiring synthesis and research gaps which will inform the conduct of future studies in this domain.

Consultation with stakeholders

The results of this scoping review will be used in consultation with key stakeholders within the National Council on Climate in Nigeria, and beyond, to determine the need for developing holistic and nuanced policies that cater to CA efforts aimed at decarbonising health systems. If a need is identified, stakeholders will be invited to contribute to policy review, and development using a collaborative evidence-informed approach.

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Author contributions

OBF conceived and drafted the study protocol. NR, DN, KM and LR reviewed the draft and provided critical revisions.

Conflicts of interest

None declared

Patient and public involvement

No patients will be involved.

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Appendices

Appendix I: PubMed search strategy conducted on September 30, 2024.

Query	Search Details	Results
((decarbon*[Title] OR "sustainable health*" OR "net zero"[Title]) AND (((("Climate Change"[Mesh:NoExp]) OR "Global Warming"[Mesh]) OR "Carbon Footprint"[Mesh]) OR "Greenhouse Effect"[Mesh]) OR ("climate change"[Title/Abstract] OR "global warming"[Title/Abstract] OR "carbon footprint"[Title/Abstract] OR "greenhouse effect"[Title/Abstract]))) AND ((Developing Countries[Mesh] OR Global Health[Mesh] OR Africa OR Caribbean OR "West Indies" OR "South America" OR "Latin America" OR "Central America" OR Afghanistan OR Albania OR Algeria OR Angola OR "American Samoa" OR Armenia OR Armenian OR Azerbaijan OR Bangladesh OR Benin OR Byelarus OR Byelorussian OR Belarus OR Belorussian OR Belorussia OR Belize OR Bhutan OR Bolivia OR Bosnia OR Herzegovina OR Hercegovina OR Botswana OR Brazil OR Brasil OR Bulgaria OR "Burkina Faso" OR "Burkina Fasso" OR "Upper Volta" OR Burundi OR Urundi OR Cambodia OR "Khmer Republic" OR Kampuchea OR Cameroon OR Camerons OR "Cape Verde" OR "Central African Republic" OR Chad OR China OR Colombia OR Comoros OR "Comoro Islands" OR Comores OR Mayotte OR Congo OR Zaire OR "Costa Rica" OR "Cote d'Ivoire" OR "Ivory Coast" OR Cuba OR Djibouti OR "French Somaliland" OR Dominica OR "Dominican Republic" OR "East Timor" OR "East Timur" OR "Timor Leste" OR Ecuador OR Egypt OR "United Arab Republic" OR "El Salvador" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR "Gabonese Republic" OR Gambia OR Gaza OR "Georgia Republic" OR "Georgian Republic" OR Ghana OR "Gold Coast" OR Grenada OR Guatemala OR Guinea OR Guinea-Bissau OR Guam OR Guiana OR Guyana OR Haiti OR Honduras OR India OR Maldives OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kazakh OR Kenya OR Kiribati OR Korea OR Kosovo OR Kyrgyzstan OR Kirghizia OR "Kyrgyz Republic" OR Kirghiz OR Kirgizstan OR "Lao PDR" OR Laos OR Lebanon OR Lesotho OR Basutoland OR Liberia OR Libya OR Macedonia OR Madagascar OR "Malagasy Republic" OR Malaysia OR Malaya OR Malay OR Sabah OR Sarawak OR Malawi OR Nyasaland OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR "Agalega Islands" OR Mexico OR Micronesia OR "Middle East" OR Moldova OR Moldovia OR Moldovian OR Mongolia OR Montenegro OR Morocco OR Ifni OR Mozambique OR Myanmar OR Myanma OR Burma OR Namibia OR Nepal OR "Netherlands Antilles" OR Nicaragua OR Niger OR Nigeria OR Pakistan OR Palau OR Palestine OR Panama OR "Papua New Guinea" OR Paraguay OR Peru OR Philippines OR Philipines OR	("decarbon*[Title] OR "sustainable health*" [All Fields] OR "net zero"[Title]) AND ("Climate Change"[MeSH Terms:noexp] OR "Global Warming"[MeSH Terms] OR "Carbon Footprint"[MeSH Terms] OR "Greenhouse Effect"[MeSH Terms] OR ("Climate Change"[Title/Abstract] OR "Global Warming"[Title/Abstract] OR "Carbon Footprint"[Title/Abstract] OR "Greenhouse Effect"[Title/Abstract])) AND ("developing countries"[MeSH Terms] OR "global health"[MeSH Terms] OR ("africa"[MeSH Terms] OR "africa"[All Fields] OR "africa s"[All Fields] OR "africas"[All Fields]) OR ("caribbean people"[MeSH Terms] OR ("caribbean"[All Fields] AND "people"[All Fields]) OR "caribbean people"[All Fields] OR "caribbeans"[All Fields] OR "caribbean s"[All Fields] OR "West Indies"[MeSH Terms] OR ("west"[All Fields] AND "indies"[All Fields]) OR "West Indies"[All Fields] OR "caribbean"[All Fields] OR "caribbean region"[MeSH Terms] OR ("caribbean"[All Fields] AND "region"[All Fields]) OR "caribbean region"[All Fields] OR "West Indies"[All Fields] OR "South America"[All Fields] OR "Latin America"[All Fields] OR "Central America"[All Fields] OR ("afghanistan"[MeSH Terms] OR "afghanistan"[All Fields] OR "afghanistan s"[All Fields]) OR ("albania"[MeSH Terms] OR "albania"[All Fields]) OR ("algeria"[MeSH Terms] OR "algeria"[All Fields]) OR ("angola"[MeSH Terms] OR "angola"[All Fields] OR "angola s"[All Fields]) OR "American Samoa"[All Fields] OR ("armenia"[MeSH Terms] OR "armenia"[All Fields]) OR ("armenian people"[Supplementary Concept] OR "armenian people"[All Fields] OR "armenians"[All 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<p>Phillipines OR Phillippines OR Romania OR Rumania OR Roumania OR Rwanda OR Ruanda OR "Saint Lucia" OR "St Lucia" OR "Saint Vincent" OR "St Vincent" OR Grenadines OR Samoa OR "Samoan Islands" OR "Navigator Island" OR "Navigator Islands" OR "Sao Tome" OR Senegal OR Serbia OR "Sierra Leone" OR Sri Lanka OR Ceylon OR "Solomon Islands" OR Somalia OR Sudan OR Suriname OR Surinam OR Swaziland OR Syria OR Principe OR Tajikistan OR Tadzhhikistan OR Tadjikistan OR Tadjhik OR Tanzania OR Thailand OR Timor-Leste OR Togo OR "Togolese Republic" OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Turkmen OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Uzbek OR Vanuatu OR "New Hebrides" OR Vietnam OR "Viet Nam" OR "West Bank" OR Yemen OR Zambia OR Zimbabwe OR Rhodesia OR developing countr* OR less developed countr* OR under developed countr* OR underdeveloped countr* OR middle income countr* OR low income countr* OR deprived countr* OR underserved countr* OR under served countr* OR poor countr* OR developing nation* OR less developed nation* OR under developed nation* OR underdeveloped nation* OR middle income nation* OR low income nation* OR deprived nation* OR underserved nation* OR under served nation* OR poor nation* OR LMIC OR lmic OR third world* OR lami countr* OR transitional countr* OR "global health")</p>	<p>("burundi"[MeSH Terms] OR "burundi"[All Fields]) OR ("burundi"[MeSH Terms] OR "burundi"[All Fields] OR "urundi"[All Fields]) OR ("cambodia"[MeSH Terms] OR "cambodia"[All Fields] OR "cambodia s"[All Fields]) OR "Khmer Republic"[All Fields] OR ("cambodia"[MeSH Terms] OR "cambodia"[All Fields] OR "kampuchea"[All Fields]) OR ("cameroon"[MeSH Terms] OR "cameroon"[All Fields] OR "cameroons"[All Fields] OR "cameroon s"[All Fields]) OR ("cameroon"[MeSH Terms] OR "cameroon"[All Fields] OR "cameroons"[All Fields] OR "cameroon s"[All Fields]) OR ("cameron"[All Fields] OR "cameron s"[All Fields]) OR "Camerons"[All Fields] OR "Cape Verde"[All Fields] OR "Central African Republic"[All Fields] OR ("chad"[MeSH Terms] OR "chad"[All Fields]) OR ("china"[MeSH Terms] OR "china"[All Fields] OR "china s"[All Fields] OR "chinas"[All Fields]) OR ("colombia"[MeSH Terms] OR "colombia"[All Fields] OR "colombia s"[All Fields]) OR ("comoros"[MeSH Terms] OR "comoros"[All Fields] OR "comoro"[All Fields]) OR "Comoro Islands"[All Fields] OR ("comore"[All Fields] OR "comores"[All Fields]) OR ("comoros"[MeSH Terms] OR "comoros"[All Fields] OR "mayotte"[All Fields]) OR ("congo"[MeSH Terms] OR "congo"[All Fields]) OR ("democratic republic of the congo"[MeSH Terms] OR ("democratic"[All Fields] AND "republic"[All Fields] AND "congo"[All Fields]) OR "democratic republic of the congo"[All Fields] OR "zaire"[All Fields]) OR "Costa Rica"[All Fields] OR "Cote d'Ivoire"[All Fields] OR "Ivory Coast"[All Fields] OR ("cuba"[MeSH Terms] OR "cuba"[All Fields]) OR ("djibouti"[MeSH Terms] OR "djibouti"[All Fields]) OR "French Somaliland"[All Fields] OR ("dominica"[MeSH Terms] OR "dominica"[All Fields]) OR "Dominican Republic"[All Fields] OR "East Timor"[All Fields] OR ("east"[All Fields] AND "timur"[All Fields]) OR "Timor Leste"[All Fields] OR ("ecuador"[MeSH Terms] OR "ecuador"[All Fields] OR "ecuador s"[All Fields]) OR ("egypt"[MeSH Terms] OR "egypt"[All Fields] OR "egypt s"[All Fields]) OR "United Arab Republic"[All Fields] OR "El Salvador"[All Fields] OR ("eritrea"[MeSH Terms] OR "eritrea"[All Fields]) OR ("ethiopia"[MeSH Terms] OR "ethiopia"[All Fields] OR "ethiopia s"[All Fields]) OR ("fiji"[MeSH Terms] OR "fiji"[All Fields]) OR ("gabon"[MeSH Terms] OR "gabon"[All Fields]) OR "Gabonese Republic"[All Fields] OR ("gambia"[MeSH Terms] OR "gambia"[All Fields] OR "gambia s"[All Fields]) OR "Gaza"[All Fields] OR "Georgia Republic"[All Fields] OR "Georgian Republic"[All Fields] OR ("ghana"[MeSH Terms] OR "ghana"[All Fields] OR "ghana s"[All Fields]) OR "Gold Coast"[All Fields] OR ("grenada"[MeSH Terms] OR "grenada"[All Fields]) OR ("guatemala"[MeSH Terms] OR "guatemala"[All Fields] OR "guatemala s"[All Fields]) OR ("guinea"[MeSH Terms] OR "guinea"[All Fields] OR "guinea s"[All Fields] OR "guineas"[All Fields]) OR ("guinea bissau"[MeSH Terms] OR "guinea bissau"[All Fields] OR ("guinea"[All Fields] AND "bissau"[All Fields]) OR "guinea bissau"[All Fields]) OR ("guam"[MeSH Terms] OR "guam"[All Fields]) OR ("guianas"[All Fields] OR "guyana"[MeSH Terms] OR "guyana"[All Fields] OR "guiana"[All Fields]) OR ("guyana"[MeSH Terms] OR "guyana"[All Fields]) OR ("haiti"[MeSH Terms] OR "haiti"[All Fields] OR "haiti s"[All Fields]) OR ("honduras"[MeSH Terms] OR "honduras"[All Fields]) OR ("india"[MeSH Terms] OR "india"[All Fields] OR "india s"[All Fields] OR "indias"[All Fields]) OR ("maldives"[All Fields] OR "maldives"[MeSH Terms] OR "maldives"[All Fields]) OR ("indonesia"[MeSH Terms] OR "indonesia"[All Fields] OR "indonesias"[All Fields] OR "indonesias"[All Fields]) OR ("iran"[MeSH Terms] OR "iran"[All Fields]) OR ("iraq"[MeSH Terms] OR "iraq"[All Fields]) OR</p>	
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	<p>(("tonga"[MeSH Terms] OR "tonga"[All Fields] OR "tonga s"[All Fields]) OR ("tunisia"[MeSH Terms] OR "tunisia"[All Fields]) OR ("turkey"[MeSH Terms] OR "turkey"[All Fields] OR "turkey s"[All Fields] OR "turkeys"[MeSH Terms] OR "turkeys"[All Fields]) OR ("turkmenistan"[MeSH Terms] OR "turkmenistan"[All Fields]) OR ("turkmen"[All Fields] OR "turkmens"[All Fields]) OR ("micronesia"[MeSH Terms] OR "micronesia"[All Fields] OR "tuvalu"[All Fields]) OR ("uganda s"[All Fields]) OR ("ukraine"[MeSH Terms] OR "ukraine"[All Fields] OR "ukraine s"[All Fields]) OR ("uzbekistan"[MeSH Terms] OR "uzbekistan"[All Fields]) OR ("uzbek"[All Fields] OR "uzbeks"[All Fields]) OR ("vanuatu"[MeSH Terms] OR "vanuatu"[All Fields]) OR "New Hebrides"[All Fields] OR ("vietnam"[MeSH Terms] OR "vietnam"[All Fields] OR "vietnam s"[All Fields]) OR "Viet Nam"[All Fields] OR "West Bank"[All Fields] OR ("yemen"[MeSH Terms] OR "yemen"[All Fields]) OR ("zambia"[MeSH Terms] OR "zambia"[All Fields] OR "zambia s"[All Fields]) OR ("zimbabwe"[MeSH Terms] OR "zimbabwe"[All Fields] OR "zimbabwe s"[All Fields]) OR "Rhodesia"[All Fields] OR ((("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] OR "development"[All Fields]) AND "countr*"[All Fields]) OR ("less"[All Fields] AND ("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields]) AND "countr*"[All Fields]) OR ("under"[All Fields] AND ("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] OR "development"[All Fields]) AND "countr*"[All Fields]) OR ((("underdeveloped"[All Fields] OR "underdevelopment"[All Fields]) AND "countr*"[All Fields]) OR ((("middle"[All Fields] OR "middles"[All Fields]) AND ("income"[MeSH Terms] OR "income"[All Fields] OR "incomes"[All Fields] OR "income s"[All Fields]) AND "countr*"[All Fields]) OR ((("poverty"[MeSH Terms] OR "poverty"[All Fields] OR ("low"[All Fields] AND "income"[All Fields]) OR "low income"[All Fields]) AND "countr*"[All Fields]) OR ((("deprival"[All Fields] OR "deprivation"[All Fields] OR "deprivations"[All Fields] OR "deprive"[All Fields] OR "deprived"[All Fields] OR "deprives"[All Fields] OR "depriving"[All Fields]) AND "countr*"[All Fields]) OR ((("underserved"[All Fields] OR "underserved"[All Fields] OR "underservicing"[All Fields]) AND "countr*"[All Fields]) OR ("under"[All Fields] AND ("serve"[All Fields] OR "served"[All Fields] OR "serves"[All Fields] OR "serving"[All Fields] OR "servings"[All Fields]) AND "countr*"[All Fields]) OR ((("poverty"[MeSH Terms] OR "poverty"[All Fields] OR "poor"[All Fields]) AND "countr*"[All Fields]) OR ("develop"[All Fields] OR "develope"[All Fields] OR</p>	
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	<p>"developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] OR "development"[All Fields] AND "nation*" [All Fields]) OR ("less"[All Fields] AND ("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] OR "development"[All Fields] AND "nation*" [All Fields]) OR ("under"[All Fields] AND ("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR "developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] AND "nation*" [All Fields]) OR ("underdeveloped"[All Fields] OR "underdevelopment"[All Fields]) AND "nation*" [All Fields]) OR ("middle"[All Fields] OR "middles"[All Fields]) AND ("income"[MeSH Terms] OR "income"[All Fields] OR "incomes"[All Fields] OR "income s"[All Fields]) AND "nation*" [All Fields]) OR ("poverty"[MeSH Terms] OR "poverty"[All Fields] OR ("low"[All Fields] AND "income"[All Fields]) OR "low income"[All Fields]) AND "nation*" [All Fields]) OR ("deprival"[All Fields] OR "deprivation"[All Fields] OR "deprivations"[All Fields] OR "deprive"[All Fields] OR "deprived"[All Fields] OR "deprives"[All Fields] OR "depriving"[All Fields]) AND "nation*" [All Fields]) OR ("underserved"[All Fields] OR "underserved"[All Fields] OR "underservicing"[All Fields]) AND "nation*" [All Fields]) OR ("under"[All Fields] AND ("serve"[All Fields] OR "served"[All Fields] OR "serves"[All Fields] OR "serving"[All Fields] OR "servings"[All Fields]) AND "nation*" [All Fields]) OR ("poverty"[MeSH Terms] OR "poverty"[All Fields] OR "poor"[All Fields]) AND "nation*" [All Fields]) OR "LMIC"[All Fields] OR ("developing countries"[MeSH Terms] OR ("developing"[All Fields] AND "countries"[All Fields]) OR "developing countries"[All Fields] OR "lmics"[All Fields] OR "lmic s"[All Fields]) OR ("third"[All Fields] OR "thirds"[All Fields]) AND "world*" [All Fields]) OR ("lami"[All Fields] AND "countr*" [All Fields]) OR ("transit"[All Fields] OR "transited"[All Fields] OR "transiting"[All Fields] OR "transition"[All Fields] OR "transitional"[All Fields] OR "transitionals"[All Fields] OR "transitioned"[All Fields] OR "transitioning"[All Fields] OR "transitions"[All Fields] OR "transits"[All Fields]) AND "countr*" [All Fields]) OR "global health"[All Fields])</p>	
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APPENDIX B – PRIMSA-SCR CHECKLIST

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Title page
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	viii - ix
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	7-8
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	8
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	10 – Open Science Framework; protocol published on OSF in April 2025 (osf.io/a62ky)
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	11-12
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with	11-12

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		authors to identify additional sources), as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix B
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	12-13
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	13-14
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	13-14
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Not applicable
Synthesis of results	13	Describe the methods of handling and summarising the data that were charted.	13-14
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	15
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10-13
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Not applicable
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	15-49

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	18	Summarise and/or present the charting results as they relate to the review questions and objectives.	15-49
DISCUSSION			
Summary of evidence	19	Summarise the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	50-59
Limitations	20	Discuss the limitations of the scoping review process.	61-62
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	65-66
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Not applicable

PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: [10.7326/M18-0850](https://doi.org/10.7326/M18-0850).

APPENDIX C – SEARCH TERMS

PubMed

(
("climate adaptation"[Title/Abstract] OR "climate change adaptation"[Title/Abstract] OR "climate resilient"
[Title/Abstract] OR "resilience to climate change"[Title/Abstract] OR "climate crisis"[Title/Abstract])

AND

("health system"[Title/Abstract] OR "healthcare system"[Title/Abstract] OR "health services"[MeSH Terms] OR
"health sector"[Title/Abstract] OR "healthcare delivery"[Title/Abstract])

AND

("decarbonization"[Title/Abstract] OR "carbon reduction"[Title/Abstract] OR "carbon neutrality"[Title/Abstract]
OR "low-carbon"[Title/Abstract] OR "net-zero emissions"[Title/Abstract] OR "environmental
sustainability"[Title/Abstract] OR "green healthcare"[Title/Abstract])

AND

("policy"[Title/Abstract] OR "policies"[Title/Abstract] OR "strategy"[Title/Abstract] OR
"strategies"[Title/Abstract] OR "framework"[Title/Abstract] OR "governance"[Title/Abstract])
)

SCOPUS

(TITLE-ABS-KEY ("climate adaptation" OR "climate change adaptation" OR "climate change" OR "climate
crisis") AND TITLE ("decarbon*" OR "carbon reduction" OR "carbon neutrality" OR "low-
carbon" OR "net-zero emissions" OR "net zero" OR "environmental
sustainability" OR "sustainab*" OR "green healthcare") AND TITLE-ABS-KEY ("health
system" OR "healthcare system" OR "health services" OR "health sector" OR "healthcare
delivery" OR "planetary health")

WHO Global Index Medicus

"climate change" AND "health*" AND (mj:("Climate Change" OR "Climate" OR "Public Health" OR "Environ`
mental Health" OR "Humans" OR "Global Warming" OR "Greenhouse Effect" OR "Air Pollution" OR
"Environment" OR "World Health Organization" OR "Health" OR "Global Health" OR "Urban Health" OR "Health
Personnel" OR "Delivery of Health Care" OR "Environment and Public Health" OR "Food Supply" OR "Asian
People" OR "Developing Countries" OR "Environmental Pollution" OR "Republic of Korea" OR "Policy Making"
OR "Public Policy" OR "Asia" OR "Developed Countries" OR "Africa" OR "Health Policy" OR "Nigeria" OR
"Ozone" OR "Papua New Guinea" OR "Physician-Patient Relations" OR "Physician's Role" OR "Physicians" OR
"Population" OR "Primary Health Care" OR "Schools, Medical" OR "Students, Medical" OR "Bangladesh" OR
"Health Policy, Planning and Management" OR "Health Infrastructure") AND la:("en")) AND (year_cluster:[2004
TO 2025])

APPENDIX D – DATA EXTRACTION TABLE

1. Author(s).	2. Title
3. Year of publication.	4. Country or Region
5. World Bank Income classification	6. Journal
7. Study Design/Type of Study	8. Aims/purpose.
9. WHO Operational Framework Components 1 - Leadership & Governance	10. WHO Operational Framework Components 2 - Climate-smart Health Workforce
11. WHO Operational Framework Components 3 - Vulnerability and risk assessments	12. WHO Operational Framework Components 4 - Integrated risk monitoring and early warning
13. WHO Operational Framework Components 5 - Health and climate research	14. WHO Operational Framework Components 6 - Low-carbon infrastructure, technologies and supply chain
15. WHO Operational Framework Components 7 - Management of environmental determinants of health	16. WHO Operational Framework Components 8 - Climate-informed health programmes
17. WHO Operational Framework Components 9 - Climate-related emergency preparedness and management	18. WHO Operational Framework Components 10 - Sustainable climate financing
19. Ottawa Charter Action Areas 1 - Building public health policy	20. Ottawa Charter Action Areas 2 - Creating supportive environments
21. Ottawa Charter Action Areas 3 - Strengthening community action	22. Ottawa Charter Action Areas 4 - Developing personal skills
23. Ottawa Charter Action Areas 5 - Reorienting health services	

APPENDIX E – LIST OF REVIEWED LITERATURE

S/N	Author(s)	Title	Year	Country/region	WB Income classification (HIC, UMIC, LMIC)	Journal/source	Study Design/Type of study (peer-review, book chapter etc)	Aims/Purpose (Original Study)
1	Armocida, B. et al.	Decarbonization of the Italian healthcare system and European funds. A lost opportunity?	2022	Italy/EU	HIC	Frontiers in Public Health	Opinion piece	Perspective on EU climate-related policies and implications for the Italian health system
2	Salas RN, Friend TH, Bernstein A, Jha AK.	Adding A Climate Lens To Health Policy In The United States	2020	US	HIC	Health Affairs	Commentary	Integrating climate-informed assessments into health care decision making and health policy for a more resilient and equitable American health care system
3	Nayna Schwerdtle P et al.	‘Calibrating to scale: a framework for humanitarian health organizations to anticipate, prevent, prepare for and manage climate-related health risks’	2020	Global	HIC, UMIC, LMIC	Globalization and Health	Commentary/case studies	Increase the capacity of humanitarian organizations to protect health in an unstable climate by presenting an adapted framework to promote climate resilience and climate action in humanitarian settings
4	Hensher M, and McGain F.	Health care sustainability metrics: Building a safer, low-	2020	US	HIC	Health Affairs	Opinion piece	Examines lessons from health care’s long experience with performance and quality measurement and reporting that can be applied to the creation of health care sustainability metrics

		carbon health system						
5	Quintana A V., et al	COP26: an opportunity to shape climate-resilient health systems and research	2021	Global	HIC, UMIC, LMIC	The Lancet Planetary Health	Commentary	Call to action for increased need for health systems research in climate resilience/action
6	Kluge H et al	Environmental sustainability of health systems: time to act	2023	Panel across multiple countries	HIC, UMIC	The Lancet	Commentary	A call to action to promote environmental sustainability of health systems
7	Thomson D, Varangu L, Webster RJ.	A climate resilience maturity matrix for Canadian health systems	2023	Canada	HIC	Healthcare Management Forum	Original research	Climate Resilience Maturity Matrix that brings together both mitigation and adaptation actions into a high-level tool for health leaders, for supporting organizational review, assessment, and decision-making for climate change readiness. This tool is intended to consolidate key data, provide a clear communication tool, allow for objective rapid baselining, enable system-level gap analysis, facilitate comparability/transparency, and support rapid learning cycles.
8	Teshome M.	The Transformative Role of Adaptation Strategies in Designing Climate-Resilient and Sustainable Health Systems	2023	Least Developed Countries	LMIC	Journal of Prevention	Practitioner Narrative	Spotlights opportunities for more resilient and equitable health systems across key dimensions of health surveillance, service delivery, infrastructure, finance, capacity development and policy coherence. Proposes transformative approaches to support the formulation and implementation of health-informed climate adaptation strategies and actions
9	Mosadeghrad AM et al	Strategies to strengthen a climate-resilient health system: a scoping review.	2023	Global	HIC, UMIC, LMIC	Globalization and Health	Original research/Scoping review	Identify interventions and actions to strengthen a climate-resilient health system to deal with the adverse health effects of climate change.

10	Smith R.	Twelve Cs for getting health systems to net zero	2023	England	HIC	BMJ	Opinion piece	Summary of lessons on achieving net zero in UK health systems at a net zero conference in the UK
11	Lokotola CL	Towards a climate-resilient primary health care service.	2023	South Africa	MIC	South African Family Practice	Original research	Uses key frameworks to suggest practical steps that family doctors can take in leading climate adaptation and mitigation within PHC.
12	Martins FP et al .	The Double Burden: Climate Change Challenges for Health Systems	2024	Global	HIC, UMIC, LMIC	Environmental Health Insights	Original research/scoping review	Identify key themes, trends, and research gaps at the intersection of climate change and health systems. highlight how case studies and other academic literature have addressed equity issues within the framework of climate-resilient health systems.
13	Braithwaite J, Zurynski Y, Smith CK lyn et al .	Creating climate-resilient, sustainable health systems: Perspectives from health ministers.	2024	Netherlands and Bahamas	HIC, LMIC	Routledge Handbook of Climate Change and Health System Sustainability	Book chapter	Documents perspectives from two health ministers - Netherlands and Bahamas- on addressing climate and health issues.
14	Hough E, and Cohen Tanugi-Carresse A.	Supporting Decarbonization of Health Systems—A Review of International Policy and Practice on Health Care and Climate Change.	2024	Global	HIC, UMIC, LMIC	Current Environmental Health Reports	Review	Identify international commitments and policies relating to climate smart, low carbon sustainable health systems with a view to identifying actions and enablers that could be adapted to US policy contexts
15	Blom IM et al.	Evaluating progress and accountability for achieving COP26 Health Programme international ambitions for sustainable, low-	2024	Global	HIC, UMIC, LMIC	The Lancet Planetary Health	Review	To build on ATACH efforts to achieve sustainable healthcare systems through a scientific analysis of the COP26 Health Programme commitments by identifying, applying, and evaluating relevant indicators.

		carbon, resilient health-care systems.						
16	Vidal-Cuellar CL, et al.	Pathways to strengthen the climate resilience of health systems in the Peruvian Amazon by working with Indigenous leaders, communities and health officers.	2024	Peru	LMIC	BMJ Global Health	Original research/Mixed methods	Aimed to inform the climate change resilience of health systems in the Peruvian Amazon by working with Indigenous leaders, community members and health officers from two Amazon regions
17	Akhtar TM and Reid MJA.	The Urgency of Climate-Resilient Health Systems in Pakistan: Lessons From the 2022 Floods.	2024	Pakistan	LMIC	International Journal of Public Health	Commentary	Review the impact of the 2022 floods and outline the importance of sustained investment in climate- responsive health systems in Pakistan and across East Asia.
18	Kumar S, Kumar A, and Singh M.	Building Climate-Resilient Health Systems in India: A Comprehensive Health Systems Approach	2024	India	LMIC	Cureus	Editorial	Discuss the importance and initiatives taken under the health systems building blocks as a primary component for achieving universal health coverage and health outcomes at the union and state levels in India to better understand the preparedness of the Indian health system resilience for climate change
19	Smith CL, Rojas C, Zurynski Y, et al.	What Australia must do to create a climate-responsive health system.	2024	Australia	HIC	Internal Medicine Journal	Viewpoint	Identify what Australia needs to do to create a climate response health system with a review of what it currently has on climate and health adaptation.
20	Barber B, Rainham DG, Tyedmers P, et al	Taking action towards climate-resilient, low-carbon, health systems: Perspectives from Canadian health	2024	Canada	HIC	Healthcare Management Forum	Original research/Qualitative	Survey to better understand perceptions of responsibility for practicing and advocating for climate-resilient and low-carbon health systems among healthcare professionals and health leaders.

		leaders and healthcare professionals						
21	Gerk A, et al .	Promoting climate-resilient health systems through national surgical plans	2024	Ecuador/Latin America	UMIC	The Lancet Regional Health - Americas	Commentary	Review of the Ecuador's National Surgical Strengthening Plan (NSSP)/National Surgical, Obstetric, and Anesthesia Plan (NSOAP) promoting climate-resilient health systems
22	Thomson D, Zimmermann GL, Gohel B.	Climate-resilient acute care clinical operations: A framework that informs how operations within acute care build climate-resilient health systems.	2025	Canada (Provincial level - Alberta)	LMIC	Healthcare Management Forum	Original research article	Presentation of the Climate-Resilient Acute Care Clinical Operations Framework (Acute Care Framework) to guide the development, implementation, and evaluation of strategies within clinical operations to build more climate-resilient acute care systems.
23	Gohel B, Turcotte S.	Building climate-resilient and low-carbon healthcare systems in Canada: A need for policy shift for a path to net zero.	2025	Canada	HIC	Healthcare Management Forum	Original research article	A comparative policy approach focusing on similar national and international health systems, providing insights into potential solutions that Canada could adopt or adapt to its unique policy setting and its focus on building climate-resilient and low-carbon healthcare systems
24	Hussain M, et al	From Vulnerability to Strength: Transforming Health Systems for Climate Resilience.	2025	US	HIC	Journal of Urban Health	Original research article	Synthesizes key themes and strategies that (1) emerged during the February 2024 New York Academy of Medicine (NYAM) convening of more than 200 professionals to discuss how to transform healthcare systems to be more resilient in the face of ongoing and worsening climate-related stressor and (2) existing literature on climate change, health, and resilience, underscoring how health systems might play a pivotal role in fostering climate and health resilience.

25	Blom IM, et al	Towards a net-zero healthcare system in Kenya: Stakeholder perspectives on opportunities, challenges and priorities	2025	Kenya	LMIC	The Journal of Climate Change and Health	Original research article/qualitative research	A critical analyses of the progress and prospects of Kenya’s commitment to a net-zero, resilient healthcare system, adopting a health policy and systems research approach using qualitative methods (in-depth interviews and a Delphi consensus process with workshop) to gather diverse stakeholder perspectives. It examined the integration of interventions within Kenya’s healthcare system, focusing on the design, implementation, and evaluation of interventions. The study also assessed key barriers and identifies facilitators of the process
26	Nayna Schwerdtle P, et al.	A rapid review of climate resilient and low carbon health systems - Case studies in six western pacific countries.	2025	Western pacific (Australia, Fiji, South Korea, Laos, Mongolia, and Viet Nam)	HIC, UMIC, LMIC	The Journal of Climate Change and Health	Review	provide an overview of case studies for building climate resilient and low carbon health systems in selected WPR countries and applying the WHO Operational Framework to analyse implementation in practice, and capture relevant case studies that exemplify climate resilience and decarbonization in health systems across selected Western Pacific countries