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Original Research

Building climate-resilient and low-carbon health systems in Nepal: Insights from a policy document review and qualitative interviews with key stakeholders

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ABSTRACT

Objectives: This study aimed to investigate the health sector's progress on building a climate-resilient and environmentally sustainable health system in Nepal. The objectives were to identify specific challenges related to the World Health Organisation's (WHO's) ten-component operational framework and provide actionable insights to inform evidence-based strategies for health policymakers.
Study design: Mixed-method design involving policy analysis and qualitative interviews.
Methods: This study conducted a desk-based review of policies relevant to climate and health, and conducted qualitative interviews with 12 stakeholders (government policymakers, private sector and civil society). Participants were purposively selected based on their expertise in climate change and health, ensuring diverse perspectives. The findings were systematically organised and analysed using the ten components of the WHO operational framework for building climate-resilient and environmentally sustainable health systems.
Results: Integration of evidence from the policy document review and the qualitative interviews showed that, despite a strong policy foundation supporting the transition to low-carbon, climate-resilient health systems, implementation remained unsatisfactory, primarily due to poor data, weak intersectoral collaboration, insufficient capacity and inadequate funding allocated to climate resilience within the health sector. Issues related to the framing of climate change as either an environmental or a public health problem across ministries, demonstrated by divergent views on establishing early warning and monitoring systems, significantly affected ownership and responsibility for implementing existing policies.
Conclusions: This study identified the need to strengthen inter-ministerial and cross-disciplinary collaboration in addressing climate change as a risk multiplier across many sectors. Such collaboration would enable international development partners and allow the state government to appropriately allocate resources to address topical challenges, including capacity building, infrastructure development and the establishment of integrated mechanisms to support transition to a climate-resilient health system in Nepal.

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1. Introduction

Climate change presents a multifaceted array of risks to population health.[1] Regardless of the specific pathways, health systems bear the burden of population health impacts, manifesting as overcrowded health facilities, delays in emergency service delivery and challenges in providing timely patient care.[2] Poorly functioning health systems, without surge capacity, resilient infrastructure, and early-warning and response systems, become rapidly overwhelmed by crises, such as heatwaves and floods, causing a breakdown of services and a substantial increase in all-cause mortality.[3] As such, climate-resilient health systems are an urgent priority, defined as health systems capable of anticipating, responding to, coping with, recovering from, and adapting to climate-related shocks and stress.[4] To help the health sector systematically and effectively prepare for the additional health risks posed by climate change, the World Health Organisation (WHO) developed a framework consisting of 10 functions across six building blocks (leadership, workforce, information systems, essential medical products and technologies, service delivery and financing) that are essential for the effective functioning of all health systems.[4] While numerous studies have evaluated the health impacts of climate change, there is a paucity of policy research examining how national health systems, especially in low- and middle-income country (LMIC) settings, are institutionally and operationally preparing to adapt.[5] Strengthening institutional and operational resilience within national health systems is crucial in preventing reversals in health gains, reducing inequities and ensuring sustained access to essential care under escalating climate stressors.[5] Building resilience in the health sector requires integrating climate change considerations into the budgeting process, strategic health planning and frameworks such as 'Health in All Policies'. These should be aligned with broader national strategies, such as National Adaptation Plans (NAPs), to support a coherent, multisectoral response to climate change.

Nepal is among the most vulnerable countries to climate variability and change due to its fragile ecosystems, burden of climate-sensitive health, well-being and livelihood outcomes, and limited adaptive capacity.[6] Nepal has already experienced the consequences of the geographic expansion of vector-borne diseases, including frequent outbreaks of vector-borne diseases in highlands, increasing trends of water-borne diseases in mountainous regions and frequent occurrences of extreme events such as heatwaves.[7,8]

Observations suggest that the most recent shift towards a three-tiered federal structure (national, provincial and local) generated significant challenges in coordination across the three levels of government, worsening policy-practice divides on health system resilience.[5] Federalisation has exacerbated challenges such as poor coordination across the government tiers, delayed allocation of funds, unequal distribution of staff, procurement issues and inadequate supervision of service quality.[9] Following the transition to a three-tiered structure system of governance, several studies updated the status of Nepal's health system.[9,10] However, there remains a gap in understanding of how the decentralised health system is prepared to address health risks in a changing climate. Nepal is committed to acting on climate change in line with the Paris Agreement, despite the country's negligible emissions. Although Nepal's climate change policy framework is built on its Health National Adaptation Plan (H-NAP)[11] and its ambitious Nationally Determined Contributions (NDC),[12] implementation is hindered by persistent institutional and technical capacity gaps that continue to impede effective health-sector adaptation.

To assess progress and identify challenges in Nepal's transition to a low-carbon and climate-resilient health system, this study applied the WHO's operational framework to inform mapping policy–practice disconnects. This was achieved through a structured assessment of policy documents and in-depth stakeholder interviews related to system readiness and implementation barriers. The current research offers actionable guidance for smarter resource allocations, enhanced cross-sector collaboration and adaptive design for more effective interventions. These insights are broadly relevant to other LMICs facing similar ambition implementation gaps.

2. Methods

A qualitative thematic review was conducted of grey and peer-reviewed literature related to climate change and health research, employing the READ approach for document analysis.[13] The READ method consists of four sequential steps: reading the documents, extracting data, analysing data, and distilling and reporting the findings.[13,14] Conducted in accordance with the WHO's operational framework of climate-resilient and environmentally sustainable health systems (leadership and governance, climate-smart health workforce, assessments of climate and health risks and greenhouse gas emissions [GGEs], integrated risk monitoring, health and climate research, climate-resilient low-carbon infrastructures, management of environmental determinants of health, climate-informed health programmes, climate-related emergency preparedness, and sustainable climate and health financing), the study identified implementation barriers and facilitators that could not be accurately captured through document-based analysis alone. The WHO framework also informed the rules of implementation for the deductive coding strategy employed in this study, which was applied to policy documents and interview transcripts. This ensured that findings were directly connected to the documented evidence. Through this approach, institutional readiness and policy implementation were assessed across federal, provincial and local levels, directly addressing the aim to map policy and practice gaps in building a climate-resilient health system.

2.1. Document sources and analysis

Relevant policies and reports (at least one reference to either climate or health) were identified using government websites, such as the Ministry of Health and Population, the Ministry of Forest and Environment (climate change management division), the Nepal Health Research Council, the National Planning Commission, the Ministry of Finance, the Ministry of Home Affairs and the Nepal Law Commission, while other grey and published literature were identified using PubMed and Google Scholar. Similarly, international reports were reviewed from sources such as the WHO, the Asian Development Bank, the Asian Disaster Preparedness Center and the United Nations Framework Convention on Climate Change (UNFCCC). These documents were identified through a rigorous search strategy using keywords such as "Climate," "Health," and "Nepal" and Boolean operators "OR" and "AND" across the sources searched. All relevant policies related to climate and health were included in the desk review regardless of the timeline, whereas grey literature and reports were included from 2010 to 2025. Moreover, policies written in both Nepali and English language were included in the desk review. In total, 43 documents were reviewed, including 9 policies and strategic plans related to climate change, 5 documents focussed on health in the context of climate change, 16 grey literature publications and 13 peer-reviewed articles. The identified documents underwent independent evaluation by three researchers (MLD, DB and MD). Using Microsoft Excel (version 2021), data related to climate change and the six building blocks of health systems were extracted, using a data collection tool (Appendix 3) and compiled based on consensus reached during biweekly team meetings. A comprehensive content analysis was then conducted to synthesise information according to the ten components of the WHO's operational framework.[14,15]

2.2. Interview data collection and analysis

Interviews were conducted with 12 key informants (public health policymakers and stakeholders) to identify initiatives undertaken to mitigate and adapt to health threats posed by climate change.

Table 1
Findings of Desk Review

No.	Components from WHO Operational Framework	Findings from desk review of recent policy developments and programmatic action in this area
1.	Climate transformative leadership and governance	Nepal's policy and political commitment to climate change were initiated after ratifying the United Nations Framework Convention on Climate Change (UNFCCC).[18] Furthermore, the Constitution of Nepal 2015 ensured "health in all policies" by granting every citizen the right to basic health services and by strengthening climate change policy and political commitments.[19] The Nepal government developed several policies related to climate change and health, including the Climate Change Policy 2011,[20] and 2019 (updated),[21] Health National Adaptation Plan (H-NAP) (2017–2021),[22] National Adaptation Plan (2021–2050),[23] Local Adaptation Plan for Action,[24] Second Nationally Determined Contributions (NDCs)[25] and Nepal's Long-Term Strategy for Net-emission Zero.[26] These policies were designed for Nepal to achieve a climate-resilient health system. Moreover, integrating climate change into the National Health Policy 2019,[21] and Nepal's Health Sector Strategy (NHSS)[27] was a significant step forward for the intersection of climate change and health in Nepal. In addition, Nepal developed a multi-sectoral action plan for non-communicable diseases (NCDs) from 2021 to 2025, including air pollution and climate change.[28] However, challenges in implementing these plans and policies persist due to insufficient collaboration and communication between various entities.[29] The Ministry of Population and Health created a Climate Change Management division (CCMD) that makes policies and plans related to climate change and health.[30] The National Adaptation Plan (NAP) of Nepal prioritised maternal and child health as a significant area vulnerable to climate change; however, specific adaptation strategies are lacking.[14,31] Additionally, Nepal's Health H-NAP and subsequent NDCs explicitly recognised the disproportionate burden of climate risks on women, children and persons with disabilities, yet these frameworks lack detailed mechanisms for inclusive planning, targeted service delivery or equity-focused monitoring indicators.[23,25]
2.	Climate-smart health workforce	Nepal's government conducted various capacity-building activities and training programmes for public health professionals on climate change and health. For instance, the Nepal Health Research Council trained two cohorts of professionals in climate and health research.[32] Similarly, the National Health Training Center conducted multiple training sessions at provincial and local levels to raise awareness among individuals and communities regarding the health impacts of climate change.[33] Furthermore, the Nepal Health Research Council developed a research manual with support from the WHO to aid aspiring researchers conducting climate change and health studies.[34] Nepal's geographical landscape poses a challenge to distributing the health workforce in rural and urban areas.[35] Moreover, political instability[36] and migration of skilled health workers to other nations have become challenges in sustaining a competent health workforce.[37]
3.	Assessment of climate change-related health risks and greenhouse gas emissions	Nepal completed its latest round of Vulnerability and Adaptation (V&A) assessment in the national-level health sector in 2021.[38] Based on the findings of the V&A, the new H-NAP (2023–2030) was approved by the Ministry of Health and Population. The V&A highlighted that children, women, old people and persons with disabilities are at greater risk of climate change.[38] The Meteorological station and Epidemiology Diseases and Control Division (EDCD) record weather/climate and health-related data, respectively. Furthermore, Nepal developed several plans and strategies to minimise the emission of greenhouse gases (GHGs).[39] However, limited data and the absence of proper monitoring mechanisms for GHG emissions are a threat.[40]
4.	Integrated risk monitoring, early warning and greenhouse gas emission tracking	The Early Warning and Reporting System (EWAR) integrates climate-sensitive diseases (e.g., dengue and malaria) and reports them weekly.[41] However, weather/climate variables such as temperature, precipitation and humidity are not recorded by EWAR; rather, they are recorded by the meteorological station. Hence, coordination and collaboration are crucial to estimating the risk of climate change on health.[42,43] Nepal set targets for the emission of GHG for the years 2025 and 2030; however, these don't include emissions from the health sector.[25]
5.	Health and Climate Change Research	The Nepal Health Research Council included climate change in its priority area in 2006 and 2019,[44] resulting in comprehensive studies to assess the impacts of climate change on vector-borne and diarrheal diseases.[7,8,45] Furthermore, a pilot study was conducted to forecast diarrheal diseases in selected districts based on meteorological variables.[45] While there are several research studies on climate change and health in Nepal, many areas are missing.[46]
6.	Climate-resilient and low-carbon sustainable technologies, infrastructure and supply chains	Several health facilities in the southern part of Nepal are prone to flooding. Similarly, health facilities situated in the northern parts are prone to landslides and storm surges.[47] Thus, geographical disparities are a major concern for the Nepalese health system, which needs to be accounted for in climate-resilient infrastructure guidelines. Nepal committed to reducing healthcare waste in almost 1400 healthcare institutions, making them carbon-free through promoting non-burn technologies.[25]
7.	Management of environmental determinants of health	The government endorsed the Health Care Waste Management Guideline in 2014 to support the effective management of hospital waste generated within the country.[48] The Epidemiology and Disease Control Division of Nepal developed water quality guidelines with a dedicated section for surveillance of water quality.[49] In addition, to control air pollution and mitigate the emission of GHGs, the Kathmandu Valley Air Quality Management Guidelines 2019 were implemented.[50]
8.	Climate-informed health programmes	The Ministry of Health and Population integrated climate change into health programmes and launched awareness, vector control, community engagement, and capacity-building programs on climate change and health.[32,51]
9.	Climate-related emergency preparedness and management	Each district has a disaster response committee led by the Chief District Officer (CDO), which includes local health offices. These committees coordinate emergency preparedness and response.[52] Moreover, the district health office system has a separate Rapid Response Team (RRT) engaged at the community level,[53] although some municipalities do not have their own RRT.[53]
10.	Sustainable climate and health financing	Nepal secured climate financing from diverse channels from 2010 to 2022, including the Adaptation Fund (US $9.50 M), Global Environmental Facility (US$74.44 M), Green Climate Fund (US$87.80 M) and Climate Investment Fund (US$150.79 M).[54] In addition, the World Bank and Asian Development Bank significantly contribute to Nepal's climate projects. The World Bank and the government of Nepal recently entered into a Financing Agreement, signing a commitment of US$100 million to bolster Nepal's development efforts with a focus on promoting sustainability, climate resilience and inclusivity.[55] Similarly, the Asian Development Bank (ADB) has contributed to Nepal's strategy for sustainable, climate-resilient and inclusive development through investments in infrastructure, enhancing access to essential services, and safeguarding disadvantaged populations from the impacts of disasters and climate-related risks. As of 2025, ADB has pledged US$7.7 billion through 494 loans, grants and technical assistance for Nepal's public sector.[56]

WHO, World Health Organisation.

Participants were purposefully selected to include key informants and stakeholders from institutions such as the Ministry of Health and Population, the Department of Health Services, the Epidemiology and Disease Control Division, the Health Management Information System, the National Health Training Centre, the Provincial Health Directorate, the District Health Office at the province level, local-level health coordinators and representatives of United Nations (UN) organisations. This selection process aimed to ensure diverse perspectives and information aligned with the study's objectives. Details of participants' backgrounds are presented in Appendix 1 in the supplementary material.

All interviews were conducted in person by a trained interviewer with extensive prior experience working in the field of health systems and climate, using an interview guide (Appendix 2). The interviewer kept detailed reflexive field notes and a reflexivity journal augmented by regular peer-debriefing sessions to address personal assumptions throughout data collection and analysis, in line with the consolidated criteria for reporting qualitative research (COREQ)'s 'research team and reflexivity' domain and best practices for transparent qualitative reporting.[16] Recorded interviews were then transcribed and translated into English by two independent authors. The translated texts were rechecked by an additional author and minor edits for readability (e.g., punctuation and grammar) were made when necessary, ensuring the original meaning was accurately preserved. Themes were derived from the qualitative data using a deductive approach structured around the ten components of the WHO's operational framework.[4]

2.3. Integration

Results from the qualitative interviews were then integrated with the thematic desk review to enhance the robustness and interpretability of the results following Denzin's triangulation 2.0 framework.[17] Two independent analyses created a convergence-divergence color-coded matrix. Consensus meetings resolved discrepancies, and the color-coded convergence and divergence matrix was finalised (see Appendix 4).

3. Results

3.1. Findings from the desk review

Table 1 provides a summary of findings from the desk review, organised by components of the WHO operational framework.

3.2. Findings from qualitative studies (key informant interviews)

3.2.1. Climate transformative leadership and governance

Findings highlighted the significance of collaboration and coordination among various government entities from national and other international agencies, such as the WHO and other UN agencies, mainly focusing on leadership and governance. Participants focused on the health dimension and argued that health-specific bodies, such as the Ministry of Health and Population, should take leadership and collaborate with other ministries to make the health system more resilient. Nepal's climate-health governance is an open policy framework, but federalisation in recent years has increased inter-level coordination gaps. National policymakers emphasised the scope of H-NAP, but provincial and local actors reported shortages of operational guidance, budget and standard operating procedures (SOPs), as one policymaker stated:

> "While the impact of climate change on health is substantial, the overall leadership of the Ministry of Information and Climate Change falls short in addressing health concerns. Taking a lead role and collaborating with relevant stakeholders would be a significant milestone." [#5, Policymaker]

The majority of participants mentioned the design and implementation of the H-NAP and the challenges associated with transitioning to federalism while aligning health and climate resilience efforts, all within the broader context of leadership and governance. These insights illustrate the complex and multifaceted role of leadership and governance in addressing climate change and health issues. Furthermore, participants highlighted that federalism has brought overlapping roles and responsibilities in federal, provincial and local government, creating confusion. Similarly, participants noted that some local governments have qualified health personnel and robust data, while some lack these, creating uneven technical and administrative capacity hurdles.

> "… it was a document made without being in full-fledged federalism with all levels of government, that's why it is the first in the context of the current federalism." [#3, Policymaker]

Some participants also spoke about the difficulties faced when translating knowledge into policy. The majority reported that challenges revolved around engaging stakeholders at the provincial and local levels, and implementing these policies and strategic plans across these governance structures.

> "What I wanted to say is that there is no support to facilitate generation of knowledge to policy; however, knowledge has to be translated into policy." [#5, Policymaker]

3.2.2. Climate-smart health workforce

Most participants noted the challenge of not having a health workforce sufficiently knowledgeable or trained to address climate health risks, as the majority are in the fields of illness, surveillance and water quality research.

> "Only four positions are available in the climate division. One is for the under-secretary post, one for an officer, one for a nursing officer, and one for a statistics officer. The staff is insufficient if we are to concentrate on this program because we have other areas to focus on, such as illness surveillance, water quality surveillance, and research." [#1, Policymaker]

Furthermore, one interviewee focused on the depletion of innovation and research in climate-sensitive diseases due to limited human resources. Additionally, the finding outlined the challenges of shortages of an overburdened health workforce, along with the importance of training health workers related to climate-sensitive diseases, as detailed below.

> "Due to a health workforce crisis or overburden in the health workforce, they can't apply creative ideas in practice about climate-sensitive diseases or health problems or conditions." [#1 Policymaker]

Furthermore, participants stressed the importance of health personnel in managing health data efficiently and addressed the generational gap, because young people are better equipped for managing data.

> "The information has been entered by the health institutions and sent to the DHIS2, but it also depends on the health personnel of the health institutions. If they are of the younger generation and perfect at using a laptop, then they can do it. And if they are older and not efficient enough to use computers and laptops, then they haven't entered the real-time information in DHIS2, or the information may vary." [#3 Policymaker]

Participants called for the development of training packages, training of health workers and addressing the impact of frequent turnover on institutional memory.

"We made a training package, in connection with our training centre, and provided training to many people inside the training cohort." [#2 Policymaker]

3.2.3. Assessment of climate and health risks and greenhouse gas emissions

Participants expressed the importance of a multisectoral approach to conduct vulnerability and adaptation (V&A) assessments, as one policymaker argued below.

"We have to form a multisectoral representation, like one from the Nepal Health Research Council (NHRC), one from the Department of Hydrology and Meteorology (DHM), one from the Department of Home Affairs, one expert on infectious diseases, one from the laboratory, one sociologist, and so on." [#3 Policymaker]

Other participants discussed the NAP document, that was prepared based on the findings of the V&A assessment, as explained below.

"There is a fundamental aspect of climate change from the health sector in the National Adaptation Plan (NAP). The Ministry of Health and Population (MoHP) proactively developed the National Adaptation Plan (NAP) for the health sector in the past." [#1 Policymaker]

Nepal is one of the first countries to assess emissions of GHGs from the health sector in South Asia.

"WHO supported the Ministry of Health and Population, Government of Nepal, to assess health sector greenhouse gas emissions in 2023, and the assessment showed the health sector contributes 4.1 % of national emissions in Nepal. The findings are in the publication process." [#12 Climate and Health Expert]

Participants indicated that vector-borne diseases are rising, regardless of altitude, as mosquito vectors were observed in mountainous regions in Nepal, highlighting the necessity of expanding resources to reduce the health risks of climate change.

"Vectors have been reported at higher altitudes, so we must translate and link the facts into planning, policy, and budgeting. Non-endemic districts have been endemic recently. 20-year-old traditional planning should be modified as the endemic has been rapidly growing in all 77 districts. We need to expand, and budgets should be allocated accordingly." [#7 Health Professional]

3.2.4. Integrated risk monitoring, early warning and greenhouse gases emissions tracking

Surveillance systems capture disease incidence effectively but lack climate data inputs, weakening predictive capacity. Participants expressed that even though they had established climate-sensitive disease surveillance programmes with technical support from the WHO, challenges persist as detailed below.

"Regarding the technical concerns to be resolved, we are in constant discussion with WHO, including sentinel disease surveillance sites and how to conduct surveillance from a climate perspective with health workers, the administrative chief, and the medical superintendent. We held advocacy meetings with the superintendent because data are necessary for quality forecasting." [#1 Policymaker]

Whereas, another interviewee emphasised that collaboration from other agencies would be an asset for improving the Early Warning, Alert, and Response System (EWARS).

"Other separate, dedicated, independent agencies should be formed to collaborate with EWARS." [#6 Policymaker]

3.2.5. Health and climate change research

Participants highlighted that there is a gap in research in terms of the availability of many global reports on climate and health systems; however, this does not always mean there is equal knowledge, data and understanding at the national level, as one educator argued.

"We talk about research; there is a big gap. We looked at the global evidence from diverse sources like Johns Hopkins University, Canada and the UK because we do not have local evidence." [#2, Health Educator]

Some participants highlighted that, given the multidimensionality of climate change, it is challenging to conduct research on all the areas. The scope of research has extended to pathways beyond the direct impacts of climate change on health, such as food insecurity and climate-related migration, which were previously unexplored.

"Evidence generation has started in climate change and health. We must work more on it because it has a multi-dimensional effect on health; research evidence generation isn't complete, but we have started it, which is good." [#1 Policymaker]

3.2.6. Climate-resilient and low-carbon technologies, infrastructure and supply chain

Participants underscored the importance of various mitigation efforts, such as zero-carbon commitments through carbon policy, especially focusing on industries like the pharmaceutical industry and the transportation sector.

"While preparing the guidelines, the ministry should make a policy for the pharmaceutical industries to use solar or electrical energy to eliminate carbon emissions. Green technologies for transportation and production of medical items can contribute to it." [#3, Policymaker]

Moreover, participants focused on building climate-resilient health-related infrastructure, and on promoting more sustainable technologies, such as electric vehicles.

"One is the recently developed climate-resilient water safety strategy, which was developed in partnership with the WHO, NHTC, EDCD, and the water department." [#2 Policymaker]

"We can promote using electric vehicles (EVs) instead of fossil fuel vehicles in the health sector, like ambulances, vehicles used by the health workforce, and vehicles used for transportation." [#3 Policymaker]

3.2.7. Management of environmental determinants of health

Participants reported that communicable and non-communicable diseases caused by changes in climate are increasing. The majority of participants highlighted that proper waste disposal practices could help.

"There are greater morbidity and mortality from chronic and non-communicable diseases than infectious diseases. We think that climate change has a role." [#7, Health Professional]

Most of the participants reiterated that appropriate waste disposal practice is critical.

"We dump or burn the healthcare waste from the health institutions (vaccination centres, outreach clinics), as well as the waste of their surroundings in the outer open environment." [#4, Health Professional]

3.2.8. Climate-informed health programmes

Participants highlighted that climate-informed health programmes are crucial and have accordingly included knowledge related to EWARS in school curriculum and developed a healthy city policy.

"To strengthen the health system, we developed a healthy city policy. It included aspects of early reporting and environmentally friendly activities. To make people aware of these interventions, we are discussing incorporating them into school health programmes, and we have discussed EWARS with colleges too." [#2 Health Professional]

Moreover, the majority of participants have started sensitising health personnel to the issues surrounding climate and are alerting people about climate-related events through radios and other forms of media.

3.2.9. Climate-related emergency preparedness and management

In the context of emergency preparedness and management, participants highlighted that proper planning is required for disaster management, along with collaboration and support from the other entities.

3.2.10. Climate and health financing

In the domain of climate change and financing, participants explained the critical aspects of funding, budget allocation and financial support required to implement climate-resilient health systems. They expressed the need for legal paperwork and financial resources to back climate and health-related initiatives, highlighting the importance of securing cooperation and support from relevant ministries.

"*We require funding, TORs (Terms of reference), and legal paperwork for the process." [#1 Policymaker]*

Moreover, participants stressed that financial hurdles in achieving climate-resilient health systems are evident due to limited budget allocation on climate- and health-related programmes, limited utilisation of local resources and budget constraints. As one policymaker noted,

"*The departments and the centres of the divisions propose their respective activities or programs for the upcoming fiscal year. They haven't proposed any activities or programmes for climate-sensitive diseases or climate-resilient health systems." [# 3 Policymaker]*

3.3. Summary of findings (integrative summary)

Both the desk review and qualitative interviews consistently emphasise Nepal's growing recognition of climate change as a public health priority, and the key role of leadership and governance in the policy-to-action translation, from the 2011 climate policy and the updating of H-NAP in 2023–2030 to multisectoral coordination mechanisms. The review and interviews identified continuing implementation gaps and the need for stronger, more proactive institutional leadership (Appendix 4). Similarly, results from the review and interviews centred around the urgent need for and scarcity of a competent health workforce, either through WHO-facilitated training cohorts or the incorporation of climate-resilient courses into nursing and medical curricula. The desk review reported on existing programmes and the interviews highlighted in-country personnel burnout, turnover and information and technological (IT) challenges.

The review and interviews confirmed the importance of V&A assessments and the NAP process, with qualitative participants emphasising the need for a multisectoral approach in conducting V&A assessments. Early warning systems and monitoring are shared priorities, such as hydrometeorological disease forecasting and pilot EWARS projects. However, while desk reviews highlighted existing surveillance frameworks, key informant interviews stressed the need for dedicated analytic teams and real-time data integration.

There was consensus on the need for more research on scaling up locally driven, policy-relevant interventions to effectively manage climate-sensitive health outcomes and to promote health-system resilience, constrained by limited data checking and record verification procedures. Climate-resilient infrastructure and technology, from zero-carbon city planning to flood-proofed buildings, were included in the review and interviews.

Climate and health finance were repeatedly highlighted as crucial elements in the review and interviews, with detailed budget lines and international funding commitments contrasting with on-the-ground funding gaps. The results indicate the need for more transparent financial matrices, ministry coordination, and local funding disbursement for bridging policy and practice divides. Additional details are presented in appendices 4 and 5.

4. Discussion

This study reviewed concerns from key stakeholders and health policymakers in developing a climate-resilient, low-carbon health system in Nepal. The similarity between the results of the review, interviews and relevant literature is notable, highlighting the critical role of governance and leadership in addressing the intersection of climate change and public health. Nepal's 2019 national health policy,[57] recognised climate change as a determinant of health.[5] The H-NAP and NAP 2021–2050 emphasise the integration of climate change into development and health policies.[23] The importance of intersectoral collaboration and coordination among different stakeholders to tackle the complex issue of the health impacts of climate change is corroborated by other publications.[58]

The qualitative findings in the current study converge with recognition of the crucial role of assessment and adaptation in confronting the impact of climate change on health. The completion of V&A exercises in all provinces and the recent development of the H-NAP 2023–2030 showcase the importance of vulnerability, capacity and adaptation strategies within the health sector. This suggests that the impact of climate change on health could be minimised through collaboration and coordination between central, provincial and local governments through appropriate adaptation measures such as raising awareness, enhancing disease surveillance, constructing resilient infrastructure, and mainstreaming climate into health policies, strategies and plans. Furthermore, the analyses stressed the significance of a multisectoral approach and the inclusive involvement of various sectors in the process. Similarly, the importance of robust monitoring and surveillance in the context of climate change and health emerged as an important theme. This was reflected in the interview data that acknowledged and attributed the changing patterns of health outcomes to climate change. Integrated climate and health data facilitates V&A assessments, enhances local research and assists in preparedness by advancing all components of the WHO's operational framework. Additionally, while the document review emphasised the importance of disease surveillance and identified priority sectors, such as Water, Sanitation and Hygiene (WASH), the interviews delved into the role of specific surveillance systems for monitoring vector prevalence in districts and highlighted the necessity of early warning systems.

The results underscore the critical need for collaborative efforts in advancing research on health and climate change. It aligns with the health and climate research component of the WHO's framework, which highlights the importance of enhancing community resilience to address climate-related health concerns through research and partnership with educational institutions.[3] The findings emphasised the role of education in climate-informed health initiatives and highlighted the use of data and surveillance in conducting climate-health research. Other studies conducted in Nepal underlined the need for good quality indicators, comprehensive datasets and a well-trained climate-smart health workforce to support evidence-based decision making for climate resilience in the health sector.[43,46,59] Moreover, Sapkota et al. encouraged academia to promote graduate-level research and emphasised the need for studies addressing gaps in health systems research and non-communicable diseases.[60]

Likewise, the current results on climate-resilient technologies and infrastructure in the health sector align with literature on the need for functional health infrastructures during extreme weather and acute shocks. The findings also highlight the need for environmentally friendly

practices in healthcare facilities, such as sustainable waste management, clean energy, improvements in sanitation and water, thus reducing environmental footprints. These results align with recommendations from a global review of progress in 83 countries towards developing low-carbon, climate-resilient health systems,[61] as well as guidance from global health authorities.[62] Research has shown that engaging communities and establishing local ownership through communication strategies enhances preparedness and environmental health management.[63,64]

The stakeholders interviewed in the present study recognised the importance of establishing committees or teams dedicated to emergency response and the significance of coordination for an organised response to emergencies. Similarly, the document analysis highlighted the importance of coordination and response mechanisms within the health sector. Disaster contingency planning was widely discussed, including concerns about prioritising reactive post-event actions.[65] Finally, the findings underscored the critical role of financing.[54] The alignment between the review, interviews and the literature emphasised the collective importance of securing financial support for climate-resilient health systems, and highlighted Nepal's vulnerability to climate change and the significant economic impact of climate-related challenges.[54]

Future research should focus on long-term impact assessment of climate change on health, policy implementation barriers, adaptive capacity building, cross-sector collaboration and establishment of robust surveillance systems. There remains a critical gap in data sharing practices, highlighting research needs on digital innovations for integrating climate and health data, enhancing early warning and local research. Similarly, assessing the knowledge level of health professionals on the nexus between climate and health is essential to inform training activities. These areas are crucial for understanding and addressing the intricate relationship between climate change and public health in Nepal.

While this research is focused on Nepal's novel climate-health architecture, the pattern of high-level policy ambition ahead of subnational capacity for implementation is familiar in most decentralised LMIC contexts.[66] The same challenges are noted in countries as diverse as India, Kenya and Bangladesh, with coordination between levels, capacity shortfalls in the workforce, fragmentation in the data and finance gaps continually undermining locally driven climate-health action. Furthermore, in decentralised health systems, government bodies generally lack fiscal autonomy and human resources are inadequate to convert national agendas into provincial or local responses. Bottlenecks usually arise from weakened data systems and overlapping government mandates that prioritise emergency response over preventive public health measures. These constraints on financing and governance inevitably create barriers to building climate-resilient health systems.

4.1. Conclusions

Nepal has made bold policy commitments to achieve climate-health resilience; however, an implementation gap persists. Using the WHO's operational framework, this study identified three major gaps: (1) poor inter-ministerial and federal–provincial coordination in leadership and governance; (2) inadequately trained and unevenly distributed staff in the health workforce; and (3) fragmented surveillance systems that fail to incorporate meteorological data in integrated risk monitoring and early warning. These findings provide actionable guidance for stakeholders: policymakers can institutionalise the H-NAP by establishing inter-tier SOPs and dedicated budgets aligned with each WHO component; donors can support e-learning modules, data integration pilots and infrastructure upgrades; and programme managers at provincial and local levels can use these component-specific findings to prioritise training cohorts, formalise data-sharing agreements and implement resilience standards.

Future efforts should prioritise (1) investments in interoperable climate-health information systems, (2) system-wide training programmes and (3) piloting multisectoral governance committees to accelerate implementation. Without immediate and coordinated action across all WHO priority areas, Nepal's climate-health ambitions risk remaining stuck in the planning stage. The next critical step is turning commitments into actions, ultimately supporting the transition towards climate-resilient health systems.

Author statement

Ethical approval

The study received ethical approval from the Nepal Health Research Council (Reg. No. 336/2022). Written informed consent was obtained from all participants enrolled in the study.

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Competing interests

The authors declare that they have no competing interests.

Appendix A. Supplementary data

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