

Cover Sheet

Title: Navigating Uncertain Futures: Dilemmas and Opportunities in Climate and Health in LMICs

Authors:

Gareth Priday¹, Jose Ramos¹, Frederick Ato Armah², Mey Jurdi³, Martin Muchangi⁴, Gina Polo-Infante⁵, Tin Tin Su⁶, Yaser Abunnasr³, Nazia Ahmad⁷, L. Lauren Brown⁸, David Teye Doku⁹, Melina Galdos¹⁰, Rima R. Habib³, Simon Hearn¹¹, Rawya Khodor¹², Adelaide Lusambili¹³, Stephen J. McCall¹⁴, Samuel Muhula⁴, Walter Mukwana¹⁵, David Olaya⁵, Vincent Pagiwa¹⁶, Hussein Mohammad Rizal¹⁷, Aminath Shazly¹⁸, Tan Pei Jean⁶, Anita G. Villacís¹⁹, Anya Gopfert²⁰, Holly Gray²¹, Montasser Kamal²², Natacha Lecours²², Sam Oti²², Robert K.D. McLean²²

Affiliations:

1. Action Foresight
2. Climate Change & Health Innovation Hub for West & Central Africa (CHINNOVA), Association of African Universities, Ghana
3. Middle East & North Africa Hub for Action Research on Climate Change & Health, American University of Beirut, Beirut, Lebanon
4. Eastern & Southern African Hub for Research & Policy on Climate Change & Health, Amref Health Africa, Nairobi, Kenya
5. Latin America & Caribbean Hub for Climate Change and Health (CLIMAS), Pontificia Universidad Javeriana, Bogotá, Colombia
6. Regional Hub for Asia Climate Change and Health (REACH), Monash University Malaysia, Bandar Sunway, Selangor, Malaysia
7. Regional Hub for Asia Climate Change and Health (REACH), Sunway Centre for Planetary Health, Sunway University, Bandar Sunway, Selangor, Malaysia
8. Division of Infectious Diseases, Vanderbilt University Medical Center, Nashville, Tennessee, United States
9. University of Cape Coast, Cape Coast, Central Region, Ghana
10. Climate and Health, Wellcome Trust, London, United Kingdom
11. Ryne Consulting, United Kingdom
12. American University of Beirut, Beirut, Lebanon
13. Environmental Health and Governance Centre (EHAG), Africa International University, Nairobi, Kenya
14. Center for Research on Population and Health, Faculty of Health Sciences, American University of Beirut, Beirut, Lebanon
15. Eastern & Southern African Hub for Research & Policy on Climate Change & Health, KPMG, Kenya
16. Eastern & Southern African Hub for Research & Policy on Climate Change & Health, University of Botswana, Gaborone, Botswana
17. Jeffrey Cheah School of Medicine and Health Sciences, Monash University Malaysia, Bandar Sunway, Selangor, Malaysia
18. Regional Hub for Asia Climate Change and Health (REACH), Maldives National University, Malé, Maldives

19. Centro de Investigación para la Salud en América Latina (CISeAL), Pontificia Universidad Católica del Ecuador, Quito, Ecuador
20. Global Health, UK Health Security Agency, London, United Kingdom
21. Global Health, Foreign, Commonwealth and Development Office, London, United Kingdom
22. Global Health Division, International Development Research Centre, Ottawa, Canada

Author emails:

Author	Email
Gareth Priday	gareth@actionforesight.net
Jose Ramos	jose@actionforesight.net
Frederick Ato Armah	faarmah@aau.org
Mey Jurdi	mjurdi@aub.edu.lb
Martin Muchangi	martin.muchangi@amref.org
Gina Polo-Infante	pologp@javeriana.edu.co
Tin Tin Su	tintin.su@monash.edu
Yaser Abunnasr	ya20@aub.edu.lb
Nazia Ahmad	naziaa@sunway.edu.my
L. Lauren Brown	laura.brown@vumc.org
David Teye Doku	ddoku@ucc.edu.gh
Melina Galdos	m.galdos-frisancho@sussex.ac.uk
Rima R. Habib	rima.habib@aub.edu.lb
Simon Hearn	simon@ryneconsulting.com
Rawya Khodor	rk160@aub.edu.lb
Adelaide Lusambili	adelaide.lusambili@aku.edu
Stephen J. McCall	sm227@aub.edu.lb
Samuel Muhula	samuel.muhula@amref.org
Walter Mukwana	wmukhwana@kpmg.co.ke
David Olaya	d.olaya@javeriana.edu.co
Vincent Pagiwa	vpagiwa@ub.ac.bw
Hussein Mohammad Rizal	hussein.mohammadrizal@monash.edu
Aminath Shazly	aminath.shazly@mnu.edu.mv
Tan Pei Jean	tan.pei jean@monash.edu
Anita G. Villacís	agvillacis@puce.edu.ec
Anyia Gopfert	anya.gopfert@ukhsa.gov.uk
Holly Gray	holly.gray@fcdo.gov.uk
Montasser Kamal	mkamal@idrc.ca
Natacha Lecours	nlecours@idrc.ca
Sam Oti	soti@idrc.ca
Robert K.D. McLean	rmclean@idrc.ca

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Abstract

Climate-health planning in Low- and Middle-Income Countries (LMICs) is constrained by structural health-system vulnerabilities, cross-sectoral coordination challenges, and trade-offs that remain invisible within sectoral planning processes. This study addresses three methodological gaps: the scarcity of multi-regional, LMIC-led climate-health futures; the absence of methods that translate foresight into decision-making dilemmas; and the lack of approaches that integrate participatory foresight with structured intersectoral perspective-taking. A participatory futures workshop with 29 climate, health and funding experts drawn from five regional research locations across Africa, Asia, Latin America and the Caribbean, and the Middle East used the serious game 'Future Care Force' to negotiate intersectoral responses across divergent ten-year scenarios. To our knowledge, this was a first-of-its-kind gathering of Global South expertise in climate and health. The consensus between experts on climate and health trajectories underlies fundamental uncertainties and the need to examine alternative futures. A serious game provides a platform to imagine divergent climate and health futures, participants worked through epistemic complexity to reveal dilemmas and opportunities. The analysis identifies four cross-cutting structural dilemmas: technology deployment, knowledge authority, system architecture, and pace of change. The study positions serious games a method for making cross-sectoral trade-offs visible, an epistemic precondition for adaptive pathway development.

KEYWORDS: *Climate-health, Low- Middle-Income Countries, adaptive pathways, serious games, foresight, co-production*

Background

Convergence of Climate Change and Global Health

The convergence of climate change and public health presents one of the most urgent developmental and equity challenges of the 21st century. This is particularly true in the Global South. Between 1970 and 2021, over 90% of deaths from weather, climate, and water-related hazards occurred in Low- and Middle-Income Countries (LMICs) (2023). The capacity to respond to climate impacts in LMICs is constrained by structural health systems, cross-sectoral coordination failures, and budgetary limitations (WHO 2023; IPCC 2023). Underpinning these is an epistemic challenge: health outcomes in climate-affected contexts are emergent properties of interacting systems across sectors, where no sector's knowledge base is sufficient to understand or govern the whole. These impacts are not evenly distributed within countries: populations facing intersecting disadvantages, including gender, age, disability, poverty, and displacement, bear disproportionate harm, especially during climate-related disasters (UN Women and DESA 2025; WHO 2023). The consequences are already disrupting healthcare delivery and public health infrastructure over policy-relevant time horizons of a decade or less (Romanello et al. 2025; IPCC 2023), making this a near-term planning challenge. Health system outcomes in LMICs are linked to conditions in other sectors, including water, sanitation, energy, food security, mobility, and displacement patterns. International supply chain shocks propagate into service delivery through medicine stockouts and workforce displacement (FAO and WHO 2019; Field et al. 2012).

A persistent barrier to effective response is the misalignment between global climate finance, national health priorities and sub-national execution capacity. Despite existing climate finance mechanisms, dedicated funding flows for health remain limited (The Global Fund 2023). Misalignment often exists between these mechanisms, health priorities, and sub-national implementation capacity. Integrating health implications across multiple sectors might help unlock climate finance, but government departments and funders can lack the governance structures to co-budget and co-govern interventions that span sectoral boundaries (FAO, UNEP, WHO, and WOA 2022; Wilhelm et al. 2025). These cross-sector impacts fall on the health workforce itself. Climate-related displacement of health workers, along with worsening conditions that lead to burnout and compassion fatigue, creates a feedback loop in which system capacity degrades as demand intensifies (Romanello et al. 2025; Watts et al. 2021).

Technology, particularly artificial intelligence, is increasingly promoted as a solution to workforce shortages and infrastructure constraints in LMIC health systems. Questions

remain about whose capacities are being built, which communities are served, and how data and consent are governed (Yu and Zhai 2024; Schwalbe and Wahl 2020; Morley et al. 2020). The infrastructure required for technology-intensive approaches is unevenly distributed, generating a tension between technology-led pathways and community-led approaches grounded in local relationships and trust. These types of cross-sectoral trade-offs produced by siloed governance often remain hidden and only become visible at the intersection of sectors when they are brought into negotiation.

Each of these pressures; finance misalignment, sectoral fragmentation, and technology deployment, operates within a contested temporal frame. Decisions taken can constrain future options, scaling can premature entrench solutions and risks reducing options as conditions change (Haasnoot et al. 2013; Tiberius 2011). Decisions about speed are also decisions about which actors and knowledge systems can participate and keep pace. Where responses of this kind reduce future adaptive capacity, they are increasingly recognised as maladaptive (Schipper 2020). Maladaptive outcomes increase vulnerability and reduce communities' opportunities for future adaptation and sustainable development (Magnan et al. 2016; Schipper 2020). Isolated engineering fixes, short-term projects, failure to account for interactions, and narrow approaches that neglect longer-term considerations can produce maladaptive outcomes (Bertana et al. 2022; Ranon et al. 2026). Maladaptive outcomes can constrain present and future decisions by locking communities into development pathways long after the initial project was implemented (Gajjar et al. 2019).

Co-producing the way ahead

This study uses a participatory approach to futures research to surface these hidden and “fuzzy” dilemmas, which resist technical resolution because of epistemic knowledge limitations and the time horizons of the planning process. Participatory futures is treated here as a sub-domain of knowledge co-production. Co-production is an umbrella term to describe collaborative approaches to knowledge generation that bring perspectives and experiences together to uncover shared, and often more rigorous, solutions (McLean et al. 2022; McLean et al. 2023; McLean et al. 2024). This paper addresses this gap through a participatory futures exercise involving health and climate experts from five Advancing Research for Climate and Health (ARCH) hubs representing LMIC regions.

Figure 1 - LMIC regions represented

This study responds to three methodological gaps in the climate-health literature. First, multi-regional, LMIC-led climate-health futures focused on near-term horizons are scarce. The

futures that shape investment and policy are predominantly produced by Global North institutions. These futures embed assumptions and priorities that may not align with the contexts where climate-health impacts are most severe (UN Futures Lab 2025; Abimbola and Pai 2020; Khan et al. 2021). Adaptation framings developed under this asymmetry risk asking the most vulnerable to do more with less, deepening rather than addressing historical injustice (Pelling 2010; Büyüm et al. 2020). Secondly, existing foresight exercises rarely translate their outputs into a synthesis of dilemmas tied to the concrete cross-sectoral trade-offs that government and other stakeholders must manage. Third, methods that integrate participatory foresight with intersectoral perspective-taking are lacking, limiting insight into how cross-sectoral trade-offs play out when stakeholders with different mandates negotiate shared responses under deep uncertainty.

To address these gaps, this study employed a methodology that combined participatory futures with serious gaming. Experts working at the climate-health interface were drawn from the Canada's International Development Research Centre (IDRC) and United Kingdom's Foreign and Commonwealth Development Office (UK FCDO)-initiated ARCH initiative. ARCH is a global climate and health research initiative comprising five regional locations from across Africa, Asia, Latin America and the Caribbean, and the Middle East (www.idrc.ca/ARCH). As a co-production team, we ran a serious game which enabled experts to assume specific stakeholder roles, generating layered perspectives across professional expertise, regional context, and institutional mandates, and to negotiate intersectoral coordination across a 10-year climate-impacted horizon. The work reported in this manuscript is a contributing component to a broader Dynamic Evaluation of the ARCH global initiative (Hearn et al. 2026). The study was guided by three research questions:

- RQ1: What plausible climate-affected health futures do LMIC experts construct when engaged through participatory foresight?
- RQ2: What fuzzy and structural dilemmas emerge when cross-sectoral trade-offs are negotiated under divergent future conditions?
- RQ3: How can participatory futures via a serious game methodology surface hidden cross-sectoral dilemmas that conventional planning processes leave implicit and unexplored, and what structural dilemmas emerge?

Conceptual Framework

Epistemic complexity and expanded temporal horizons presents a dual challenge for climate-health decision making. Health is an emergent property of a socio-ecological system that only cross-sectoral perspectives can reveal. Climate change requires long-term

foresight and cross- sector perspectives to inform near-term preparations. Without this dual lens, health systems risk institutional lock-in, creating path dependencies. Path dependence describes a form of historical lock-in where prior decisions channel resources into an established trajectory, which narrows the remaining plausible alternatives (Mahoney 2000). Each step along the path raises the relative benefits of continuing and increases the costs of switching, a self-reinforcing dynamic that make the trajectory progressively harder to leave (Pierson 2000).

Mitigating these challenges requires knowledge co-production, a structured process to surface hidden and fuzzy dilemmas that siloed planning keeps hidden. This is a precondition for adaptive governance applied in the climate-health domain, the capacity to drive continuous learning and incremental course correction, a process that can translate hidden and fuzzy dilemmas into clearer challenges for response development (Strambach 2008; Strambach and Halkier 2013).

This conceptual framework analyses health system challenges across two dimensions:

Epistemic Complexity and Time Horizon.

The X-Axis: Epistemic Complexity

Epistemic complexity emerges from the co-presence of multiple legitimate standpoints and interpretive frameworks within a decision space. Epistemic framing shapes how actors understand reality, identity, and what counts as valid knowledge and appropriate action (Alasuutari and Qadir 2019). These frames also define problems, causal interpretations, moral evaluations, and policy responses (Goffman 1974; Entman 1993; Schön and Rein 1994). These frames become the objects of epistemic politics, in which knowledge claims are mobilised and contested across institutions (James 2024). Under conditions of uncertainty, when facts are uncertain, values contested, and stakes high, no single epistemic framework provides all the explanations plural knowledge systems must be engaged with (Funtowicz and Ravetz 1993). Epistemic complexity thus refers to the density, diversity, and incompatibility of epistemic frames that must be simultaneously navigated, prioritised, and, where possible, reconciled in decision-making.

The Y-Axis: Time Horizon

The vertical axis represents the temporal scale of decision-making, ranging from short-term operational responses to long-term anticipatory strategies. Short-term decisions are shaped by immediate needs and institutional constraints. Short-term decisions can lead to path dependency as immediate needs constrain future options through increasing returns, lock-in

(Arthur 1989), sunk costs, coordination effects (Pierson 2000) and narrowing of alternatives (Mahoney 2000).

These dynamics are problematic when decision-makers treat uncertainty as calculable risk and rely on narrow probabilistic models that obscure uncertainty, ambiguity, and ignorance (Stirling 2010). Over longer time horizons no single predictive framework can adequately guide decision-making (Funtowicz & Ravetz 1993). Anticipatory governance approaches shift the emphasis from reactive optimisation toward proactive preparation. Actors can engage with multiple plausible futures and consider potential emerging conditions (Muiderman et al. 2020; Ramos 2014). Temporal complexity is the challenge of making present decisions whose consequences unfold across longer time horizons under uncertainty.

Figure 2 - Conceptual Framework of Time Horizon and Epistemic Complexity

Mapping these axes reveals distinct decision-making zones shown in Figure 2. The bottom-left is inhabited by narrow silos and short-term thinking that obscures systemic dilemmas. This risks path dependency and obsolescence in a rapidly changing landscape. The optimal zone for informing decision-making is the upper-right. In this area, medium to long-term foresight intersects with cross-sector perspectives. High uncertainty and competing valid perspectives require collaborative sense-making, rather than narrow technical solutions, surfacing fuzzy dilemmas.

Unlike wicked-problem and adaptive-governance frameworks, which describe complexity or prescribe adaptive responses, this model explains how the interaction between epistemic plurality and temporal orientation generates specific governance failure modes and potential for maladaptation. Appendix B shows an extended version of the conceptual framework with more discussion on maladaptation.

Methodology

Participatory Futures (PF) refers to approaches designed to involve citizens in exploring and shaping potential futures, a 'crossover' between public engagement and futures studies, aiming to scaffold the public imagination to overcome short-termism and address long-term societal challenges (Ramos et al. 2019). Our use of PF had four main phases over 2025 (chronology in supplementary material).

1. Design and prototyping of a serious game

2. Preparation for ARCH hub engagement
3. ARCH hub engagement in Kuala Lumpur
4. Analysis of data and validation of findings

Throughout these steps and the development of the findings and review cycles, we took a co-production position, centered on the expertise of Global South practitioners. It is rare for climate and health experts to come only from the Global South to envision climate-affected health futures, which is a significant contribution of the research.

Design and Prototyping of Serious Game

Serious games are designed to harness the psychological and collaborative power of gameplay to motivate players to tackle real-world problems (McGonigal 2011). Serious games and normative future-visioning techniques have been used to explore adaptation trade-offs and reveal tensions between existing and desired development pathways (Neset et al., 2020; Pelling et al., 2024).

A serious game titled “*Future Care Force*” was developed to apply the research findings of an IDRC futures research project to specific health systems contexts. The game was co-produced to improve stakeholder engagement, build foresight capability and affect knowledge translation.

The game was iteratively prototyped through online and live sessions in Bangladesh, Mexico, Melbourne, and Taiwan, with co-production reflections after each session informing modifications for global and local use. This culminated in its preparation for use at the ARCH gathering in Kuala Lumpur in June 2025, tailored to address the climate and health focus of the ARCH. The publicly accessible version of the game emerged from this (futurecareforce.org).

Preparation for <anonymised for review> Engagement

Between March and June 2025, 29 experts from the ARCH network were engaged. The participants represented institutions across East Africa (20%), West Africa (15%), Asia (8%), Latin America (34%), and the Middle East and North Africa (23%).¹ The professional composition included climate/environment specialists (52%), health-system researchers (41%), and climate-health funders (7%).

¹ These percentages are approximations only.

Morphological Analysis

Morphological Analysis, as applied to scenario development, is a structured method for systematically constructing a range of possible futures by decomposing a complex problem space into its constituent parameters or driving factors (Ritchey 2011). Morphological analysis was used to shape the overall scenario worlds for the workshop engagement. The Morphological analysis utilised four core factors: Climate impacts, social resilience, governance, and technology, each with five possible sub-states. ARCH initiative members were asked in a survey about the likelihood of the states over 10-year time horizon.

Survey with ARCH hubs

Informed consent was obtained from participants for their data to be used in the research, for the survey and the workshop, resulting in two extra participants in the workshop. An online expert survey (n=27) with ARCH hub members was conducted to rank the likelihood of alternative future states for the four high-level factors identified in the Morphological Analysis (Ritchey 2011). Based on these rankings, four internally consistent combinations were developed to shape the general structure of the scenario workshop and were role-played across four tables.

The survey also asked ARCH hub members to rank 100+ emerging issues/trends by their relevance to climate and health (drawn from a global scan and two Global South ethnographic futures research processes). These emerging issues and trends were derived from the initial project work in 2024. Their responses led to the selection of the most salient issues, organised by the WHO health systems framework (World Health Organisation 2007), which were then used as active elements in the serious game played in Kuala Lumpur.

Kuala Lumpur ARCH hub Engagement

As a component of a week-long ARCH inception meeting, a participatory futures workshop was held in Kuala Lumpur with 29 leading climate and health experts. The workshop utilised the “Future Care Force” serious game, in which participants assumed specific stakeholder roles (e.g., community health workers, policymakers, technology developers) using role cards. The participants were divided across 4 tables, each with a dedicated facilitator. Each table included experts from different locations, as well as funders (IDRC, UK FCDO, Wellcome Trust). This was a rare opportunity to engage global health and climate experts, with the majority drawn from LMIC contexts.

Figure 3 - Participants ready to start gameplay

The significance of this engagement extends beyond convening experts across time zones and disciplines. The ARCH hub structure ensured that representation was genuinely global

in scope yet deliberately LMIC-dominant in composition, with the majority of participants drawn from institutions and communities in the Global South. This configuration directly addresses one of the most persistent and widely noted deficiencies in the climate and health literature, the systematic underrepresentation of LMIC voices, knowledge and lived experiences in the production of global evidence and foresight. We believe the resulting findings carry greater weight as a consequence, as the results are co-constructed through the perspectives of those most proximate to the frontlines of climate-health vulnerability, and enact a process of epistemic justice applied to climate and health. The workshop's design repositions Global South practitioners from subjects of study to co-producers of the climate-health futures under examination.

The game placed experts under multiple simultaneous constraints. Each table received a specific combination of future states derived from the morphological analysis (e.g., tipping-point cascade & fragmented breakdown & institutional paralysis). The experts were assigned stakeholder roles that typically differed from their professional identity. They then received emerging issues, drawn from the survey-validated set, as signals from this future, and were required to construct a coherent picture of what this future meant for health systems, and then negotiate an intervention within that future's constraints. The game's design meant that participants could not default to their preferred future, their professional expertise or a consensus position; participants had to work with the materials and perspectives they were given. Drawing on futures studies theory and practice, the game used five modes of foresight: forecasts, systems, critical, participatory, and action-oriented to encourage multi-perspective thinking and co-creation of actionable pathways (Ramos 2016).

Figure 4 - Example output from a table

Analysis of data and validation of findings

Drawing on robust strategy principles and the goal of reducing analytical blind spots (Ramírez and Wilkinson 2016), we aimed to identify common issues across all four divergent futures. While participants did not create formal scenarios in each group, each group's conversations and their systemic reflections on intersecting trends and emerging issues provided the implicit raw material for constructing images of alternative futures.

The scenario synthesis followed a human-led, AI-assisted qualitative analysis process designed to increase analytical breadth while preserving traceability and interpretive accountability. LLMs were not treated as independent qualitative analysts. The LLMs were used as provisional organising tools to support first-pass clustering and comparison of workshop materials. This use was informed by emerging work on LLMs as aids to qualitative

analysis (Hayes 2025; Roberts et al. 2024), recognising that such LLM assistance remains methodologically contested and may produce plausible but weakly grounded interpretations (Roberts et al. 2024).

Jones (2025) argues for transparent and complete disclosure in the use of AI in qualitative research. The co-production team employed AI at several stages of this study. The research team transcribed the workshop using Otter.ai (cloud-based automatic speech recognition), and de-identified the resulting transcripts by removing speaker names and identifying details before any further AI-assisted analysis. Analysts then organised the de-identified transcripts, post-its, and table records into a traceable evidence base.

In De Paoli's (2024) analysis, he argues that while use of LLMs are useful for thematic analysis, human verification and interpretation is required to counter issues such as differences in LLM interpretations and hallucinations. In this study, provisional thematic organisation and first-pass clustering of this material were aided by three large language models: Claude Opus [4.5] (Anthropic, consumer Claude.ai with the no-training setting enabled, 30-day retention); Gemini [2.5 Flash] (Google, consumer); and DeepSeek [DeepSeek-V3.1 mode July–September 2025; 3.1/3.2 hybrid from October 2025]. This use was confined to the early organising phases of thematic analysis. We iteratively tested prompts across these models and retained outputs only when they could be traced to specific workshop evidence (for example, quotations verifiable against the transcripts); we rejected low-evidence or weakly traceable outputs. We manually verified quotations against the original transcripts, a step that Mehta et al. (2025) argue for to ensure analysis grounded in authentic workshop dialogue.

LLM outputs were used as provisional organising aids only; thematic analysis, interpretation, and write-up were performed by two human coders working directly against the original <anonymised for review> workshop transcripts and table-level records. The human coders reviewed the retained outputs and synthesised and refined themes on the basis of their own reading of the material, with disagreements reconciled through direct comparison with the primary materials to produce a provisional list of themes, which were then rechecked against those same primary records. In total, five commercial AI systems were used in this study: Otter.ai for transcription; Claude Opus [4.5], Gemini [2.5 Flash], and DeepSeek for provisional organisation; and Claude Opus, Gemini, and Grammarly for copyediting and language refinement. We acknowledge that the use of AI in qualitative analysis is still in its early phases of development with the issues noted by De Paoli (2024) and Mehta et al. (2025) and we have sought to address these concerns.

Table hosts reviewed the findings against their own experience of the discussions, helping to confirm whether the synthesis reflected the emphasis and meaning of each group's discussions. This constituted a form of respondent validation, in which those closest to the original discussions assessed the credibility of the emerging synthesis. *<anonymised for review>* participants conducted a final review of the results as part of the broader co-production process. Participants reviewed and commented on interim and final analysis as a participatory checking approach (Birt et al. 2016). The originality and accuracy, and integrity of content including accuracy of references is confirmed by the authors.

Findings

Expert Assessments of Climate-Health Futures (RQ1)

The five states for each factor (e.g. for climate change, included moderate escalation, managed transition) were derived from our 2024 research into climate and health. These 20 possible states (five for each morphological factor) are detailed in Appendix C. Survey responses from the ARCH hub experts revealed a fundamental lack of consensus between expert assessments across the four morphological factors: climate change, social resilience, technology innovation and deployment, and governance.

The absence of consensus was not confined to any single factor, nor did it dissolve when expert responses were disaggregated by disciplinary background: climate experts and health experts alike exhibited divergent expectations across all four dimensions. It signals a condition of fundamental uncertainty at the heart of the climate and health nexus: a domain in which even those with deep technical expertise cannot agree on the trajectory of the forces most likely to shape future health systems. For planners and policymakers charged with making long-horizon decisions, decisions that necessarily rest on assumptions about what the future will look like, this poses a serious and underappreciated challenge. Planning based on a narrow or fixed set of assumptions in a context of such irreducible uncertainty leaves systems exposed to futures they were never designed to accommodate.

The survey results validate the methodological logic of the morphological analysis. If there were strong consensus around a single trajectory, the case for exploring alternative futures might be questioned. The opposite is true here. The distribution of expert responses across divergent future states makes a compelling empirical case for scenario plurality: we cannot responsibly prepare for one future when the evidence suggests that multiple, substantially different futures remain plausible. Given the need to be proactive about addressing climate and health challenges, this future uncertainty highlights the importance of exploring and

preparing for multiple futures. Survey results for the morphological analysis are outlined in Appendix C.

Trends and emerging issues

Participants (n=27) assessed over 100 trends and emerging issues categorised by the WHO health systems building blocks (World Health Organisation 2007), via a survey, according to their relevance to climate and health futures in a 10-year horizon. Based on the survey results, 28 trends and emerging issues were selected for use during the workshop serious game, which supported participant discussion (see appendix D for survey results and futurecareforce.org for details of the full list of emerging issues and trends used).

Future Worlds

The survey identified which sub-states experts considered plausible; analysts then constructed internally consistent combinations from those sub-states. A positive transformation future that scored lowest in survey likelihood rankings but was included to ensure the game tested participant reasoning across genuinely divergent conditions and to avoid a homogeneous scenario set (Ramírez and Wilkinson 2016). Table 1 Morphology based future core dynamics by table code summarises the dynamics that each group engaged with.

Table 1 Morphology based future core dynamics by table code

Climate Health Futures (RQ2)

This analysis draws on the future worlds created by the 29 experts participating in the <anonymised for review> game. The themes and dilemmas that appear across them are components of plausible futures, as they occur in the different futures that participants created. In this analysis, TG, TJ, TA, and TL refer to specific statements made at one of the four physical tables that the groups were assigned to in the workshop.

1. Technology- Equity
2. Community-Led Healthcare
3. Climate-Resilient Infrastructure
4. South-Led Knowledge Networks
5. Workforce and Economic Constraints

Technology Equity Dilemma

Across climate-affected low- and middle-income country health systems, technology occupies a contested role. While digital innovation holds genuine promise for strengthening health service capacity and resilience, it risks entrenching and amplifying the very inequalities it purports to solve. This dilemma is not technical, it is a structural one, reflecting deeper fault lines in how resources, knowledge, and power are distributed across global health systems. Without intervention, the accelerating pace of technological change might widen the gap. Four interconnected tensions define this dilemma as shown in Table 2, Technology equity tensions.

Table 2 Technology equity tensions

Community-Resilience Dilemma

Across climate-stressed health systems in low- and middle-income countries, social trust and community agency have emerged as foundational infrastructure. Where formal institutions are paralysed by rigid hierarchies, underfunding, or political dysfunction, it is local relationships and legitimacy that determine whether populations survive climate and health crises. However, those with the deepest knowledge and community trust are systematically excluded from decision-making authority, leaving the most capable actors unable to act. Four tensions define this dilemma, as shown in Table 3, Community resilience tensions.

Table 3 Community resilience tensions

Climate-Resilient Health Infrastructure

The climate emergency has fundamentally reframed what health infrastructure means. No longer a static sectoral asset, health infrastructure must now be understood as a vulnerable node embedded within broader socio-ecological systems — energy, food, water, and social determinants — all of which are simultaneously under stress. When these interconnected systems falter, health service continuity collapses. Experts and participants consistently moved beyond conventional definitions of infrastructure to grapple with a harder question: how do health systems maintain function when the environmental and social scaffolding they depend upon is actively degrading? Four tensions define this dilemma as shown in Table 4, Climate resilient health infrastructure tensions.

Table 4 Climate resilient health infrastructure tensions

South-Led Knowledge Networks for Local Innovation

Across climate-stressed health systems, a growing consensus has emerged that externally driven, top-down knowledge architectures are inadequate for the scale and specific nature of challenges facing the Global South. South-led knowledge networks represent a strategic alternative: leveraging shared experience, indigenous knowledge systems, and local context to generate health solutions that are equitable, relevant, and independent of the Global North. The central tension is not simply about innovation, but about who produces it, who governs it, and whether scalability can be achieved without sacrificing the deep contextualisation that makes solutions work in practice. Five tensions define this dilemma, as shown in Table 5, South-led knowledge networks tensions.

Table 5 South led knowledge networks tensions

Workforce and Economic Constraints

Workforce shortages and funding crises form a self-reinforcing negative loop that could lead to collapse. As climate pressures intensify, resources contract, working conditions deteriorate, and skilled workers leave.

The protective function of the health system erodes when populations need it most. Paradoxically, this same pressure environment is generating new forms of decentralised, community-owned innovation, as actors stop waiting for centralised solutions and build their own. The dilemma is whether these adaptive responses can sustain ethical integrity and equitable care under conditions of extreme scarcity. Four tensions define this dilemma, shown in Table 6, workforce and economic constraint tensions.

Table 6 Work force and economic constraint tensions

Across these five thematic findings, four structural dilemmas recur. Technology questions in one theme reappeared as knowledge-authority questions in another; debates about community-led care implicated system architecture; workforce constraints surfaced as questions about the pace of adaptation. These are four cross-cutting dilemmas appearing in different forms across the themes.

Structural Dilemmas in Climate-Affected Health Systems (RQ2)

The findings surfaced priorities reflecting distinctly LMIC-specific concerns, such as the centrality of trust, the role of community health workers and informal practitioners,

competition for scarce resources, and the dependency of South-led innovation on North-controlled funding. While many of these concerns are present in the literature, they are rarely framed as dilemmas, situations where legitimate priorities conflict, and no technical optimisation can resolve the tension. To clarify, we propose that these tensions are better understood as four structural dilemmas, as shown in Table 7 Structural dilemmas. Each dilemma cuts across the thematic domains identified in the findings and poses a governance question for adaptation planning to navigate explicitly.

Table 7 Structural dilemmas

These four dilemmas do not map onto single thematic domains. Participants faced decisions about technology decisions that raised questions about whose knowledge counted. Decisions also depended on how the health system's structure affected the pace of change. Each dilemma appeared across multiple themes and manifested differently under each scenario. This cross-cutting character suggests treating technology, workforce, and governance as separate domains in climate-health planning risks missing their interactions. The dilemmas are not technology or governance problems; they only become visible when the game's epistemic complexity is negotiated.

The Serious Game as a Method for Surfacing Hidden Dilemmas (RQ3)

The serious game methodology functions as a “boundary object”, a tangible form that participants use to build shared understanding and which is an enabling organisational structure. It is specifically designed to transform divergent professional perspectives into visible, systemic dilemmas. By using role displacement, participants were forced to advocate for perspectives outside their expertise. For example, a researcher might articulate the infrastructure constraints of a community health worker. This process breached traditional sectoral boundaries and introduced layers of epistemic complexity. The interplay of expertise, personal experience, and role made hidden dilemmas suddenly visible.

The game transformed 'siloes' thinking into a generative condition for the productive collision of multiple valid interpretive frames; it was this collision, rather than any individual's expertise, that surfaced fuzzy dilemmas, revealing, for instance, how AI might simultaneously expand service reach while degrading the social trust that community health systems depend on. Using divergent futures revealed the structural nature of these challenges, preventing them from being dismissed as temporary problems. Mapping these tensions across different futures exposed institutional lock-in and the fragility of 'expert' plans under conditions like institutional paralysis.

The serious game provided a way to reveal future epistemic complexity and “fuzzy” dilemmas that strengthen present-day decision-making. In institutional or organisational terms, when epistemic inclusion opens and legitimises new discourses, a cultural-cognitive shift enables flexibility and a broader range of institutional pathways (Strambach and Halkier 2013). Gaming this complexity does not provide an absolute certainty of the future that an organisation can use to solve defined futures problems, as including new perspectives and issues will change “the problems” identified; rather, this approach to gaming offers new interpretive patterns, provisional and relational elements, that support adaptive governance required to anticipate yet unimagined climate and health needs.

Discussion

This study addressed a persistent gap in climate and health planning by centring Global South practitioners through the co-production of climate and health futures. LMIC climate and health experts envision climate-affected health futures as moving towards business-as-usual or decline; favourable futures are discounted by the majority in their baseline results.

Where practitioners closest to the issues cannot agree on likely trajectories, planning models that rely on a single ‘most likely’ future appear poorly matched to the conditions under which decisions are made. Expert disagreement reflects the epistemic complexity of the climate-health nexus, where legitimately different sectoral positions produce legitimately different assessments of the same future. Planning that suppresses this complexity by seeking consensus prematurely can reduce future adaptive capacity. Our results reinforce calls for pathways-oriented approaches that keep options open rather than optimising for predetermined end-states (Haasnoot et al. 2013), aligning with concerns that legacy infrastructure and policy choices can lock systems into trajectories that foreclose future alternatives (Haasnoot et al. 2024; Singh 2025). For climate–health planning, robustness across multiple plausible futures becomes a design principle.

The study also identified a mix of priorities, including those more commonly discussed ones, such as data governance. Others, such as the development of South-South networks and indigenous practices, are not often presented in Global North-led research. These priorities, discussed in detail above, diverge from those typically prioritised in Global North-led research.

The four structural dilemmas surfaced through the game are not governance problems amenable to sectoral solutions. Each dilemma appeared across multiple thematic domains and manifested differently under each of the scenario conditions, suggesting that its source is structural rather than technical. This is consistent with the conceptual framework: when

epistemic complexity operates across a longer time horizon, the cross-sectoral trade-offs it generates cannot be resolved within any single sector's planning frame. The game showed that these dilemmas become visible only when the perspectives needed to reveal them are brought into negotiation, and that making them visible is itself a precondition for adaptive governance. Planning processes that treat technology, knowledge, architecture, and pace as separable domains will continue to generate these trade-offs invisibly. The implication is not that the dilemmas can be resolved, but that they must be navigated.

Implications for further research, policy and practice

For climate–health planning, several implications follow. First, uncertainty should be treated as a baseline condition rather than a deficit to be eliminated through better data. Second, technology governance requires sustained attention regardless of whether planning scenarios are framed optimistically or pessimistically. Third, South–led networks appear as promising pathways for building adaptive capacity outside long-standing aid dependencies. South-led networks represent a form of adaptive practice, with actors combining knowledge across contexts and generating adaptive capacity. Supporting South led networks requires funding architectures and governance arrangements that recognise and resource this mechanism, and do not treat change as dependent on ideal conditions. Operationalising South-led networks must also recognise that adaptation is inherently context-specific. Categories such as rural, Indigenous, farming, and fishing communities should not be treated as homogeneous, as they encompass substantial social, cultural, ecological, and territorial diversity. The four structural dilemmas identified in this study are likely to manifest differently across contexts, shaped by factors such as digital connectivity, seasonal accessibility, informal care systems, governance arrangements, and land tenure. Although our work provides a novel and essential snapshot of Global South expertise, advancing a full decolonial vision therefore would benefit from embedding co-investigation within territorially rooted communities from the earliest stages of research design, moving beyond institutional co-production toward the meaningful inclusion of Indigenous, farming, fishing, and other locally grounded communities as co-investigators and knowledge holders.

Gajjar et al. (2019) demonstrated how past development pathways produce adaptation constraints in the present, and Pelling et al. (2024) integrated diverse epistemologies to create desired futures. Our contribution employed divergent futures resulting in structural dilemmas that are not resolvable by technical optimisation and that occur across all four futures. Together, these approaches suggest that anticipatory governance calls for attention to how the past constrains, what futures are desired, and what are the structural dilemmas across possible futures.

The findings reflect a snapshot of expert perspectives at a particular moment; repeating similar participatory foresight exercises across different moments and with broader constituencies could help assess the stability of the patterns identified and support adaptive learning in climate-health planning. Future research should also examine how these structural dilemmas evolve across different territorial and governance contexts and evaluate whether the proposed framework remains applicable across diverse LMIC settings. However, the Future Care Force game has been tested by these experts and is available for anyone to freely use and adapt.

Limitations

Several limitations should be acknowledged. Although participants were recruited from five locations, the sample cannot capture the full diversity of LMIC contexts, particularly territorially rooted communities across different ecological, cultural, and governance settings. Consequently, the findings should not be interpreted as representative of all contexts or populations.

This was a single session; different sessions, or multiple sessions, may have surfaced more dilemmas and opportunities. Nonetheless, we are unaware of any comparable participatory futures work focused specifically on the climate-health nexus, with experts predominantly drawn from LMIC institutions across Africa, Asia, Latin America, and the Middle East. While the co-production approach sought to invert typical researcher-participant dynamics, facilitation and initial analysis remained foresight practitioner-led, introducing potential framing risks. However, the development of game inputs (e.g. survey item results), game participation (i.e. issue identification and prioritisation) and development, review and approval of all analysis outputs enabled expert co-production and oversight and helped to minimise the risk of bias.

Conclusion

By centering LMIC experts and practitioners in co-producing foresight, this study challenges assumptions within prevailing adaptation frameworks, though many of the themes are likely to apply to non-LMICs. Four key structural dilemmas emerged across the themes: efficiency/equity, formal/indigenous knowledge, centralised/distributed systems, speed/deliberation. The concepts introduced in this paper, such as epistemic complexity and fuzzy dilemmas, point toward a different understanding of what upstream planning work requires. Surfacing the dilemmas is not the final step but the first: it creates the epistemic

conditions under which the legitimization of multiple valid framings can begin, and it is that legitimization, accumulated incrementally across actors and scales, that adaptive governance ultimately depends on. The conceptual framework could also be employed to explore sources of maladaptive development. The Future Care Force game used in this study, and the hundred emerging issues and trends, is publicly available for use in climate and health research and teaching (<https://futurecareforce.org/>).

Disclosure Statement

The Future Care Force game is made publicly available for free use and adaptation in climate and health research and teaching. The game is freely available and adaptable under a creative commons licence. No author currently derives financial benefit from its use or distribution. The authors note that the game's public availability does not preclude individual authors offering paid training, facilitation, or consulting services using the game in the future; any such arrangements would be independent of the research reported here and the game will continue to remain in open access should such action be taken. Natacha Lecours, Montasser Kamal, Sam Oti, Robert McLean are employed by the International Development Research Centre, Anya Gopfert and Holly Gray are employed by the UK Foreign and Commonwealth Development Office both of which fund the ARCH initiative from which study participants and co-producers were drawn. Gareth Priday and Jose Ramos received funding for this study through a competitive grant from IDRC.

This study was conducted as a component of the Dynamic Evaluation of the Advancing Research for Climate and Health (ARCH) initiative funded by the International Development Research Centre (IDRC) and the UK Foreign, Commonwealth and Development Office. Evaluation at IDRC is governed by the regulations of IDRC (<https://idrc-crdi.ca/sites/default/files/sp/Documents%20EN/evaluation-at-idrc.pdf>) and the Government of Canada's Policy on Results (<https://www.tbs-sct.canada.ca/pol/doc-eng.aspx?id=31300>). Adherence to this framework facilitates ethical guidance and oversight for evaluation activities including data collection with human participants. This research stream was conducted over 2-years with earlier work, operating under the same ethical principles, providing the inputs to the research reported on in this paper. All activities reported in this manuscript are fully aligned with the Helsinki Declaration and informed consent was obtained from all participants prior to the survey and the workshop. Participants were climate, health and funding experts. Data collection related to their professional judgements and the risk associated with participation was minimal. Participants were informed of the

purpose of the research, the intended use of their contributions, the participatory and co-produced nature of the analysis, and their right to withdraw.

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Tables

Table 1 Morphology based future core dynamics by table code

Physical group Name	Future Core Dynamics 2035
TG	Disruptive technological advancements lead to breakthrough climate solutions.
TJ	AI-driven healthcare systems will achieve efficiency and environmental sustainability through algorithmic control.
TA	Technological stagnation and fragmented breakdown of global systems force health communities to retreat into localised, labour-intensive care models, where traditional knowledge gains authority.
TL	Fragmented technological development enables wealthy groups to build exclusive health fortresses, climate chaos triggers cascading system collapse.

Table 2 *Technology equity tensions*

Bifurcated Trajectories: Technology risks creating parallel health systems: one high-tech and resilient, the other increasingly excluded as investment flows away from vulnerable communities.
Infrastructure Trade-offs: High-tech solutions frequently collide with the absence of basic resources, electricity, shelter, connectivity — rendering digital tools inaccessible where they are needed most.
Cognitive & Social Attrition: AI-driven efficiency may erode professional medical skills over time and create accountability vacuums when automated systems fail.
Knowledge Architectures: Equitable outcomes depend on who controls data. Privately governed systems risk subordinating public health needs to the priorities of wealthier funding sources.

Table 3 Community resilience tensions

Relational Resilience vs. Fragility: Community agency functions as a strategic bulwark. Local relationships and proximity enable the adaptive care needed to prevent climate impacts from deepening cycles of vulnerability.
Social Trust as Functional Infrastructure: Trust enables formal and informal workers to act as interlocutors, validating interventions and creating localised pockets of resilience where formal systems cannot reach.
The Legitimacy Gap: Traditional practitioners hold deep local knowledge and community access, yet remain excluded from formal authority, creating a disconnect between those who understand and those who decide.
Bottom-Up Governance: Where institutional paralysis prevails, community-led solutions become a survival necessity, scaling governance upward from the village level to fill the vacuum left by failing centralised systems.

Table 4 Climate resilient health infrastructure tensions

Systemic Vulnerability and Continuity: Health systems are vulnerable nodes within failing socio-ecological networks. Resilience requires climate-adaptive designs that anticipate tipping points across energy, food, and community systems.
Energy as Adaptive Capacity: Localised renewable energy transitions from an environmental aspiration to a strategic necessity, maintaining health service functionality when centralised grids fail under climate pressure.
The Vicious Cycle of Social Determinants: Climate stressors undermine the scaffolding of health, nutrition, supply chains, mental wellbeing, creating feedback loops that deplete both populations and the human resources needed to respond.
Scarcity and Geopolitical Competition: Resource constraints compound over time into geopolitical dynamics of extraction and exclusion, where stronger actors secure what remains and the most vulnerable populations lose any viable path to adaptation.

Table 5 South led knowledge networks tensions

Locally-Led, Polycentric Action: As centralised governments face institutional paralysis, resilience shifts to networks of cities and civil societies capable of acting autonomously when formal structures are rigid or absent.
Indigenous Practice as a Strategic Asset: Local and traditional practitioner knowledge is reframed as a decolonised strategic asset, producing health models with inherently greater community trust and contextual relevance.
Co-Produced Technological Sovereignty: Technology must be governed as a public good, with citizens defining and contributing data rather than remaining passive recipients of externally produced systems.
Agile Financing for Autonomy: Rigid top-down funding cycles are inadequate for climate-impacted contexts, requiring locally embedded, unconventional financial models that prioritise self-reliance and affordable care sustainability.
The Scalability-Context Paradox: A fundamental tension exists between scalable pandemic-response systems and the deep contextualisation required for effective local intervention — bridging these remains an unresolved design challenge.

Table 6 Work force and economic constraint tensions

The Vicious Cycle of Interlocking Crises: Funding and workforce shortages form a mutually reinforcing system. As resources disappear, those providing care become as vulnerable as those receiving it, collapsing the health system's protective function from within.
Technology as a Double-Edged Sword: Innovation can liberate workers from routine tasks, but if poorly governed, it replaces human skill and community trust with technical dependency, reducing overall care quality and resilience.
Frugal Innovation as a Necessity: Economic scarcity forces a shift toward decentralised, community-owned innovation financed through unconventional sources — no longer a marginal alternative, but a survival imperative.
Integrity Under Scarcity: Intense economic pressure risks distorting the health system's core mandate, forcing difficult choices between ethically compromised quick fixes and service models that are principled but financially unsustainable.

Table 7 Structural dilemmas

Dilemma	Competing Priorities	Governance Question
Technology deployment	Efficiency and scaling vs. equity, inclusion, and community control	Who owns, benefits from, and is excluded by technological choices?
Knowledge authority	Formal/scientific knowledge vs. community, indigenous, and practitioner knowledge	Whose evidence counts in planning and investment decisions?
System architecture	Centralised coordination vs. distributed, locally-embedded capacity	Where does adaptive capacity reside, and who governs it?
Pace of change	Rapid deployment and scale vs. deliberate, ethical, and contextualised pathways	What trade-offs are acceptable, and who bears the costs of speed?

Appendix A: Chronology of Research

Table 8 - Chronology of Research

1 - Design and prototyping	Serious game	Ideation and prototyping of a serious game to make the research usable to a wide audience for strategic exploration (strategic ideation, innovation, theme / problem identification)	Nov 2024 - April 2025
	Online testing	Prototyping based on online engagements with 6 + groups	Feb - March 2025
	Live testing	Prototyping based on live engagements in Mexico City, Taiwan and Melbourne	April - May 2025
2 - Engagement with <anonymised for review> before and in <anonymised for review> and adaptation of game for Climate and Health theme	Morphological analysis	Formulation of morphological analysis to establish scenario building blocks	May 2025
	Survey with ARCH Hubs	Survey with IDRC ARCH hubs: Rank key emerging issues, trends and uncertainties from 100 + to use in Kuala Lumpur. Rank building blocks from morphological analysis	May 2025
	Kuala Lumpur ARCH engagement	Use of game in Kuala Lumpur project - 29 experts (Climate, Health, Funding)	June 2025
3 - Analysis of data and composition of findings	Development of scenarios	Four scenarios were developed based on the four group conversations in the <anonymised for review> meeting	Aug 2025
	Use of LLMs to identify	Two analysts used 5 LLMs to identify most prominent themes,	Sept 2025

	convergent themes	with a write up of the themes	
	Consistency / validation	Checked themes against the raw conversation transcripts from each of the four tables in the <anonymised for review> meeting, for consistency and to incorporate participant quotations into findings	Oct 2025
4 - Write up and validation with experts	Write up	Drafting and redrafting with input from IDRC leads	
	Review and validation	Peer-Review sharing - Co-produced written analysis with ARCH experts, Foresight Experts, UK FCDO, Wellcome Trust, and IDRC.	Oct (2025)- Feb (2026)
5 - Redraft	Redraft based on feedback	Conceptual framework development. Revised analysis aligned to framework. Integration of new literature	March - June (2026)
6 - Review	Final feedback	Final feedback. Submission preparation.	July- present (2026)

Appendix B: Extended Framework

Bottom-left: The Obsolescence Trap (*Low epistemic complexity + Short-term*) Efficiency in the present produces rigidity in the future.

Short-term decision making within a single dominant epistemic frame reinforces existing trajectories by self-reinforcing commitments and institutional lock-in. As "preceding steps... induce further movement in the same direction" (Pierson, 2000 p252), early decisions constrain future options through increasing returns, sunk costs, coordination effects, and adaptive expectations (Arthur, 1989; Pierson, 2000; Mahoney, 2000). When uncertainty is reduced to calculable risk, decision-making appears efficient but obscures deeper uncertainty, ambiguity, and ignorance (Stirling, 2010). Schipper (2020) traces the same pattern in adaptation practice, where infrastructural commitments carry high sunk costs while producing a false sense of security that keeps populations exposed and erodes the informal risk awareness through which alternatives were previously generated. Magnan et al. (2016) illustrate this in cases where adaptation policies leave unquestioned which development goals adaptation is furthering, with official efforts aligning with an uncontested development pathways. This results in a narrowing of future options and increased vulnerability to maladaptation.

Bottom-right: The Fragmented Present (*High epistemic complexity + Short-term*) Plural perspectives without temporal integration produce fragmentation.

Multiple legitimate perspectives are present, however, short-term pressures prevent their integration. Epistemic contestation occurs without sufficient temporal space for synthesis, as knowledge claims are "mobilised, controlled and contested" (James, 2024 p837). Competing epistemic communities promote different causal beliefs and validity criteria (Haas, 1992; Cross 2013; Löblová, 2018), while frames provide "a cognitive road map" that can also become "an independent source of conflict" between actors (James & Quaglia, 2023 p349). The characteristic failure is what Schipper (2020) terms shifting vulnerability, where separately rational frames redistribute risk onto those outside their own beneficiary groups, and where coping presumes a return to normality that may never arrive. Ranon et al. (2026) illustrate how short-term projects whose interacting outcomes never surfaced can generate waves of disruption for the populations they are intended to benefit. The result is reactive, inconsistent, or stalled decision-making that at best copes with change, and at worst reinforces maladaptive commitments.

Top-left: The Insular Future (*Low epistemic complexity + Long-term*) Long-term planning without epistemic plurality produces blind spots.

A long-term strategy is developed, but within a single dominant epistemic frame. In this condition, uncertainty is often treated as risk, despite the fact that "an overly narrow focus on risk is an inadequate response to incomplete knowledge" (Stirling, 2010 p1031). This produces internally coherent but externally fragile futures, where decision-makers overlook ambiguity and ignorance and fail to account for contested values and high stakes (Funtowicz & Ravetz, 1993). Bertana et al. (2022), for example, identify solutions that focus on technological or engineering fixes; these single-domain responses are intended to address long-term horizons that produce short- and medium-term maladaptation. Maladaptation occurs because they do not account for impacts beyond their own domain nor integrate local knowledge. Schipper (2020) attributes planned maladaptation to well-resourced external actors designing without local social and ecological knowledge, producing rebounding vulnerability in which intended beneficiaries are left worse off. Here self-confident intervention increased vulnerability.

Top-right: The Resilience Nexus (*High epistemic complexity + Long-term*) Plural knowledge combined with long-term foresight enables adaptive resilience.

Long-term foresight, combined with multiple epistemic perspectives, enables decision-making that engages with uncertainty, explores alternative futures, and adapts over time. This aligns with anticipatory governance, understood as "governing in the present to adapt to or shape uncertain futures" (Muiderman et al., 2020 p2), and with approaches that support "multiple plausible futures" and reflexive navigation of uncertainty (Muiderman et al., 2020 p7). It also reflects plural and conditional forms of knowledge engagement under uncertainty (Stirling, 2010), and foresight traditions integrating diverse perspectives to address complex challenges (Ramos, 2014). The aim of this quadrant is one of anticipatory governance; however, we acknowledge that limitations such as issues of power or performative use of the process. Magnan et al. (2016) advocate ex ante approaches to tracking maladaptation, including precautionary measures that identify options insensitive to a range of changing climate conditions. Our approach may surface such options; however, it has been shown to identify structural dilemmas that persist across all four futures. Schipper (2020) cautions that no-regrets framings understate complexity and that maladaptation cannot be identified in advance with certainty but suggests that experience can indicate which contexts are more prone to it. This quadrant highlights those persistent problems spaces.

Summary

The interaction between epistemic and temporal complexity influence whether governance systems become locked in, fragmented, insular, or adaptive in the face of uncertainty. Each condition carries a distinct maladaptive signature, and positions are trajectories rather than fixed states, since adaptive strategies can drift into maladaptation over time (Schipper, 2020). Our futures approach is a natural companion to Pelling et al.'s (2024) normative approach.

Appendix C: Morphological analysis survey results

Morphological Results. Expert Assessments of States Across Climate, Social, Technological, and Governance Factors/Themes (%) n=27

Overall theme	Future State				
Climate change	Moderate escalation	Managed transition	Tipping point cascade	System threshold collapse	Breakthrough stabilisation
Percentage	29	20	20	18	13
Social Resilience	Selective resilience	Brittle adaptation	Fragmented breakdown	Adaptive communities	Antifragile society
Percentage	26	24	19	17	14
Technological innovation and deployment	Fragmented development	Disruptive chaos	Innovation Plateau	Steady progress	Break through acceleration
Percentage	30	19	19	17	15
Governance	Institutional paralysis	Technocratic Governance	Polycentric networks	Authoritarian Efficiency	Democratic renewal
Percentage	26	21	20	18	15

Appendix D: WHO framework emerging issues and trends survey results

	WHO Category	Results
1	Health Service delivery	Decentralisation and community-based care (19), Increasing reliance on resilient health systems (15) Growing shortage of healthcare workforce (14) and mHealth (mobile) services (14).
2	Health workforce	Workforce mental health (20), Workforce mental health (20), Rise of community health worker models (15), AI assisted workforce / AI deskilling (14),
3	Health Information Systems	Community Engagement and Ownership (19), Inadequate infrastructure and resources (19), Data equity and accessibility (17), Sustainability and capacity building (17)
4	Access to Essential Medicines	Antibiotic resistances (21), Ethical considerations in clinical trials (18), Rising costs and affordability of medicine (18), Affordability of innovative new technologies (17)
5	Financing Health Systems	Climate change on health financing (19), Sustainable financing for Universal Health Coverage (UHC) (15), Funding "crunch" (13), Sustainable local financing (11), South-South funding models (10), Equity-focused financing mechanisms (9)
6	Leadership and Governance	Capacity building for health system leadership (15), Climate health discourse (14), Ethical considerations in research (14), Data-driven decision making (13)
7	Additional	Climate-Resilient Health Infrastructure (21), Community-Based Disaster Management (CBDM) groups (19), Collaborative response agreements (17), Integrated disaster response platforms (15).

