GLOBAL CENTER ON ADAPTATION

Adaptation Insights *04*

HEALTH

Climate-resilient health systems for sustained value chains, healthcare access and services

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Authors & Acknowledgements

This Adaptation Insights on Climate-Resilient Health Systems is the result of a collaborative effort between the Global Center on Adaptation (GCA), Oxford Infrastructure Analytics, the Université Paris Cité and Université Sorbonne Paris Nord, IRD, Inserm, CEPED, the Heidelberg Institute of Global Health (HIGH), Heidelberg University. It has been developed by Dr. Edwina Mercer (Senior Program Officer), Dr. Gerald Leppert (Senior Economist), Abu Touhid Hossain (Program Officer), Farah Ramadan (Intern), Anne-Laure Solnon (Senior Specialist), and Adele Cadario (Global Lead) from GCA, Dr. Scott Thacker, Violet Massie-Vereker and Dr. Daniel Adshead from Oxford Infrastructure Analytics, Prof. Dr. Valéry Ridde from CEPED/IRD, and Prof. Dr. Manuela De Allegri from the Heidelberg University.

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GLOBAL CENTER ON ADAPTATION

ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Center on Adaptation (GCA) is an international organization, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

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Oxford Infrastructure Analytics (OIA) specialises in systemic climate risk analysis and adaptation planning for infrastructure systems. OIA was founded in 2017 from the award-winning Oxford Programme for Sustainable Infrastructure Systems, University of Oxford.

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African Union

AFRICA ADAPTATION INITIATIVE

AFRICAN DEVELOPMENT BANK GROUP

IsDB البنك الإسلامي للتنمية Islamic Development Bank

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Abbreviations

Acronyms	Definitions
AAAP	Africa Adaptation Acceleration Program
AfDB	African Development Bank
CHW	Community health workers
FEMA	Federal Emergency Management Agency
GCA	Global Center on Adaptation
HNAP	Health national adaptation plan
IFI	International financial institution
IPCC	Intergovernmental Panel on Climate Change
IsDB	Islamic Development Bank
MDB	Multilateral development bank
NAP	National adaptation plan
NDC	Nationally determined contributions
PIR	Policy institutional regulatory
PHC	Primary health care facility
RCP	Representative concentration pathway
SDG	Sustainable development goal
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Foreword

Around the world, rising temperatures, extreme weather events, cumulative stressors and cascading climate shocks are increasing the burden of disease and driving higher demand for health services, precisely at a time when health systems themselves are increasingly exposed and affected by climate change impacts. Climate change is no longer only an environmental or development challenge; it is a systemic risk to human health and well-being, economic productivity, and fiscal stability. For countries striving to achieve universal health coverage, protect hard-won development gains, aiming to reduce poverty, climate resilience is now a core health system priority.

Health is a fundamental human right and a cornerstone of sustainable development. Yet climate change is putting that right at risk, even most acutely for low-income communities, women and children, and those living in climate-vulnerable settings. Disruptions to healthcare access, supply chains, energy, water, transport, and digital systems undermine the ability of health services to function when they are needed most. As this report shows, without decisive action, climate impacts could force partial or total shutdowns of health facilities, sever access for millions of people, and reverse progress toward SDG 3. The risk is not only humanitarian—it is macroeconomic. When health systems fail, labour productivity declines, household incomes fall, poverty deepens, and public budgets face mounting emergency expenditures.

Investing in climate-resilient health systems is therefore both a development imperative and can be a highly cost-effective strategy to sustain healthcare access and services required for poverty reduction and economic stabilisation in times of climate change. Strengthening resilience—including through relatively modest, targeted investments—can safeguard essential services, protect public and private assets, and ensure continuity of care during climate shocks. As this report demonstrates, allocating as little as one percent of a hospital's value to resilience measures can protect the vast majority of its functionality during disasters. Few investments offer such high social and economic returns. In fiscal terms, resilience is not an added cost: it is a form of risk management that reduces contingent liabilities, protects capital stock, and stabilises long-term expenditure.

The insights and recommendations presented here are grounded in country realities and informed by the Global Center on Adaptation's experience embedding resilience into policies, standards, and investment streams under the Africa Adaptation Acceleration Program (AAAP). From flood risks threatening health infrastructure and access in Nigeria, to gaps in national adaptation planning across Africa, the evidence underscores the need for integrated, cross-sectoral, and country-led approaches. Encouragingly, good practices are emerging, analytical tools are improving, and practical solutions already exist. What remains insufficient is scale, coordination, and finance.

Building climate-resilient health systems is foundational to resilient development. It protects lives and livelihoods, strengthens human capital, safeguards productivity, and reduces the long-term fiscal costs of climate shocks. It enhances sovereign resilience by reducing emergency spending, protecting infrastructure assets, and stabilising economic output during crises. For international financial institutions and development partners, investment in resilient health systems represents a catalytic opportunity: relatively small, well-targeted resilience measures can unlock significant avoided losses, preserve development gains, and strengthen national systems.

This report is a call to action—for national governments, international financial institutions, development partners, and the health and climate communities—to accelerate investment, align policies, and embed resilience systematically across health systems and the sectors on which they depend.

The time to act is now. By placing climate resilience at the heart of health system strengthening, we can protect the most vulnerable, sustain essential services in a changing climate, and ensure that progress toward health, equity, and poverty reduction is not only achieved—but secured for generations to come.

Rindra Rabarinirinarison
CEO
Global Center on Adaptation

Executive Summary

Climate change is expected to threaten the health and livelihoods of up to 4.8 billion people by 2030 (UN, 2025), making it one of the most significant systemic risks to human development and economic stability.

Within the healthcare sector, climate change is projected to substantially increase service demand both directly, through exposure to more frequent and severe climate-related hazards, and indirectly, by placing stress on critical systems such as food, water, energy, and air quality that underpin population health and access to basic services.

Despite these escalating risks, financial support for health adaptation represents less than 0.5% of total multilateral climate finance (IPCC, 2022). This level of investment is insufficient to protect populations and health systems from climate-sensitive health risks, and funding often fails to reach the most climate-vulnerable settings.

An integrated and systems-oriented approach to policies, planning and investments in climate-resilient healthcare access can generate substantial public health gains and economic returns, strengthening productivity, safeguarding human capital, and enhancing long-term development resilience.

It is estimated that climate change threatens the health and livelihoods of up to 4.8 billion people by 2030 (UN, 2025). In the context of climate change, health systems that enhance or maintain value chains, healthcare services, and access to healthcare are imperative in addressing the repercussions of climate change on the population, society, and economies. However, the impacts of climate change on health systems are already evident. Examples of this include overwhelmed hospital capacities and shortages of medical supplies during heat waves and wildfires, destroyed facilities and failures of supporting systems during tropical cyclones, and inaccessible facilities during flooding. The IPCC asserts that the climate resilience of healthcare systems is an essential strategy for all countries to manage climate risk, as it can reduce the vulnerability of the majority of the global population. Whilst the significance of health system adaptation is widely recognised, progress in establishing climate-resilient health systems has been inadequate. This has prompted the IPCC (2022, p. 96) to issue a definitive statement on this matter:

"Financial constraints are the most referenced barrier to health adaptation, and therefore scaling up financial investments remains a key international priority (very high confidence). Financial support for health adaptation is currently less than 0.5% of overall dispersed multilateral climate finance projects (high confidence). This level of investment is insufficient to protect human health and health systems from most climate-sensitive health risks (very high confidence). Adaptation financing often does not reach places where the climate sensitivity of the health sector is greatest (high confidence)"

As a consequence, recognising the need for urgent and decisive steps and the limited access to finance as major obstacle, the 77th WHO World Health Assembly passed a resolution calling for the mobilisation of resources from all sources to invest in the adaptation of the health sector (WHO: Climate Change and Health, 2024). From a global perspective, health systems in African countries are among the weakest and demonstrate severe challenges in all the healthcare delivery pillars (Oleribe et al., 2019). This is particularly evident in Africa, where the adaptation of health systems to climate change is characterised by insufficient financing and inadequate investment.

This report demonstrates that investments and efforts directed towards climate change adaptation in the health sector are likely to yield substantial benefits for public health and economic prosperity: The developed climate change adaptation strategies aim to ensure the continued functioning of value chains, healthcare services, and access to healthcare in times of climate change, and to enhance the responsiveness and resilience of health systems. In order to attain these benefits, it is imperative to make substantial investments and pursue technical advancements.

Climate change is projected to drive higher demand for health services, yet the health system itself remains highly vulnerable to climate-related shocks. Health is a fundamental human right (UNGA, 1948; WHO, 2023c), with the third sustainable development goal (SDG 3) aiming to achieve good health and wellbeing for all (UN General Assembly, 2015). Climate change is expected to increase the demand for healthcare services either directly by escalating global health risks from increasing the frequency, intensity, and magnitude of climate-related hazards, or indirectly affecting human well-being by placing stress on critical systems which people rely on such as food, water, energy and air (WHO, 2023b). However, the health system itself faces significant vulnerability, with projections under the RCP 8.5 scenario suggesting that 1 in 18 hospitals could face total or partial shutdown by 2050 (Cross Dependency Initiative, 2023) with storm damage costs reported from US$ 600,000 to US$ 2 billion per facility in the US (Thomas, 2011). In Nigeria, where the government has committed a substantial US$2.2 billion investment for a national health sector reform (Ufoh, 2025), a 1-in-100-year fluvial flood event could expose approximately 61/450 clinics, 52/743 general practices, and 32/1283 hospitals to flood depths exceeding 0.3 m under the RCP 4.5 scenario in 2050, with an operational shutdown of 19 hospitals . Under the same scenario, a 1-in-100 year flood event in 2050 could block access to the nearest healthcare facility for 1.48% (~3.9 million) and 4.87% (~12.8 million people) of Nigeria's population travelling on foot and using motorised transport respectively (Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020). Strengthening the resilience of health systems to climate

change is fundamental to achieving SDG 3 and represents a highly cost-effective investment: WHO (2009) reports that allocating roughly 1 percent of a hospital's total value to non-structural retrofits can safeguard as much as 90 percent of its assets during natural disasters.

Existing guidelines, international standards and policy frameworks for climate resilient health systems remain largely asset focused and fragmented. Many systemic failures caused by climate hazards have occurred outside of the health facility such as from disruptions in sectors such as energy, water, digital, waste and transport, which have ultimately hindered medical service functionality and patient access. However, existing guidelines and international standards for climate-resilient health facilities have gaps, as they do not comprehensively consider the vulnerabilities of the healthcare system, often remaining asset-centric, at the hard (structural/technical) dimension of the health system. They concentrate on the assessment of physical climate risks at the level of individual facilities, such as hospitals. While these assessments provide useful insights, they often give limited attention to the broader systemic nature of healthcare and its critical interdependencies, including supporting systems and access to healthcare. As a result, they may underestimate the full range of vulnerabilities and the scale of potential risks, thus not always drawing the right conclusions with regard to adaptation solutions, as well as the potential benefits of systemic adaptation measures.

Efforts on health system resilience are anchored in the UNFCCC process on the Global Goal on Adaptation, which has been established in the Paris Agreement to strengthen resilience and reduce vulnerability to climate change (UN, 2015). Health has been established as one of the key areas in which countries need to build resilience and was defined as one of the core pillars of the Global Goal on Adaptation Framework "attaining resilience against climate change related health impacts, promoting climate-resilient health services, and significantly reducing climate-related morbidity and mortality, particularly in the most vulnerable communities" (UNFCCC, 2023). Already since 2010, alongside the UNFCCC National Adaptation Plan (NAP) process, health received a dedicated adaptation plan with the Health National Adaptation Plans (HNAP) (WHO, 2025a). However, a gap in systemic resilience is also evident in the policy frameworks of several African countries. A review of Health National Adaptation Plans (HNAPs) and health-related Nationally Determined Contributions (NDCs) for Africa found that approximately 60% do not acknowledge supporting systems, and 43% do not address cross-sectoral collaboration.

Two novel conceptual frameworks provide analytical basis for improving climate resilience of health systems. The two conceptual approaches provide two distinct perspectives on health system resilience: from the perspective of sustained access to healthcare for patients, the population, and vulnerable groups, and from the perspective of the healthcare service provision – comprising healthcare facilities, healthcare assets, value chains, and supporting systems. The first approach, the Integrative Framework of Health System Resilience and Climate Change focuses on sustaining access to healthcare and understands health systems as a dynamic system in the context of climate change. It conceptualises dimensions at the supply and the demand side that have an influence on healthcare access of patients and the population, and thus allows to systematically develop measures to sustain healthcare access. The second approach, the Healthcare System-of-Systems Approach, maps the complexity and interconnectedness of a health system, comprising healthcare assets as well as their supporting systems, with regard to their interdependent climate vulnerability. Thus, this approach allows to systematically develop measures to make value chains and health care services more sustainable avoiding disruptions due to climate change. Both approaches provide a systematic lens to identify degradations, disruptions, and system failures and thus provide guidance on how to improve the ability of health systems to prepare for, respond to, maintain and reorganise in the face of climate risks. By bringing together these two perspectives, this Adaptation Insights report is able to generate novel insights into the question of how to make health systems more climate resilient in order to sustain value chains, healthcare services, and access to healthcare.

The key considerations to adapt the health care system – on top of healthcare infrastructure –are highlighted in Figure 1:

Figure 1. Climate change adaptation considerations for the health system

There is an increasing body of evidence that highlights a lack of healthcare systems preparedness to the threats posed by climate hazards and that climate change adaptation of health systems is fundamentally under-financed and that investments are insufficient. The adaptation of health care systems needs to gain momentum and requires focus and investments of national governments, development partners, and international financial institutions, to achieve climate-resilient health systems with sustained value chains, healthcare access and services. Good practices are emerging, theoretical concepts of practical use are available, and technologies and instruments to adapt exist. Grounded in systematic analysis, actionable recommendations can guide implementation. The following actionable recommendations made in five main categories, derived and synthesised from the analyses of the report, are tailored to different stakeholders, from International Financial Institutions, over national governments, to international development partners.

1. Embed Climate Risks at the Core of Health System Planning, Financing, and Monitoring

Climate change is changing and simultaneously increasing healthcare demand and disrupting service delivery capacity. Yet climate risks are still too often treated as peripheral considerations rather than core determinants of health system planning, investment prioritisation, and performance monitoring.

#1 – **Integrate Climate Risk into Health Planning and Investment Prioritisation.** Assessing how localised climate impacts may drive future health demand and (temporary) reduction in healthcare system capacity will help ensure that today's investments match tomorrow's needs.

#2 – **Embed Climate Risk Screening in Investment Preparation Frameworks.** Integrate climate risk screening into investment preparation frameworks as a forward-looking methodology to safeguard investments and ensure continuity of health services under future climatic conditions. This approach can furthermore accelerate evidence-based health system adaptation, leveraging research and applied knowledge development into planning and decision-making processes.

#3 – **Establish Climate- and Weather-Informed Information Systems for Health.** Adequate national climate- and weather-informed information systems need to be established or improved, to enable climate-sensitive epidemiological modelling, and health risk assessments to inform projections of evolving healthcare needs, and to increase system responsiveness.

2. Shift from Asset-Level Resilience to System-Wide and Value Chain Approaches Considering Interdependencies

Resilience cannot be achieved by focusing only on individual facilities. Climate risks affect entire supply chains and interconnected systems, creating vulnerabilities across scales and sectors.

#4 – **Expand Standards for Health Systems and Risks Screening and Adaptation from Facilities to Full Healthcare Value Chains.** Resilient health system needs to rely on supply chains and wider functions, from the local scale (facilities) to the regional scale (pharmaceuticals supply chains, logistics, workforce mobility).

#5 – **Address Health System Dependencies, Interconnected Systems and Cross-Sector Risk Hotspots.** Climate vulnerability of healthcare systems are also closely interlinked to failures in energy, transport, water, sanitation, and digital infrastructure. Identifying interdependencies driving system deterioration or failure and hotspots of risks, where cascading disruptions are likely to affect healthcare delivery at scale, is key for effective reduction of systemic vulnerability.

3. Focus on Sustaining Access to Healthcare and Make Health Systems User-Centric, Locally-Led, and Service-Oriented

Access to healthcare is central to healthcare system performance. Climate change increasingly affects access to healthcare at the supply and the demand side, leading to failing health system, as its main function – to deliver healthcare – cannot be fulfilled. Vulnerable populations are disproportionately affected. Prioritising access, equity, and service continuity from a user perspective directly contributes to achieving a more resilient health system.

#6 – **Think health system adaptation from the goal to sustain access to health care**. In the context of climate change, a paradigm shift is advised to design and assess healthcare system performance with the goal to sustain and improve access to health care. Given the requirement for complex adaptation responses at the supply and demand side, the population needs to be considered as an actor in health system resilience.

#7 – **Strengthen Last-Mile Delivery and Physical Accessibility of Healthcare Facilities, and Users-Centred Adaptation.** Strengthening physical accessibility of healthcare facilities and decentralised service provision with a focus on reliable access to healthcare services can ensure continuity of care during climate shocks, particularly in remote and climate-exposed areas.

#8 – **Promote Localised Solutions and Devolve Decision-Making.** Localised and context-specific solutions are essential to trigger resilience at the macro level. In line with locally led adaptation principles, decision-making should be devolved to the lowest appropriate level and contribute to adaptation actions identification, prioritisation, implementation, and evaluation. Community involvement is required to effectively sustain healthcare access.

4. Build and Manage Adaptive, Dynamic, and Evidence-Based Health Systems

Health systems are dynamic systems that operate in changing environments characterised by recurrent shocks and stresses. In the context of climate change, health systems continuously go through resilience processes (proactive strategies, deterioration, (partial) failure, recovery, and improvement), at the supply and demand side. Static approaches to planning and management are insufficient to address evolving climate risks.

#9 – **Allow for Flexible Decision-Making for Dynamic System Response.** Flexible decision-making structures can allow local actors to respond rapidly to climate-related disruptions with maximum efficiency and relevance, while maintaining coherence with national strategies.

#10 – **Foster Population Capacity to Manage the Impacts of Climate Change with regard to Health and Healthcare Access.** Resilient health systems depend not only on infrastructure, but also on community preparedness, risk awareness, and climate risk management strategies to reduce the health burden associated with changing climate and extreme weather events.

#11 – **Deploy Local Early Warning Systems and Real-Time Data Platforms.** Early warning systems and real-time data management platforms at the local level are critical to enable rapid yet informed decision-making and coordinated response, eventually reducing service disruption during climate events.

#12 – **Leverage Research, Evaluation, and Knowledge Sharing to Accelerate Evidence-Based Health System Adaptation.** Effective and efficient adaptation requires evidence-based policies. This requires rigorous impact assessments and evaluations of innovative and not well-tested health system adaptation interventions, and harmonising existing frameworks of health system resilience and to take them from theory to practice. It also includes better knowledge sharing and capacity strengthening on health system adaptation and resilience with stakeholders.

5. Strengthen Regional Cooperation and Mobilise Finance for Climate-Resilient Health Systems

Climate risks transcend national boundaries and current financing levels remain insufficient to protect health systems from escalating climate impacts. Greater coordination and resource mobilisation are required.

#13 – **Embrace Healthcare Systems' Complexity in Policies and Regional Cooperation.** Reflecting more realistically climate-health linkages in policy design and regional cooperation mechanisms (cross-border collaboration, harmonised standards, and knowledge exchange) can strengthen collective resilience and reduce fragmentation.

#14 – **Align and Increase Finance for Climate-Resilient Health Systems.** Access to finance must be expanded and better aligned with adaptation needs in the health sector, allowing governments to mobilise and structure additional resources — including blended finance, guarantees, and climate funds — to direct health financing flows toward system-wide resilience rather than isolated investments.

01

Introduction

Introduction

Healthcare represents a fundamental service for society and people. Its primary objective is to improve or preserve health, which is one of the seventeen Sustainable Development Goals (SDGs) aiming to "ensure healthy lives and promote well-being for all at all ages" (Goal 3) (UN General Assembly, 2015). However, climate change is putting pressure on the achievement of this goal, with existing advancements being undermined by disruptive events and gradual changes caused by climate hazards or linked to climate change impacts. In the most recent of Sustainable Development Goals report, that takes stock of the progress towards achieving the SDGs, the United Nations estimate that, by 2030, climate change impacts put the health and livelihood of up to 4.8 billion people at risk (UN, 2025). Therefore, climate change adaptation in the health sector is of high urgency and inevitable to increase the overall resilience of the health system towards achieving SDG goal 3.

In its 6th assessment report on climate change adaptation, the Intergovernmental Panel on Climate Change (IPCC) highlights the importance of the availability of health infrastructure and access to health care for climate resilience, as it is perceived to reduce the vulnerability for most people in the world (IPCC, 2022). Furthermore, the IPCC links investments in health systems to a substantial decrease of negative climate-sensitive health outcomes and concludes with a high confidence of evidence that "strengthening the climate resiliency of health system will protect and promote human health and well-being" (IPCC, 2022, pp. 16, 25). Nevertheless, a wide range of stakeholders attest an incredible investment gap for health system adaptation (Foundation S et al., 2025; IPCC, 2022; WHO, 2021b). The IPCC is therefore very clear on this point:

> "Financial constraints are the most referenced barrier to health adaptation, and therefore scaling up financial investments remains a key international priority (very high confidence). Financial support for health adaptation is currently less than 0.5% of overall dispersed multilateral climate finance projects (high confidence). This level of investment is insufficient to protect human health and health systems from most climate-sensitive health risks (very high confidence). Adaptation financing often does not reach places where the climate sensitivity of the health sector is greatest (high confidence)" (IPCC, 2022, p. 96).

As a consequence, recognising the need for urgent and decisive steps and the limited access to finance as major obstacle, the 77th WHO World Health Assembly passed a resolution for resilient health systems calling for the mobilisation of resources from all sources and to "to invest in climate change adaptation measures that proactively address climate-related health impacts, including early warning systems for climate-related disease outbreaks and enhancing emergency preparedness and response; and pandemic prevention, preparedness and response" (WHO: Climate Change and Health, 2024).

For this reason, this edition of the Adaptation Insights series addresses the specific question of how health systems can be made climate resilient in order to sustain value chains, healthcare services, and access to healthcare. To answer this question, this report first presents the impacts of climate change on health systems and the status quo of climate change adaptation. Moreover, this Adaptation Insights presents two novel methodological frameworks as conceptual basis for the derivation of adaptation solutions for the health sector. Both approaches provide a systematic lens to identify degradations, disruptions, and system failures and thus provide guidance on how to adapt to climate change to make health systems more resilient, leading to specific actionable recommendations. To do so, the approaches address health system vulnerabilities and adaptation options from two different perspectives: From the perspective of sustaining healthcare service provision – comprising healthcare facilities and healthcare assets – and the perspective of sustaining access to healthcare for patients, the population, and vulnerable groups.

The health system has always been described as a complex system, as it involves the interaction of multiple stakeholders (e.g., population, health staff, health financing agencies, and the government), and requires medical inputs, facilities and staff. Accordingly, the definition by the World Health Organization (WHO) is holistic, that a "health system consists of all organisations, people and actions whose primary intent is to promote, restore or maintain health". This includes a variety of efforts (e.g., interventions influencing determinants of health, and health-improving activities) and it includes all actors, from individuals caring for family members, organisations carrying out health campaigns, health financing institutions, through to public and private health care providers (WHO, 2007, p. 2). Health systems also heavily depend on other economic and social systems, called supporting systems in this report, which are necessary for the health system to function properly.

As outlined, all health systems worldwide are highly impacted by climate change, but system vulnerabilities, financial constraints and adaptive capacities differ. The African continent represents a good example for challenges due to climate change. Health systems in African countries are among the weakest worldwide and show severe challenges on all pillars of healthcare delivery as defined by the WHO (Oleribe et al., 2019). Healthcare systems face particular challenges in availability of adequate human resources, in adequate budgetary allocation, and in leadership and management (Oleribe et al., 2019). Africa's health systems are rooted in a history of colonial legacy and policies, such as disengagement and structural adjustment policies of the 1980s, have deepened inequalities in health systems, coupled with ongoing funding constraints (Leppert, 2016). At the same time African countries and their health systems are disproportionally affected by severe impacts of climate change (Atwoli et al., 2022). The combination of weak health systems with a low-level resilience together with high projected climate change impacts post a significant challenge for the functioning of African health systems and healthcare delivery (Ogony et al., 2025). The contributions by the presented new approaches to addressing climate challenges in health systems are universal, but for the reasons, laid out above, the analysis focuses on Africa's health systems. Nigeria has been selected as a case study, because it is one of the most climate vulnerable countries and the country has recently committed US$ 2.2 billion to enhance climate resilience of the health system (Ufoh, 2025). The conceptual and methodological contributions presented here are globally relevant.

To make the health system more climate resilient, sustaining value chains, healthcare services, and access to healthcare, substantial investments and technical advancements are required. With the systemic lens and through the two perspectives – healthcare provision and access to healthcare –several critical recommendations are given for International Financial Institutions (IFIs), and for national governments and development partners, on how to adapt the healthcare system to climate change, how to set priorities and how investments can be made climate-proof, and how to set standards and policies for uninterrupted healthcare access and delivery.

In a first step, the impact of climate change that health systems face is outlined (chapter 2). This includes an illustrative geographic assessment of climate risks on a country's health system using the example of climate-related flooding risks for the health system of Nigeria. In the next step, the status quo of health system adaptation is presented by assessing the current standards, tools, and guidelines for adaptation and the HNAPs in Africa (Chapter 3). In the subsequent section, two new approaches are presented—based on the perspectives of healthcare provision and access to healthcare—to derive adaptation options for the health system in order to achieve climate-resilient value chains, healthcare services, and access to healthcare (Chapter 4). The presented approaches comprise the healthcare system-of-systems approach and the integrative framework of health system resilience for sustained access to healthcare. This Adaptation Insights report is concluded with a thorough discussion of high priority recommendations and an action plan for achieving climate-resilient health systems.

02

The impact of climate change on health systems

The impact of climate change on health systems

2.1 Global impacts of climate change on health systems

Climate change is projected to exacerbate global health risks by increasing the frequency, intensity, and magnitude of climate-related hazards and the burden of disease (Ebi et al., 2019). Approximately 3.6 billion people currently reside in regions highly vulnerable to its effects, with the associated direct damage health costs (excluding costs in health-determining sectors such as agriculture and water and sanitation) estimated to reach between US$ 2–4 billion annually by 2030 (WHO, 2023b). Beyond acute climate shocks that trigger humanitarian crises, climate change also exerts indirect pressures on critical systems, including food, energy, water, air (Figure 2, (WHO, 2023b)). Between 2030 and 2050, these impacts are anticipated to result in approximately 250,000 additional deaths per year, primarily due to undernutrition, malaria, diarrhoea, and heat stress (IPCC, 2022; Romanello et al., 2022; WHO, 2018, 2023b). Such experiences can negatively affect mental health, contributing to anxiety, depression, and post-traumatic stress disorder (PTSD) (CDC, 2025).

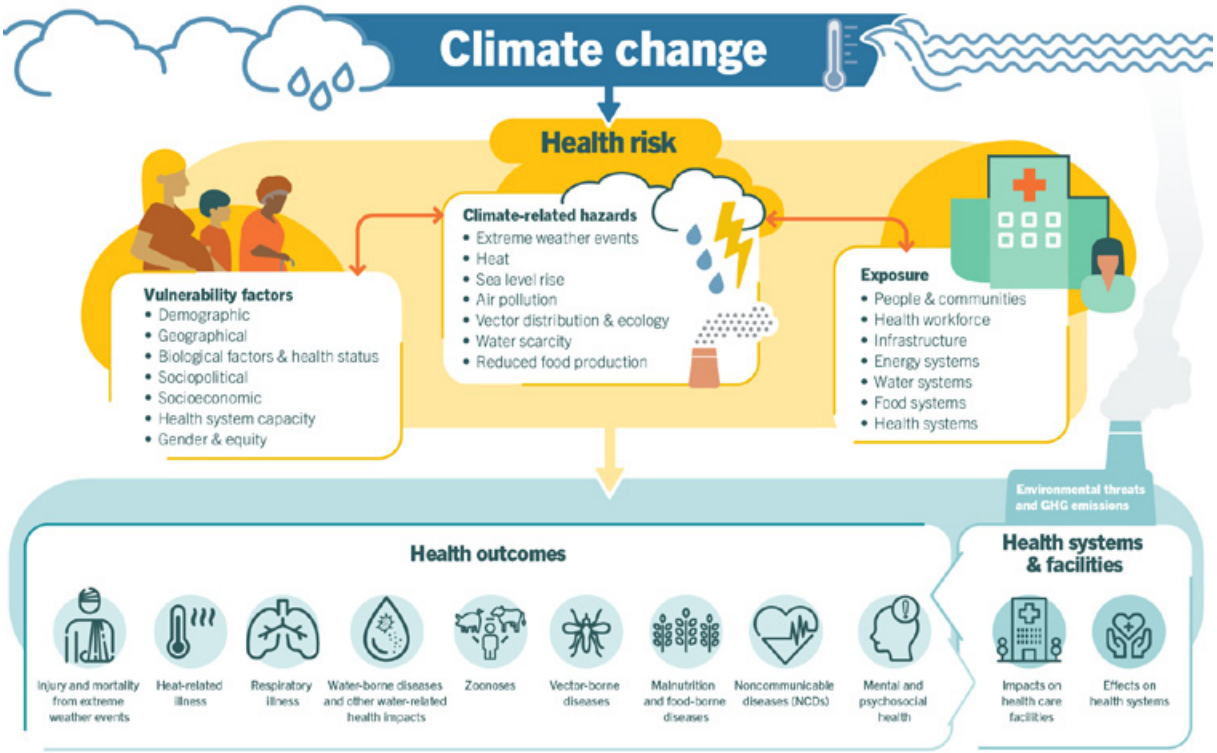


Figure 2. World Health Organization climate change and health fact sheet (WHO, 2023b)

Increased health risks therefore increase the demand for healthcare services. However, health systems are also vulnerable to climate hazards, impacting health facility functionality, medical supply chains, access routes, and workforce availability. The United Nations Population Fund estimates that close to 1,500 hospitals in Latin America and the Caribbean are in low-elevation zones vulnerable to extreme weather events, with over 80% of hospitals lying in these regions for certain countries (Wright & Chowdhry, 2024). Between 1990 and 2020, climate hazards had the potential to increase the risk of damage to hospitals by 41%, while climate change is predicted to put 1 in 18 hospitals and risk of total or partial shutdown by 2050 (RCP 8.5 scenario) (Cross Dependency Initiative, 2023). According to the US Federal Emergency Management Agency (FEMA), the economic infrastructure cost to hospitals from storm damage in the US ranges from US$ 600,000 to US$ 2 billion per facility (Thomas, 2011).

Table 1 exemplifies how different climate hazards have impacted health systems globally, including extreme heat, wildfires, strong winds and flooding. These hazards often expose vulnerabilities arising from inadequate preparedness, leading to systemic failures. For example, during the 2003 heatwave in France, approximately 14,800 deaths could have been prevented through an effective early warning system. The event overwhelmed hospital capacity, which was further strained by staff shortages due to the summer holiday period (Dhainaut et al., 2004). Similarly, in 2017, Hurricane Maria struck Puerto Rico, disabling the main power grid for several months (Andrade et al., 2022). Backup generators failed due to fuel shortages, resulting in cold chain disruptions (National Academies of Sciences, 2020). Consequently, 4,800 jobs were lost in the health and education sectors, and an estimated 3,052 deaths could have been avoided if power and cold chain management had been decentralised and fuel adequately stockpiled (Cashman, 2018; Rodríguez-Madera et al., 2021). In 2019–2020, wildfires in Australia generated an economic impact of AUD 1.95 billion and led to 429 preventable deaths, which could have been mitigated through improved wildfire emergency preparedness (AIHW, 2020). Flooding events in Mozambique (2019) and Pakistan (2022) similarly compromised health systems, causing damage to health infrastructure, increasing waterborne diseases, and limiting access to healthcare services (Hierink et al., 2020, p. 202; Lequechane et al., 2020; OCHA, 2022; WHO, 2023a). Implementation of more resilient infrastructure, such as elevated hospitals with decentralised support systems for water, energy, and cold chain management, could have substantially reduced these adverse outcomes (Government of Pakistan et al., 2022; Lequechane et al., 2020; Simpson, 2022; WHO Africa, 2019).

These events underscore the urgent need to integrate climate change considerations into cross-sectoral planning, as they demonstrate how disruptions in sectors such as energy, water, and transport can cascade to disrupt public health services and access. Climate change adaptation not only saves lives but also protects livelihoods and strengthens economic resilience.

Table 1: Global examples of health system failures, impacts, and lessons from climate hazards

Country, year	Hazard	System failure	Impact	Adaptation lessons
France, 2003	Extreme Heat	• Hospital capacity and morgues overwhelmed. • Staff shortages due to summer holiday period. (Dhainaut et al., 2004).	• ~14,800 avoidable deaths (Dhainaut et al., 2004)	• Early warning system for better preparedness (Dhainaut et al., 2004).
Puerto Rico, 2017	Hurricane (strong winds, flooding)	• Failure of supporting systems (power). (Andrad et al., 2022). • Fuel shortages for the backup generator. (National Academies of Sciences et al., 2020) • Cold chain failure. (Andrade et al., 2022).	• 4,800 jobs in education and health services lost (4.7% of that sector).(Cashman, 2018) • ~3,052 avoidable deaths (Rodríguez-Madera et al., 2021).	• Decentralise power supply including the use of renewable energy • Stockpile fuel and medication. • Decentralise cold chain management. (Guerra Velázquez, 2022).
Australia, 2019/2020	Wildfires	• Hospitals lacked sufficient air quality. (Power, 2020). • Hospital capacity overwhelmed. • (Arriagada et al., 2020).	• AUD 1.95 billion economic impact.(AIHW, 2020) • 429 avoidable deaths.(AIHW, 2020). • Respiratory and cardiovascular illnesses surged. (AIHW, 2020).	• Install HEPA air filtration. • Stockpile N95 masks. • Mobilise health staff in disaster zones.
Mozambique, 2019	Cyclone (extreme winds, flooding)	• Health facilities destroyed/severely damaged. • Cholera outbreak	• US$ 108.9 million economic loss in the Health sector. • US$ 202.4 million for health infrastructure recovery. (GFDRR, 2019). • 94 health facilities out of service.(Ministério da saúde Mocambique, 2019). • Cholera outbreak affecting 6,768 and 8 deaths (Lequechane et al., 2020). • Healthcare access decreased from 78.8% to 52.5% for children under 5 walking within 2 hours to the nearest facility (Hierink et al., 2020).	• Field hospital/ mobile clinics. • Integrated water and sanitation and health sector planning for waterborne disease surveillance. (Lequechane et al., 2020). • Build resilient health infrastructure. (WHO Africa, 2019)
Pakistan, 2022	Flooding	• Rural clinics submerged. (WHO, 2023a). • Vaccine cold chain failure. • (OCHA, 2022).	• 10% of health facilities out of service.(WHO, 2023a). • 15% of the population without access to primary and secondary health facilities.(OCHA, 2022).	• Elevate hospitals in flood prone areas. (Government of Pakistan et al., 2022) • Field hospital/ mobile clinics. (Simpson, 2022) • Decentralised cold chain management. (Government of Pakistan et al., 2022).

2.2 Impact of flooding on a health system – the case of Nigeria

In Nigeria, the health system continues to face significant challenges, including a shortage of healthcare workers, poorly maintained primary health facilities lacking essential resources, and inadequate cold chain management characterised by outdated storage infrastructure and limited accessibility in rural areas. In response to these systemic issues, the Nigerian government has secured US$ 2.2 billion to strengthen the national health sector (Ufoh, 2025). This investment will support the renovation of over 17,000 primary health centres, the training of 120,000 frontline health workers, and the expansion of national health insurance coverage, with the goal of doubling enrolment within three years (Ufoh, 2025).

Nigeria's ranks among the top ten climate vulnerable countries, globally and as the most populous nation in Africa and the sixth worldwide, which exacerbates its susceptibility to the adverse consequences of climate change (Climate Scorecard, 2018). In 2022, the nationwide floods impacting all states affected approximately 64% of households and caused an estimated loss of US$ 6.68 billion in damages (National Bureau of Statistics, 2023). Beyond the direct physical injuries caused by floodwaters and debris, secondary health impacts, such as a cholera outbreak (Ogunribido & Ogunribido, 2024), further underscored the increased demand for healthcare services. However, access to healthcare was severely constrained, as many facilities were rendered non-operational. For instance, in Kogi State, 90/106 health facilities were flooded, (WHO, 2022b), while in Jigawa State, 30 facilities were submerged and declared out of use, with over 200 additional facilities sustaining significant damage. Moreover, flood-related destruction of road infrastructure further impeded access to health services for months following the event. This case exemplifies how a climate hazard can simultaneously escalate the demand (box 1) for healthcare while severely limiting both the delivery and accessibility of these essential services. This section presents an overview of the potential impacts of increases in fluvial flooding due to climate change, on Nigeria's health system, focusing on the disruption of health facilities, and accessibility challenges.

To understand which health facilities and access routes will be vulnerable to climate change related flooding in Nigeria, a high level screening was conducted using open access tools such as the GRI Risk Viewer developed by the Oxford Program for Sustainable Infrastructure Systems (OPSIS) at the University of Oxford (Russell et al., 2025). A 1-in-100-year fluvial flood event, comparable to the 2012 and 2022 floods that disrupted healthcare services in Nigeria, was selected under a medium-term (2050) horizon using RCP 4.5 (moderate mitigation) and RCP 8.5 (high emissions) climate scenarios, typically employed to inform infrastructure adaptation planning.

Health facilities impacted

The location of existing healthcare infrastructure was mapped (Open Street Map, 2025) and overlaid with fluvial flooding scenarios from Aqueduct flood hazard maps (Ward et al., 2020) accessed through the GRI Risk Viewer Webtool (Russell et al., 2025). Figure 3 illustrates the impact of a 1-in-100-year fluvial flooding event on health facilities based on Aqueduct data under climate change scenarios for 2050 (RCP 4.5). The North Central and Northeast regions are particularly exposed, with fluvial flooding projected in the Chad Basin of Northeastern Nigeria by 2050 (RCP 4.5).

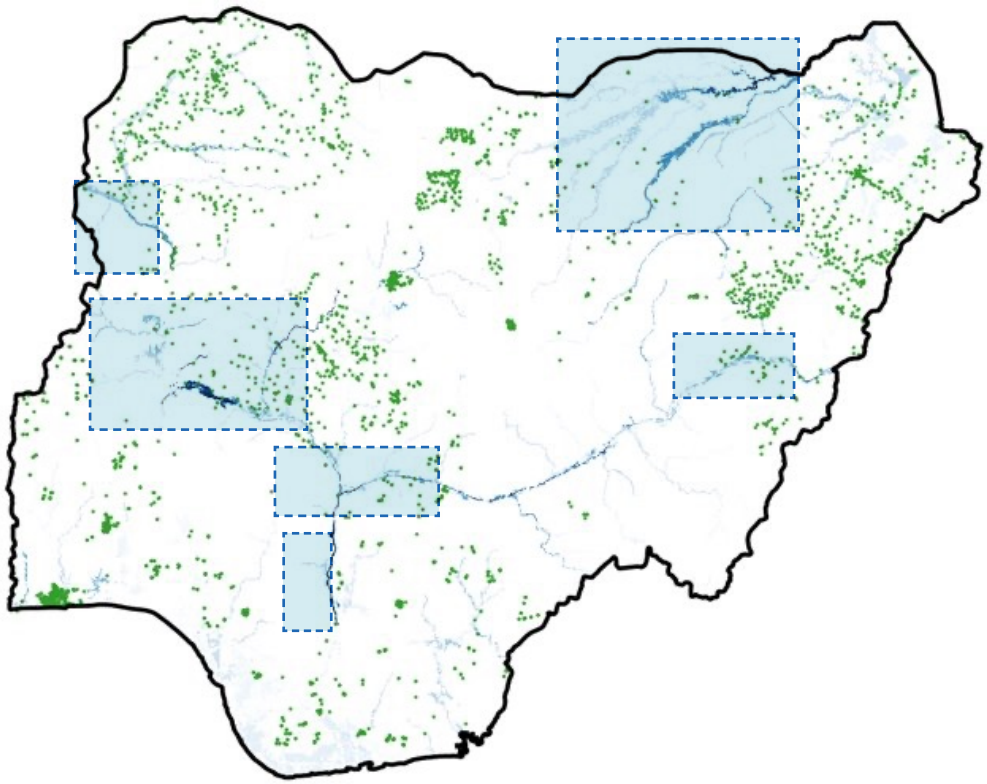


Figure 3. Health facilities impacted by a 100-year return period fluvial flooding event based on Aqueduct projected fluvial flood model for 2050 under RCP 4.5. Source: Open Street Map, 2025; Russell et al., 2025; Ward et al., 2020

Tables A1 and A2 disaggregates affected health facilities by type and flood depth, including hospitals, clinics, pharmacies, health posts, and dental practices. The baseline fluvial flood model indicates that a 1-in-100-year fluvial flood event would expose approximately 50/450 clinics, 34/743 general practices, and 28/1283 hospitals to flood depths exceeding 0.3 m. Under the RCP 4.5 scenario, and considering only existing infrastructure, these figures are projected to rise by 2050 to 61 clinics, 52 general practices, and 32 hospitals, respectively. To understand the implications of flooding on hospital infrastructure (Figure 4, Table A3), flood depths of 0.3–0.5 m are associated with the functional disruption of electrical and mechanical systems, including heating, ventilation, and air conditioning (HVAC), as floodwaters reach basements and utility areas (FEMA, 2017). At depths of 0.5–1.0 m, major service interruptions become increasingly likely, as backup power supplies and medical gas systems are at risk if located in low-lying areas (Abebe et al., 2025; Jelic, 2018). Beyond 1.0 m, hospitals are generally assumed to be non-operational, necessitating evacuation (First Street, 2025). Projections suggest that by 2050, fluvial flooding could cause temporary shutdowns at 19 hospitals under both

RCP 4.5 and RCP 8.5, compared with 17 currently. These estimates are conservative, however, as they do not account for the construction of new hospital facilities by 2050.

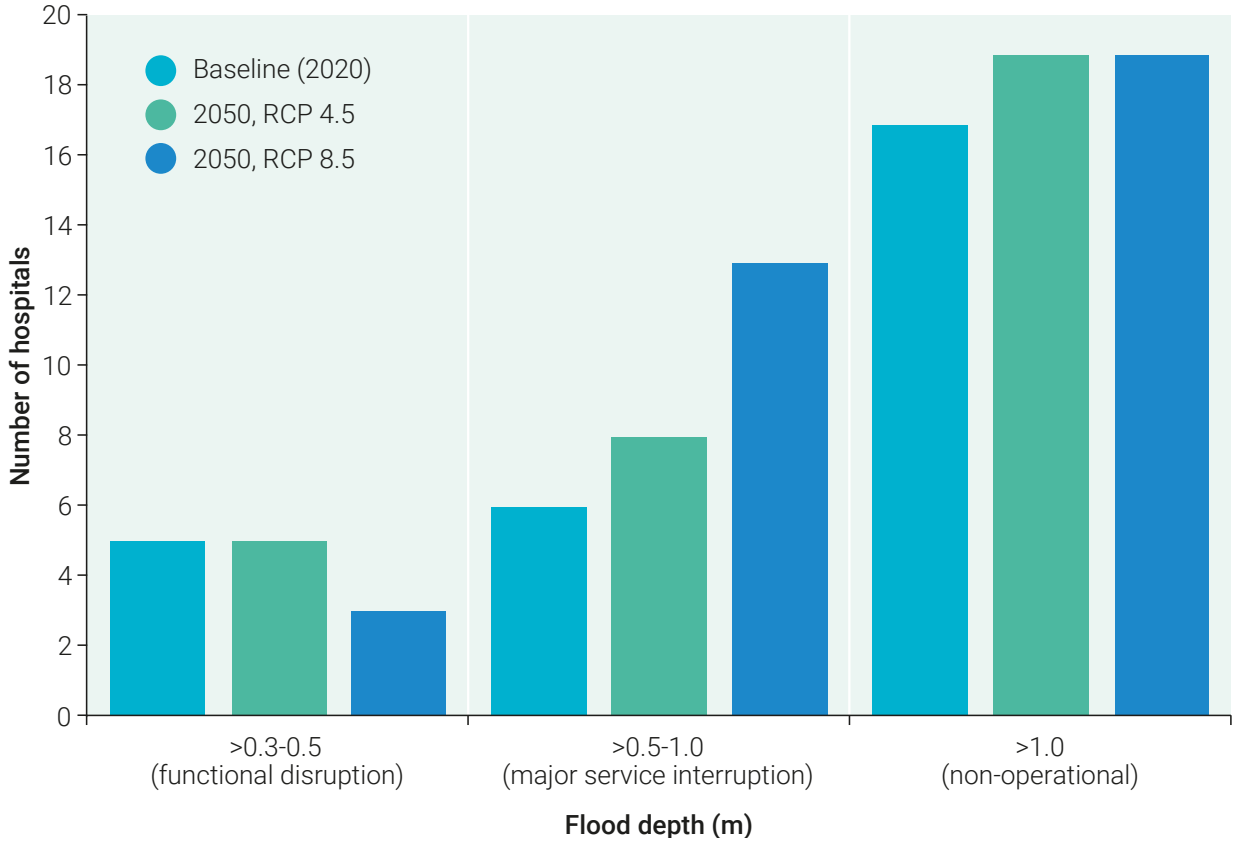


Figure 4. Comparison of fluvial flood scenarios impacting hospital functionality using Aqueduct fluvial flood models for a 100-year return period. Source: Open Street Map, 2025; Russell et al., 2025; Ward et al., 2020

Impact on accessibility

In a study by Weiss et al. (2020), walking and motorised travel times to the nearest health facility were mapped, concluding that 43.3% of the global population cannot reach a healthcare facility by foot within one hour, while 8.9% cannot reach healthcare within one hour with motorised transport. The analysis from Weiss et al. (2020) were presented to demonstrate potential accessibility challenges during a flood event in Nigeria. Accessibility disruptions are acutely exacerbated during flooding events impacting access routes and may be further intensified in the long term due to the destruction of transport infrastructure such as roads and bridges. For illustrative purposes, reduction factors were applied to walking times based on flood depth. At depths up to 0.4 m (ankle to knee height), adult walking speed is assumed to decrease by 20%. At depths of 0.4–0.9 m (knee to waist height), walking speed is reduced by 40%, and at depths exceeding 0.9 m (greater than waist height), the path is considered impassable (Li et al., 2025). For motorised transport, including cars and motorcycles, flood depths up to 0.15 m are assumed to double travel time, whereas depths of 0.15–0.3 m reduce speed to approximately one-eighth of normal. At depths exceeding 0.3 m, roads are considered impassable for average motorised vehicles (Gangwal et al., 2023). These results offer a preliminary estimate of how travel time and accessibility may be affected and are intended for demonstration purposes. A more detailed analysis is needed to account for potential chronic disruptions to road and bridge infrastructure; the rerouting to the second nearest and non-flooded facility, narrow or low-lying road segments near small water channels which may become impassable during flooding, even if average

flood depths suggest otherwise. The scenario of switching from driving to walking during a flood was also not analysed, as it was assumed that motorised travel distances are generally too great to be completed on foot.

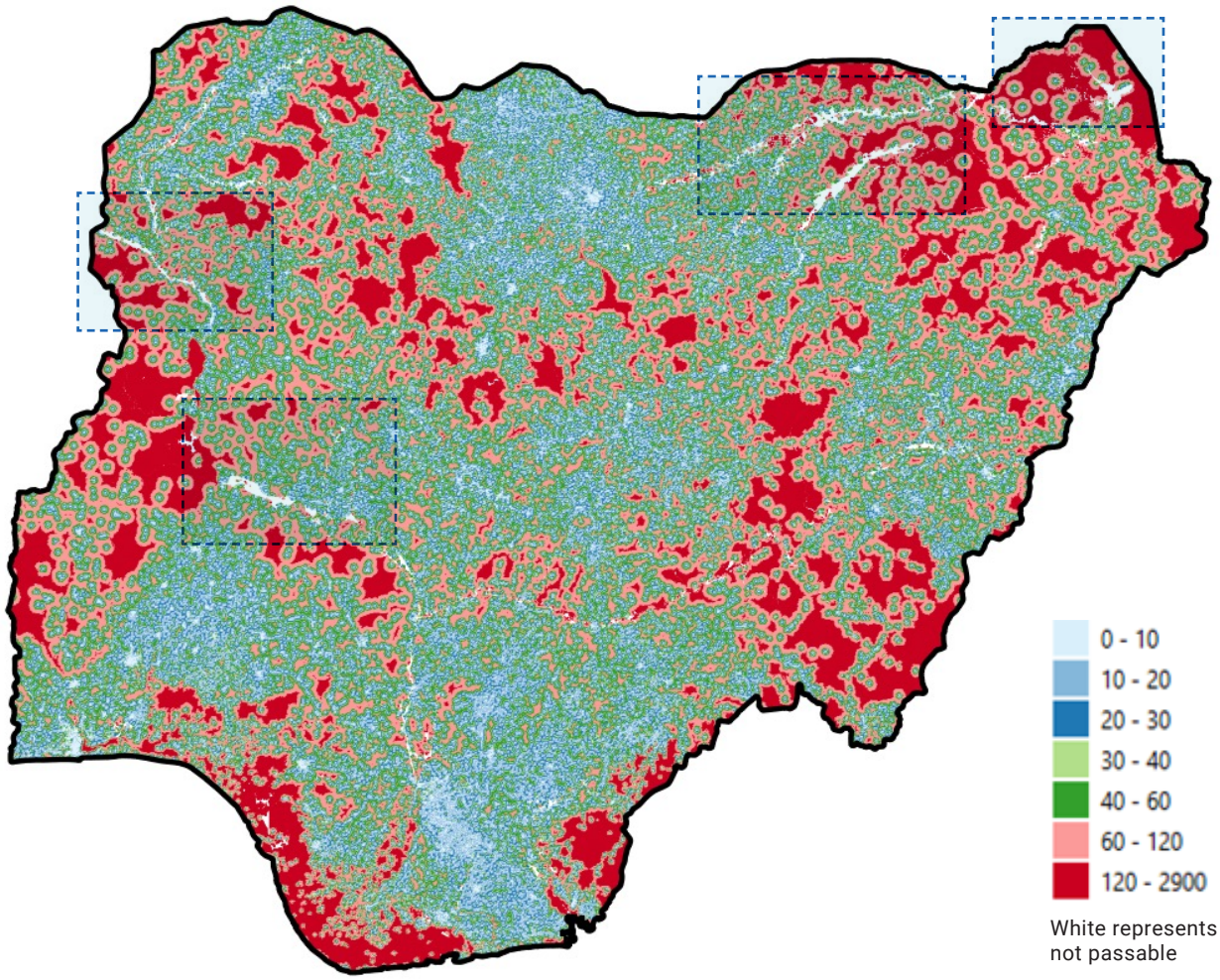
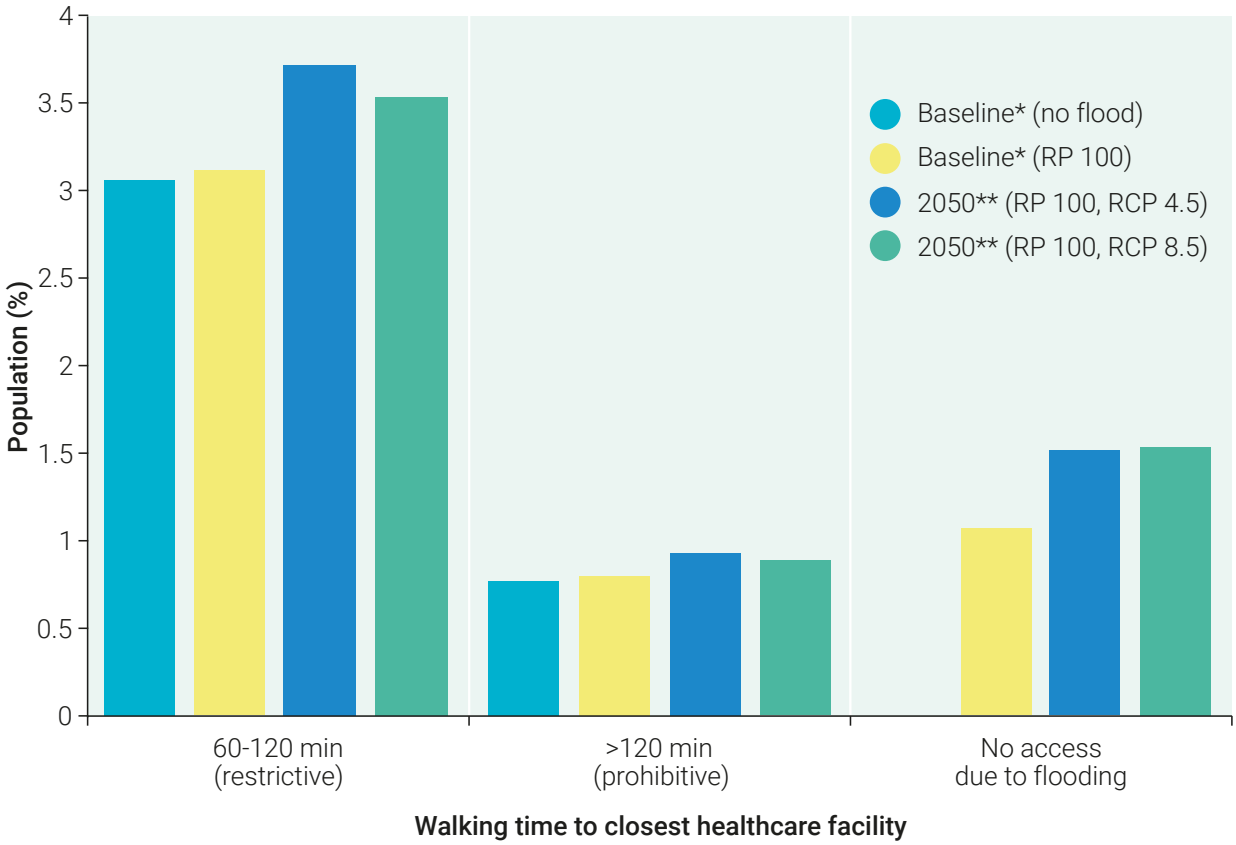


Figure 5. Walking travel times (minutes) to health facilities for RCP 4.5 scenario (2050, RP100 fluvial flood) using Aqueduct fluvial flood models combined with the travel time analysis of Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020

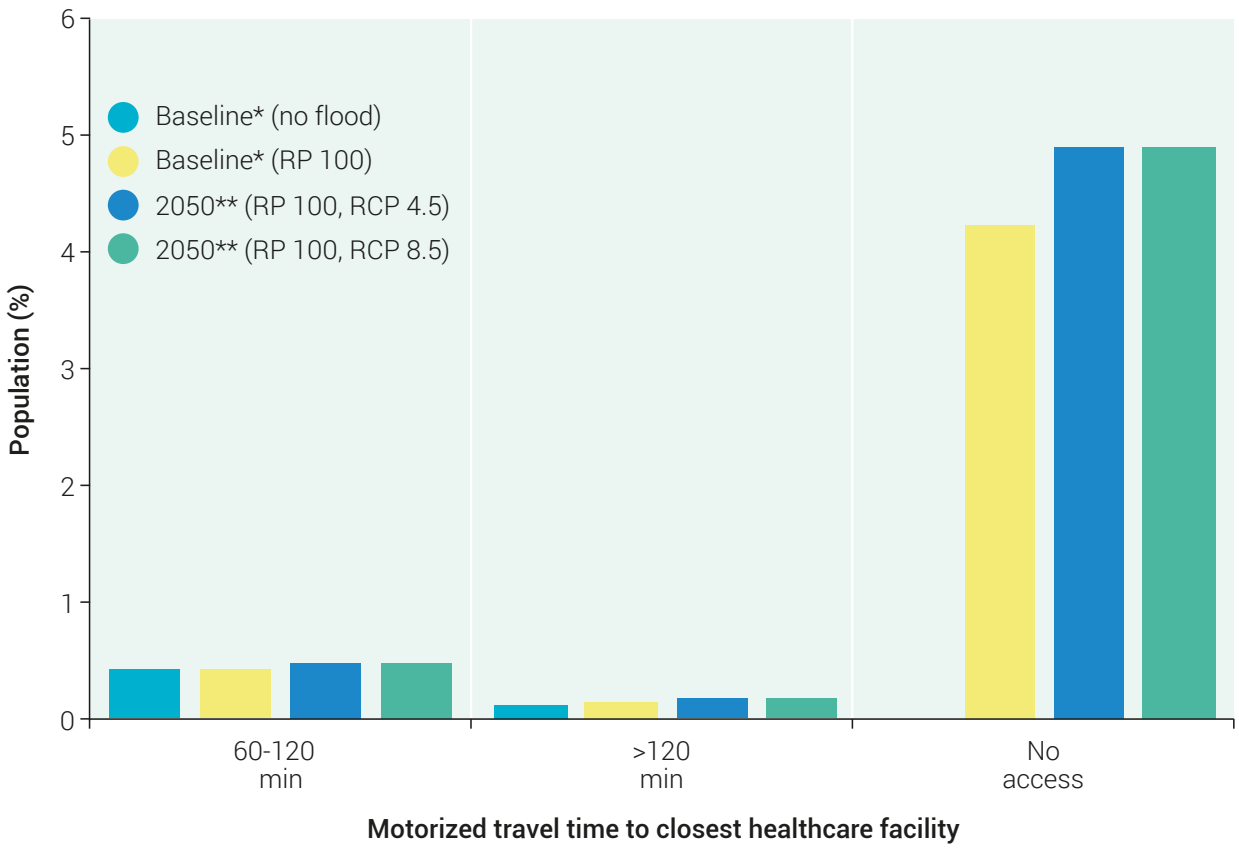
In Nigeria, an estimated 3.91% (~8 million people) of the population currently require more than one hour of walking time to reach the nearest healthcare facility (Weiss et al., 2020). During a 1-in-100-year flood event, this proportion increases to 5.08% (~10.5 million people). Under projected climate change conditions, this figure is expected to rise by an additional 0.92% and 1.01% of the population by 2050 under RCP4.5 and RCP 8.5 scenarios, respectively (Table A4). Accounting for population growth, this represents approximately 2.4 million and 2.65 million additional people with limited healthcare access, with particularly severe impacts anticipated in the North Central and North East regions (Figure 5). Notably, a 1-in-100-year flood event could completely block access to the nearest healthcare centre for about 1.09% (~2.2 million), 1.48% (~3.9 million), and 1.57% (~4.1 million) of the population under the baseline, 2050 RCP4.5, and RCP8.5 scenarios, respectively (Figure 6, Table A4).



Note: *Using a 2020 population with a total of 208,252,500; **Using a 2030 population with a total of 262,490,500.

Figure 6. Impact of fluvial flooding scenarios on walking times to the nearest healthcare facility in Nigeria combining Aqueduct fluvial flood models with the travel time analysis of Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 202).

With respect to motorised travel times to the nearest healthcare facility, 0.51% (~1 million people) of the population currently require more than 60 minutes, a figure projected to increase to 5.51% under a 1-in-100-year flood event in 2050 (RCP 4.5) (Table A5, Figure 7). In particular, the share of the population with no access during a 1-in-100 year flood event is expected to rise from 4.22% (~8.8 million people) under baseline conditions to 4.87% (~12.8 million people) by 2050, when accounting for population growth under both RCP 4.5 and RCP 8.5 scenarios. The South, North Central, and North East regions are projected to experience the most severe disruptions (Figure 8).



Note: *Using a 2020 population with a total of 208,252,500; **Using a 2030 population with a total of 262,490,500.

Figure 7. Impact of fluvial flooding scenarios on motorised travel times to the nearest healthcare facility using Aqueduct flood models combined with the travel time analysis from Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020.

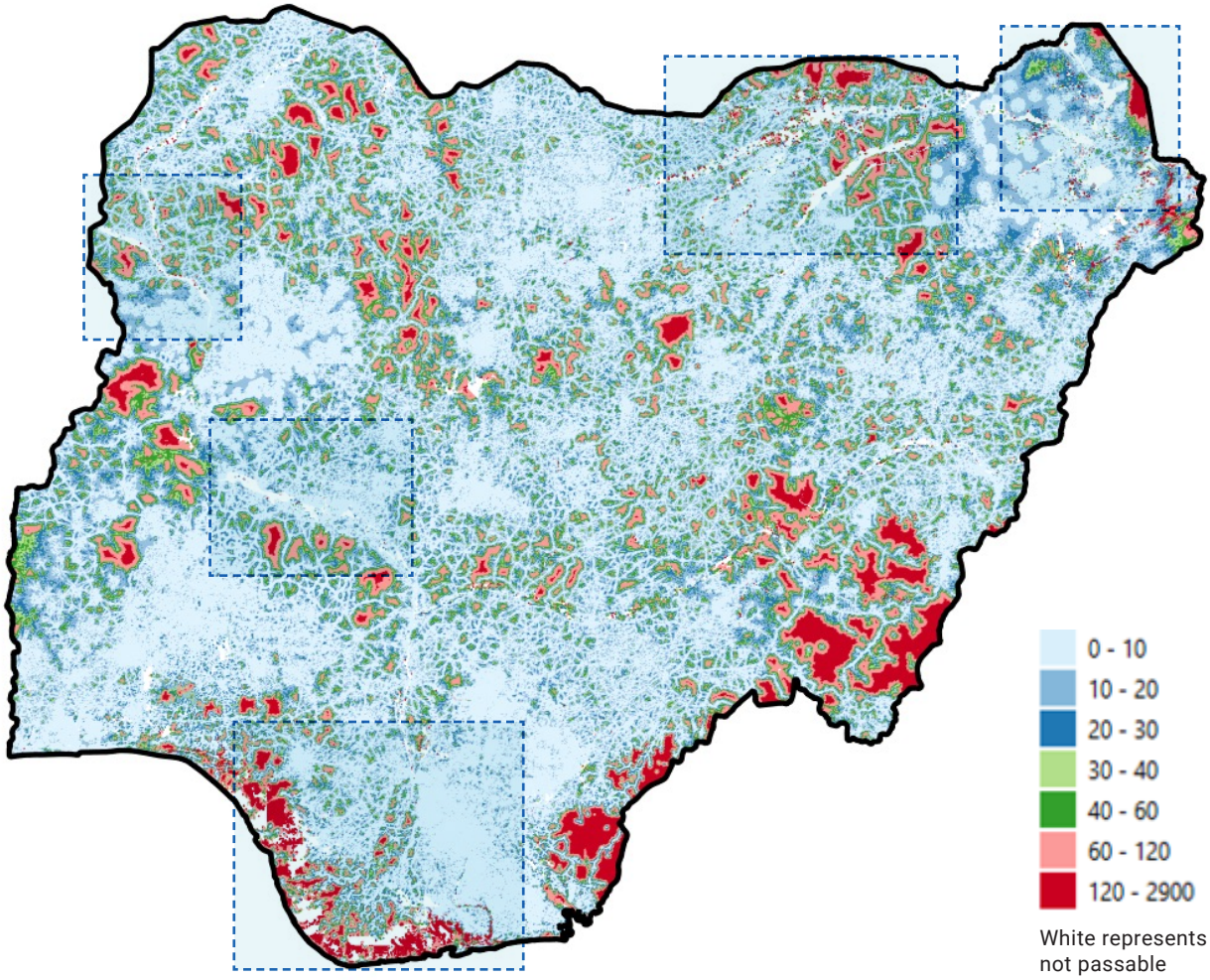


Figure 8. Motorised travel times (minutes) to health facilities for RCP 4.5 scenario (2050, RP 100 flood) using Aqueduct fluvial flood models combined with the travel time analysis from Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020.

Box 1: Case Study – Sokoto, Nigeria. Where is a climate shock likely to have the greatest impact on the users?

Climate shocks (**heatwaves, flooding, wildfire**) threaten the continuity of healthcare services, while exacerbating health issues in Sokoto, Nigeria. In wards exposed to **multiple climate hazards**, this analysis examines indicators of **healthcare demand** and identifies where **access to care is structurally most fragile** under conditions of disruption in order to determine which populations are likely to be most affected.

Projected climate hazards in Sokoto State (RCP 4.5, 2041-2060)

Temperature
-Mean increase of 1.4 °C.
-75 additional warm spell days.
Peak daily temperature up to 46°C.

Wildfires
High to very high hazard.

Flooded wards
RP 100 pluvial flood, 25 facilities at medium risk (0.21-0.60 m, 13 facilities at high risk (>0.6 m).

Increased demand*

Heat related illness
35-40°C: +15-25% prevalence of heat stress, dehydration and skin irritation.
41-47°C: +40-60% prevalence of heat exhaustion and cognitive impairment.
Exacerbated with high relative humidity risk in August and September.

Wildfire related illness
Smoke and reduced air quality during the fire season contribute to respiratory symptoms and exacerbation of existing conditions.

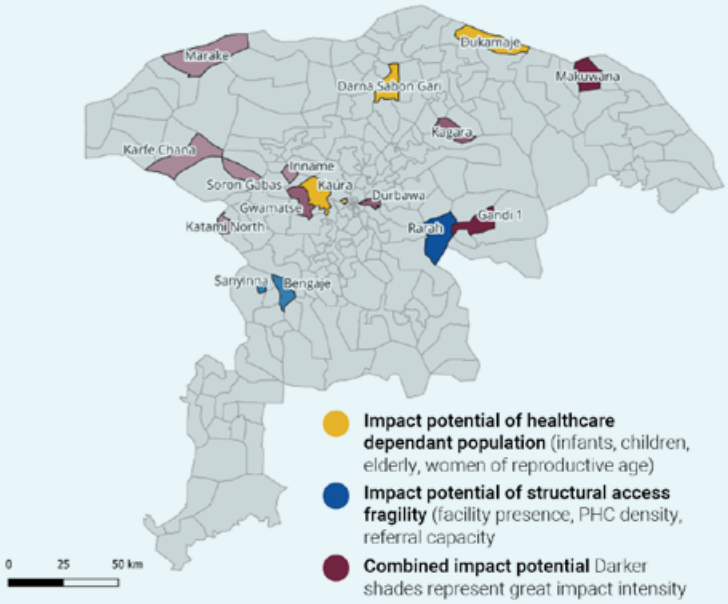
Floodwater
increases prevalence of waterborne illnesses, and injury from debris.

Reduced supply

Flood events
disrupt health services, road access and cold chain functionality.

*Greater demand expected from vulnerable health groups (infants, children, women of reproductive age, obese, elderly).

Results indicate wards which are most vulnerable during a climate shock (dark burgundy)



1. Wards such as **Gandi 1 (Rabah)** and Makuwana (Sabon Birni) emerge as the most critical, as they combine **large populations with elevated health care needs, limited service density, and weak access redundancy.**

2.Other wards, including **Dukamaje (Gada)** and **Kaura (Wamakko)**, also face elevated risk due to the **scale of demand placed on the health system**, even where access conditions are relatively stronger. These vulnerabilities are further amplified by **broader security dynamics and cross-border mobility**, which can constrain service delivery and increase pressure on already stretched facilities.

Together, these factors indicate wards where the combination of high population health care needs, fragile access, and external stressors could contribute to heightened impact during a climate shock, providing a useful basis for consideration in **resilience planning and health system strengthening**.

GCA/GlobalCad analysis; WHO (2018); Romanello et al. (2022); IPCC (2022)

03

Status quo of health system adaptation

Status quo of health system adaptation

3.1 Current standards, tools, and guidelines for climate change adaptation of health systems

International standards play a critical role in strengthening the quality, safety, and performance of healthcare systems. Key healthcare standards include the healthcare organisation management standard (ISO 7101:2023) which establishes comprehensive requirements for governance, leadership, strategic planning, risk management, quality assurance, and the delivery of patient-centred care. Similarly, the quality management systems standard for healthcare (EN 15224:2016), which is derived from ISO 9001, emphasises systematic risk management and the promotion of patient safety within clinical processes. In addition, a range of standards address the management of cold chains, including ISO 23412:2020, ISO 13485, ISO 21973:2020, ISO 9001, and ISO 13408, which collectively provide frameworks for the safe transport, storage, and handling of temperature-sensitive equipment, biological samples, pharmaceuticals, and vaccines (Table 2).

However, there are no international standards dedicated specifically to climate resilient healthcare systems, which are distinct, complex and high risk. Existing standards that incorporate elements of climate resilience tend to address related aspects of healthcare facilities. These include organisational resilience (ISO 22316:2017), business continuity management (ISO 22301:2019), environmental management (ISO 14001), and occupational health and safety (ISO 45001:2018). A series of ISO standards dedicated to climate change adaptation (ISO 14090:2019, ISO 14091:2021, and ISO 14092:2020), collectively provide a comprehensive framework for managing climate resilience; however, their guidance remains largely generic. These standards encompass high-level adaptation planning (ISO 14090), methodologies for climate risk and vulnerability assessment (ISO 14091), and guidance for developing local adaptation plans (ISO 14092). The standard most relevant concerning infrastructure resilience, ISO/FDIS 22372, is currently under development; however, it does not provide healthcare specific requirements and therefore lacks the necessary detail to guide climate resilience within this sector.

Table 2. International standards for healthcare and climate resilience

Healthcare specific standards	
EN 15224:2016 (BSI, 2016)	Quality management systems for healthcare
ISO 13485:2016 (ISO, 2016)	Medical devices quality management systems
ISO 21973:2020 (ISO, 2020a)	Biotechnology transportation
ISO 23412:2020 (ISO, 2020b)	Indirect, temperature-controlled refrigerated delivery services
ISO 7101:2023 (ISO, 2023a)	Healthcare Organization Management
ISO 13408 series (ISO, 2023b)	Aseptic processing of healthcare products
Standards with climate resilience	
ISO 14001:2015 (ISO, 2015)	Environmental management systems
ISO 22316:2017 (ISO, 2017)	Organisational resilience
ISO 45001:2018 (ISO, 2018)	Occupational health and safety systems
ISO 22301:2019 (ISO, 2019b)	Business continuity management systems
ISO 14090:2019 (ISO, 2019a)	Adaptation to climate change: Principles, requirements and guidelines
ISO 14092:2020 (ISO, 2020c)	Adaptation to climate change: Adaptation planning for local governments and communities
ISO 14091:2021 (ISO, 2021)	Adaptation to climate change: Guidelines on vulnerability, impacts and risk assessment
ISO 22372:2025 (ISO, 2025)	Guidelines for infrastructure resilience

Although formal standards for climate resilient health systems have not yet been established, a range of recommendations are available through existing tools and guidelines, predominantly published by the World Health Organization (WHO) (Table A6). These include a step-by-step framework for countries to develop Health Adaptation Plans (HAPs) in response to climate change (WHO 2014), and an operational framework guiding health systems to prepare for, respond to, and adapt to health risks through ten key components (WHO, 2015). This was updated in 2022, with specific indicators to assist countries and health authorities in measuring, monitoring, and strengthening the climate resilience of their health systems (WHO, 2022). At the facility level, the WHO provides a framework to help healthcare facilities prepare for, respond to, and recover from climate-related impacts while minimising their environmental footprint (WHO, 2020). Practical tools, such as checklists, enable managers, planners, and policymakers to identify vulnerabilities, assess risks, and address resilience gaps within health facilities (WHO, 2021). Most recently, WHO guidance emphasises making healthcare facilities safe, climate-resilient, and environmentally sustainable, with a particular focus on supporting universal health coverage and high-quality care (WHO, 2025).

In addition to the WHO's publications which address healthcare resilience globally, a number of regional and national initiatives have also been developed (Table A6). In Canada, resources provide a roadmap for designing, constructing, and operating health facilities capable of withstanding current and future climate challenges, alongside tools, data sources, and case examples to assess and address health impacts through vulnerability and adaptation (V&A) assessments (GreenCare, 2024; Health Canada, 2022). In the United States, guidance emphasises cross-sector collaboration for climate change adaptation planning and offers practical tools to strengthen healthcare organisations' capacity to withstand and recover from climate-related hazards through risk assessment, community engagement, and coordinated planning (CDC, 2024; Guenther et al., 2025). In Europe, system-wide approaches combine adaptation and decarbonisation to help health systems prepare for, respond to, and mitigate climate change impacts, illustrated with practical case studies (HCWH Europe, 2024). Resources tailored for low- and middle-income settings provide methods to identify and address climate and health vulnerabilities, assess risks, and implement context-appropriate resilience solutions for health facilities (CAA, 2025). This toolkit provides a comprehensive six-stage approach, piloted in rural primary healthcare networks in South Africa and a hospital in Chad. It addresses key themes including resilient infrastructure, supply chains, energy, water and sanitation, health service delivery, workforce, disaster planning, and governance.

Existing guidelines and standards offer decision-makers practical frameworks and indices for assessment; however, a gap remains between their development and effective implementation. This gap is influenced by factors such as the practical feasibility and contextual relevance of the guidelines (e.g., availability of resources), the level of training and awareness among practitioners, and the strength of governance mechanisms (WHO, 2010). While the guidelines generally reflect a systems-based approach and encourage cross-sector collaboration, they have gaps. For example, they do not comprehensively consider the vulnerabilities of the healthcare system and its dependencies on sub-systems, including the population's ability to access healthcare, and on supporting systems, and often remain asset-centric, concentrating on the assessment of physical climate risks at the level of individual facilities, such as hospitals. Although these analyses provide valuable insights, they often overlook the systemic nature of healthcare and its interdependencies with supporting systems—including water, energy, waste management, digital infrastructure, transport, and service access. As a result, they may not fully capture the breadth of vulnerabilities, the potential magnitude of associated risks, or the full range of benefits that could be achieved through targeted adaptation interventions, and, thus, may not identify the right adaptation needs, options and priorities.

3.2. Status of climate change adaptation of health systems in Africa

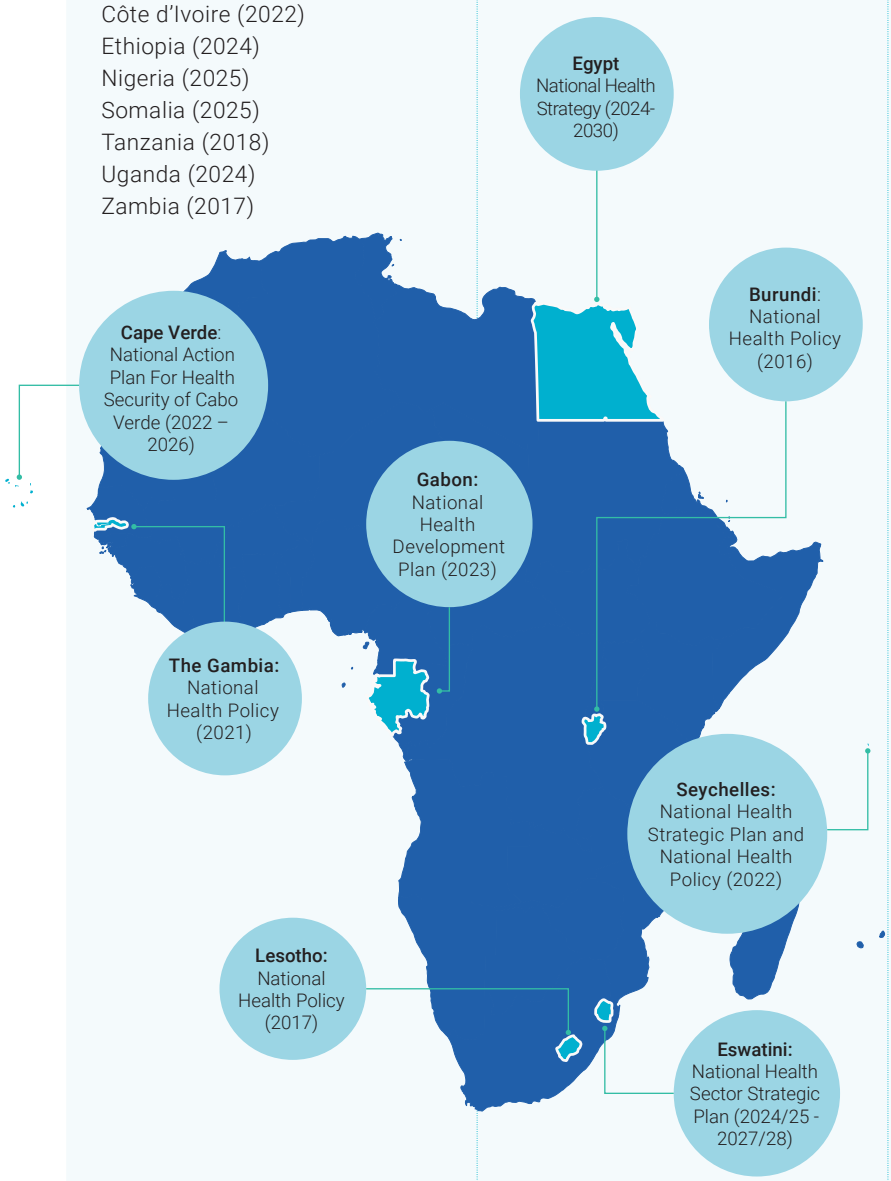
Efforts to build health system resilience are anchored in the UNFCCC process on the Global Goal on Adaptation, which has been established in the Paris Agreement. It aims at "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development" (UN, 2015). Health has been established as one of the key areas in which countries need to build resilience. Already since 2010, alongside the United Nations Framework Convention on Climate Change (UNFCCC) National Adaptation Plan (NAP) process, health has received a dedicated adaptation plan in the form of Health National Adaptation Plans (HNAPs) (WHO, 2025a). Within the Global Goal on Adaptation Framework of the Glasgow–Sharm el-Sheikh work programme, health was defined as one of the core pillars of climate change adaptation, calling for "Attaining resilience against climate change related health impacts, promoting climate-resilient health services, and significantly reducing climate-related morbidity and mortality, particularly in the most vulnerable communities" (UNFCCC, 2023).

Africa remains in the early stages of implementing health and climate change adaptation policy instruments. Currently, only eight African countries have published (HNAPs), with others in the drafting stage. In addition, nine have developed sectoral national health plans that integrate adaptation

measures, while 66% reference health in their NAPs / Nationally Determined Contributions (NDCs) under the UNFCCC (Table 3). Overall, the proportion for Health (18%) is lower than that observed in other sectors such as Agriculture and Water comprising 34% and 20% of sectoral plans respectively (GCA, 2025b). However, health system strengthening has also been demonstrated indirectly through resilience in other sectors. Countries such as Madagascar and Côte d'Ivoire are implementing reforms that stabilise electricity, water, sanitation, and fiscal transfers, they are reinforcing the foundational systems that connect climate change adaptation policy to human wellbeing. These same systems (i.e., energy reliability, WASH, and social protection) are equally vital for pandemic preparedness, ensuring that hospitals, disease surveillance units, and emergency response facilities remain operational during periods of acute stress (GCA, 2026).

Table 3. Summary African Countries with Health and Adaptation Policy Instruments

Health National Adaptation Plans	Sectoral Health Plan with Adaptation Considerations	Health in NAPs / NDCs
Cape Verde (2023) Côte d'Ivoire (2022) Ethiopia (2024) Nigeria (2025) Somalia (2025) Tanzania (2018) Uganda (2024) Zambia (2017)		Algeria (2015) Angola (2021) Benin (2022) Burkina Faso (2021) Cape Verde (2025) Cameroon (2021) Central African Republic (2021) Comoros (2021) Congo (2021) Democratic Republic of the Congo (2021-2025) Eritrea (2022) Eswatini (2025) Ethiopia (2025) Ghana (2021) Kenya (2025) Lesotho (2017) Liberia (2015) Madagascar (2022) Malawi (2021) Mauritania (2025) Mauritius (2025) Morocco (2025) Mozambique (2023) Namibia (2030) Niger (2021) Nigeria (2025) Rwanda (2035) Senegal (2020) Seychelles (2025) Somalia (2025) South Africa (2025) Sudan (2016) Togo (2018) Tunisia (2025) Uganda (2022) Tanzania (2021) Zambia (2025)



In addition, existing health and adaptation policy instruments (Table 3) demonstrate significant gaps in recognising healthcare as a holistic system. When screening the policy documents of Table 3, for keywords and phrases associated with health system resilience (identified by the standards, guidelines and systemic failures from previous events), such as 'infrastructure', 'staff', 'workers', 'access', 'supporting systems', 'water', 'electricity', 'sewage', 'digital', 'road', 'adaptation' and 'cross-sectoral' , approximately 26% do not reference health infrastructure, 43% do not mention health staff, 45% omit access to healthcare, 60% do not acknowledge supporting systems, 69% exclude adaptation for supporting systems, and 43% do not address cross-sectoral collaboration. However, some countries, mention all key themes such as Cape Verde, Ethiopia, Nigeria, Somalia and Zambia, in one or more of their policy documents. Nigeria is leading the way by integrating the full set of themes into both its recently issued HNAP and its 2025 NDC. This level of policy alignment is particularly important for ensuring that the government's US$ 2.2 billion commitment to strengthening the national health system is undertaken in a manner that enhances climate resilience, especially given Nigeria's high vulnerability to climate-related risks as emphasised in the previous chapter (Ufoh, 2025).

Although policy frameworks remain relatively underdeveloped, Africa's climate health agenda is gaining momentum through increased investment. In May 2024, (amref health africa, 2024) at the 77th WHO World Health Assembly, a resolution was passed for climate resilient health systems in Africa through greater investment in data, research and early warning signs. In September 2024 (WHO, 2025b), over 80 health and climate experts met in Senegal for the 5th Clim-HEALTH Africa meeting. They endorsed a five-year strategic plan for the African region with the aim to build resilient and sustainable health systems that will integrate climate change adaptation into national health planning. In April 2025 (WHO, 2025c), eight Southern African countries (Botswana, Lesotho, Madagascar, Malawi, Mozambique, Namibia, South Africa, Zimbabwe) launched a US$ 35 million, 3-year programme supported by the WHO and the Pandemic Fund. It focuses on early warning & disease surveillance systems; strengthening laboratory diagnostics; building a skilled public health workforce, establishing a Climate-Health Observatory for cross-border risk tracking. Following this in July 2025, the African Centre for Disease Control (CDC) launched a five-year strategic framework, aimed to enhance the resilience of health systems, advance disease surveillance, and promote sustainable public health outcomes across Africa in the context of climate change. The total budget is estimated at US$ 482,494,500, allocated across six pillars. The largest proportions of funding are directed towards Public Health Emergency and Disaster Response (25.18%) and National Health System Strengthening mechanisms (20.73%). Such initiatives remain largely focused on climate change and disease prevalence, with a low proportion of funding allocated to strengthening health system resilience.

At the national level, the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR), supported eight African countries since 2023 (Ameh et al., 2021), in advancing health system resilience through application of the Frontline Scorecard tool (Tariverdi et al., 2024). Success stories include the retrofitting of 50 health facilities in Mauritania to withstand flooding by 2028 and the integration of a climate risk assessment of the primary healthcare upgrade in Sudan.

04

New approaches in addressing health system vulnerability

New approaches in addressing health system vulnerability

Two novel frameworks provide the conceptual basis for deriving vulnerabilities in the health system, adaptation solutions, and actionable recommendations for achieving climate resilient health systems. Health system resilience is a holistic concept. In this sense, it is defined as the "capacity of health actors, institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learnt during the crisis, reorganise if conditions require it" (Kruk et al., 2017, p. 1). Access to healthcare is essential for a functioning and resilient healthcare system. If healthcare is not accessible to the population seeking care, the main function – to deliver healthcare – of a health system cannot be fulfilled. Access is therefore a central metric for the performance of healthcare systems (Levesque et al., 2013, p. 1).

The two approaches therefore provide a systematic way of identifying vulnerabilities, deterioration, disruption and system failures, and offer guidance on how to improve the ability of health systems to prepare for, respond to, maintain and reorganise in the face of climate risks. To achieve this, the approaches address health system vulnerabilities and adaptation options from two different perspectives (Table 4):

Table 4. Perspectives and approaches to health system resilience

Perspective	Approach
Perspective of healthcare service provision, comprising healthcare facilities, healthcare assets, the healthcare value chain, and supporting systems	Healthcare systems-of-systems approach
Perspective of sustained access to healthcare for patients, the population, and vulnerable groups	Integrated framework of health system resilience and climate change

Figure 9 illustrates why assessing both frameworks together enables readers to gain a comprehensive understanding of vulnerabilities and adaptation options, to achieve sustained value chains, healthcare access and services.

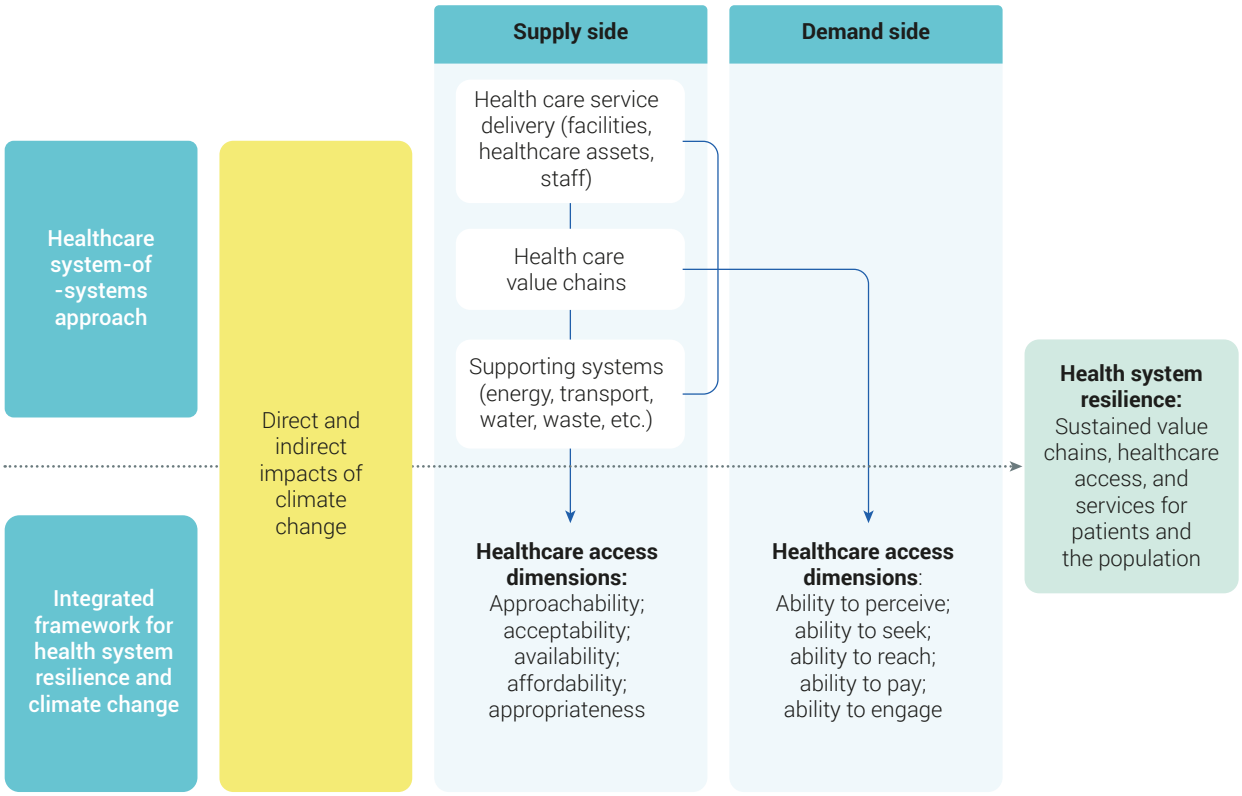


Figure 9. Conceptual approaches towards sustained healthcare access in the context of climate change

The "Integrated framework of health system resilience and climate change" (section 3.1) roots in the main idea what dimensions – at the supply and demand side – influence and constitute access to health care. For each dimension, it is assessed how it is or could be impacted by climate change and what adaption options respond to these impacts. The approach characterises the health system as a dynamic system, including all actors of a health system from patients to doctors, going through a continuous resilience process.

The "Healthcare system-of-systems approach to vulnerability and adaptation" (section 3.2) applies a different lens of the health system resilience. It frames the health care system as part of a system-of-systems, being a collection of multiple independent systems that form part of a larger, more complex system that are interconnected and depend on each other. Grounding this definition, the healthcare system-of-systems can be considered to contain the healthcare system, as well as the energy, transport, water, waste management and digital communications systems on which the healthcare system depends. Thus, to function properly, health systems depend heavily on other economic and social systems, called supporting systems.

By combining the two perspectives – healthcare provision and access to healthcare – it is possible to understand systemic vulnerabilities and prioritise a robust set of adaptation options for the health system in order to achieve climate-resilient value chains, healthcare services, and access to healthcare.

4.1. Sustaining and improving access to healthcare in the context of climate change

The integrative framework on health system resilience and climate change by Ridde et al. (2025) thoroughly assesses the dimensions relevant to health care access by considering the resilience process. Health care access is thereby understood as the opportunity to have healthcare needs fulfilled distinguishing between the accessibility of healthcare providers, organisations, institutions, and systems (supply-side factors), and the ability of populations, communities, households, and individuals to access healthcare provision (demand-side factors) (Levesque et al., 2013). The approach is based on the seminal framework presented by Levesque et al. (2013) that has been widely adopted in academia and practice (Cu et al., 2021). The usefulness of this approach lies in its relative simplicity and measurability: Alongside the process from healthcare needs to healthcare consequences (e.g., reestablished health), five demand-side dimensions and five supply-side dimensions have been identified.

The integrative framework fundamentally takes health system resilience into consideration in the context of climate change. It integrates dynamic changes to the health system and health system access due to climate change and reactions of the health system and the population. Thus, the population is perceived as an active participant of the health system through their access to and demand of healthcare services. Following the framework, climate hazards lead to disruptive events at the demand and the supply side. Thereby, the health system (supply side) – as well as the responses of the population (demand side) – are dynamic:

- Disruptive events lead to dynamic changes of the health system, which comprise the stages of pro-active adaptation strategies, deterioration, (partial) failure, recovery, and improvement, through the process of resilience. The process of resilience itself is influenced by the exposure, sensitivity, and capacity to adapt to climate hazards.

- Consequently, the health system is in a continuous process of adapting to climate-related stressors and disruptive events following formal (e.g., changes in infrastructure of procedures) and informal (i.e., situational flexibility) adaptation pathways. The ability of the system to adapt and the level of health system resilience impacts healthcare accessibility, and ultimately population health and socio-ecological outcomes.

- The same continuous process applies to the population, who also adapts to climate change-related stressors and disruptive events and, secondary, adapts to changes in health service provision. The ability of the population to adapt depends on their mobility, certain socio-economic characteristics that reduce sensitivity (e.g., health literacy, personal and social values, and income) and their ability to access healthcare.

Figure 10 gives an overview of the integrative conceptual framework of access to healthcare in the context of climate change developed by Ridde et al. (2025).

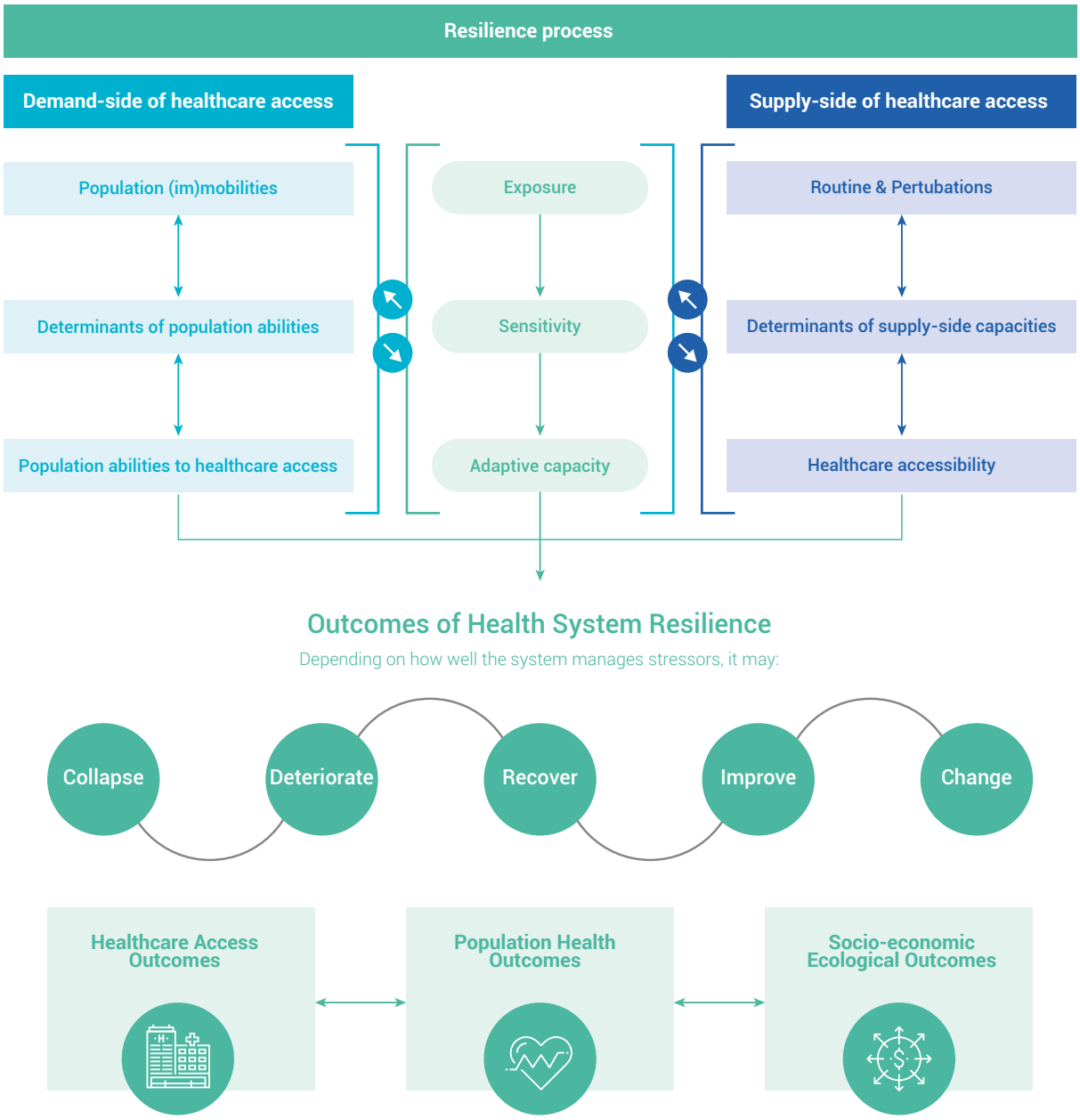


Figure 10. Integrative conceptual framework of access to healthcare in the context of climate change. Source: Ridde et al. (2025)

The integrative framework brings together the population (demand-side of healthcare access) – on the left side of the figure – and health service provision (supply-side of healthcare access) – on the right side of the figure. It lays the foundation for systematically assessing access to healthcare in the light of climate change. Applying this approach, the demand side and the supply side of healthcare is assessed with regard to their specific vulnerability and barriers for healthcare access. Based on this, suitable adaptation options are derived and presented.

4.1.1. How can we adapt the demand side of healthcare access?

Figure 11 shows the determinants of health system resilience at the demand side. In the discussion of vulnerabilities and adaptation options of the health system, the presentation systematically follows the framework from "Immobility situations", over "Socio-economic characteristics", through to the five access dimensions of the framework: "Ability to perceive", "Ability to seek", "Ability to reach", "Ability to pay", and "Ability to engage".

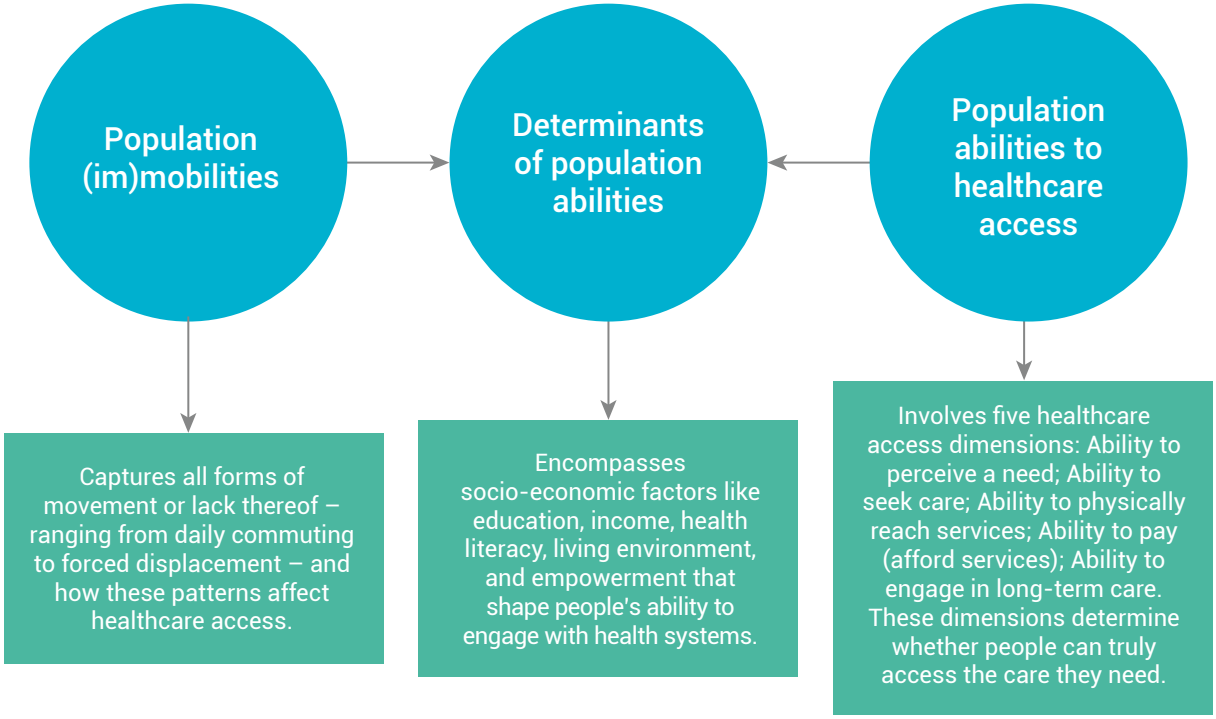


Figure 11. Demand-side determinants of health system resilience. Source: Ridde et al. (2025)

Immobility situations: Immobility of individuals and households leads to the fact that they cannot remove themselves from the direct or indirect exposure of climate hazards. Reducing direct exposure means that the subjects move, displace or migrate into an area which is not or less exposed to climate hazards or the (current or potential) impact of hazards. Reducing indirect exposure, in the context of this Adaptation Insights, means that the subject responds to disrupted health infrastructure and access to healthcare through human mobility, for instance by temporarily moving to an urban centre. If the individual or household removes itself permanently from the exposure, it is often referred to as transformative risk management (Leppert et al., 2021). This, for example, is if the households permanently move to another location or country where better healthcare access is expected. Other more temporary adaptation options comprise local relocation sites or emergency shelters with the availability of healthcare services. Mobility itself can also be improved by providing mobility or relocation services for immobile people during extreme weather events or natural disasters.

Socio-economic characteristics: Socio-economic characteristics refer to determinants of population abilities to access healthcare, such as health literacy, trust in healthcare providers, social support, income, health insurance, and empowerment. Although these are general characteristics of socio-economic development, they are as relevant in the context of climate change as they constitute the basis for the adaptive capacity of the population. Adaptation options, therefore, predominantly, refer to climate change adaptation measures needed beyond the health sector to strengthen these characteristics.

Ability to perceive: The dimension refers to whether the population perceives the need for healthcare. It is determined by "factors such as health literacy, knowledge about health and beliefs related to health and sickness" (Levesque et al., 2013). Climate hazards change the patterns of disease, for which the population may not be sufficiently sensitised. For instance, during times of extreme heat and heat waves, the risk of heat exhaustion or heat stroke increases, as do certain diseases linked to sun exposure, such as photogenodermatoses. When flooding occurs, water-borne diseases, such as cough, diarrhoea or cholera, or water related diseases such as malaria, pose a higher risk (Diallo & Ridde, 2024). Therefore, adaptation option include sensitisation for changes in health risks and early signal for the need to seek healthcare.

Ability to seek: This dimension refers to the "personal autonomy and capacity to choose to seek care, knowledge about healthcare options and individuals' rights that would determine expressing the intention to obtain healthcare" (Levesque et al., 2013). As the ability to seek is a more general dimension, deeply rooted in local culture, climate change related disruptions may change the autonomy and capacity to choose disproportionally to the disadvantage of vulnerable groups, such as women, children, elderly, and indigents. Therefore, health sector adaptation requires affirmative actions for those vulnerable groups whose ability to seek is already under pressure in normal times and worsened in the context of climate change.

Ability to reach: This dimension means the "personal mobility and availability of transportation, occupational flexibility, and knowledge about health services that would enable one person to physically reach service providers" (Levesque et al., 2013). The 'ability to reach' may be limited, for example, through the flooding of road infrastructure. Extreme weather conditions and climate-related natural disasters may result in (a) reduced personal mobility and the nonavailability of functioning transportation, in (b) decreased physical access to healthcare providers, and (c) in heightened healthcare needs. As pointed out in our geographic assessment of climate risks on a country's health system (chapter 2), travel time to facilities is an important factor of healthcare access in times of climate-related infrastructure disruptions. Such time-related elements of access have also found important by the analysis of Cu et al. (2021). Adaptation options therefore include organised transportation (e.g., buses or four-wheel drive vehicles) from settlements to healthcare facilities during such events. Adaptation options also include adapted labour regulations for climate events to strengthen the right of employees to seek healthcare when they need care.

Ability to pay: The ability to pay refers to "the capacity to generate economic resources […] to pay for healthcare services without catastrophic expenditure of resources required for basic necessities" (Levesque et al., 2013). Although, the ability to pay is a general concern in most healthcare financing systems, challenges increase during climate events. First, the population might lack immediate income earning possibilities during extreme weather events or natural disasters as opportunity costs increase of spending the available resources. Second, access to existing resources might be limited as a result of dysfunctional finance systems (e.g., banks or ATMs) and health insurance schemes. Third, lower capacities of healthcare facilities and reduced availability of essential medicine or medical aids as a result of climatic shocks may increase prices and, thus, further reduce the ability to pay. Adaptation options therefore need to include that strengthen equitable access, such as flexible payment systems at the point of service, the provision of emergency treatment at no cost, guaranteed acceptance of health insurance membership during climate events, and regulations to avoid excess pricing and black market trading of medicine and medical aids.

Ability to engage: The ability to engage relates "to the participation and involvement of the client in decision-making and treatment decisions" (Levesque et al., 2013). Participation and involvement of the client in treatment decisions is of heightened important in times of climate events, particularly when the facility decides to prioritise certain cases or treatments (e.g., triage), and when there is no or limited availability of certain treatments. Participation of the patient in such situations is essential

so that the patient can take informed decisions. This includes establishing a patient-centred approach to the treatment process in times of climate events. The development of proactive strategies about treatment protocols and processes, prioritisation, and ethical decisions requires the participation of communities in health system governance. Community governance is of particular importance considering the operation of the health system under conditions of scarcity and reduced capacity.

Table 5 gives an overview of adaptation options at the demand side following the application of the integrative framework of health system resilience by Ridde et al. (2025).

Table 5. Adaptation options for the demand side of healthcare access

Demand side factors	Adaptation options
Immobility ("trapped") situations	• Individuals or households (temporarily or permanently) move, displace or migrate into an area which is not or less exposed to climate hazards or the (current or potential) impact of hazards. • Local relocation sites or emergency shelters with the availability of healthcare services. • Provide equitable access to mobility through or relocation or mobility services for immobile people who cannot move and are trapped in a hazard-affected environment.
Socio-economic characteristics	• Climate change adaptation measures and strategies beyond the health sector to strengthen the adaptive capacity of the population, also outside the health sector itself, such as access to clean water, access to finance, food security, and options for income diversification.
Ability to perceive	• Sensitisation for climate change-related increases in health risks and related needs to seek healthcare.
Ability to seek	• Equitable adaptation solutions as part of adaption planning in the health sector aiming at vulnerable groups whose autonomy and capacity to choose, to seek and to navigate healthcare is worsened during climate change related disruptions.
Ability to reach	• Organised transportation (e.g., buses, boats, or four-wheel drive vehicles) from settlements to healthcare facilities during climate events. • Adaptation of labour regulations to strengthen the right of employees to seek care during climate events.
Ability to pay	• Flexible payment systems and subsidised rates at the point of service during crisis that guarantee access to care at times of temporary liquidity constraints, and guaranteed acceptance of health insurance membership during climate events.
Ability to engage	• Information to patients about prioritisations (e.g., triage) of certain cases or treatments about no or limited availability of certain treatments is required to take informed decisions. • Establishment of a patient-centred approach to the treatment process in times of climate events. • Enable community governance for proactive and inclusive strategies about treatment protocols and processes, prioritisation, and ethical decisions, particularly in the consideration of the operation of the health system under conditions of scarcity and reduced capacity.

4.1.2. How can we adapt the supply side of healthcare access?

Figure 12 shows the determinants of health system resilience at the supply side. The framework will be systematically followed in the discussion of vulnerabilities and adaptation options of the health system, from "Supply side capacities" to the five accessibility dimensions of the framework: "Approachability", "Acceptability", "Availability & accommodation", "Affordability", and "Appropriateness".

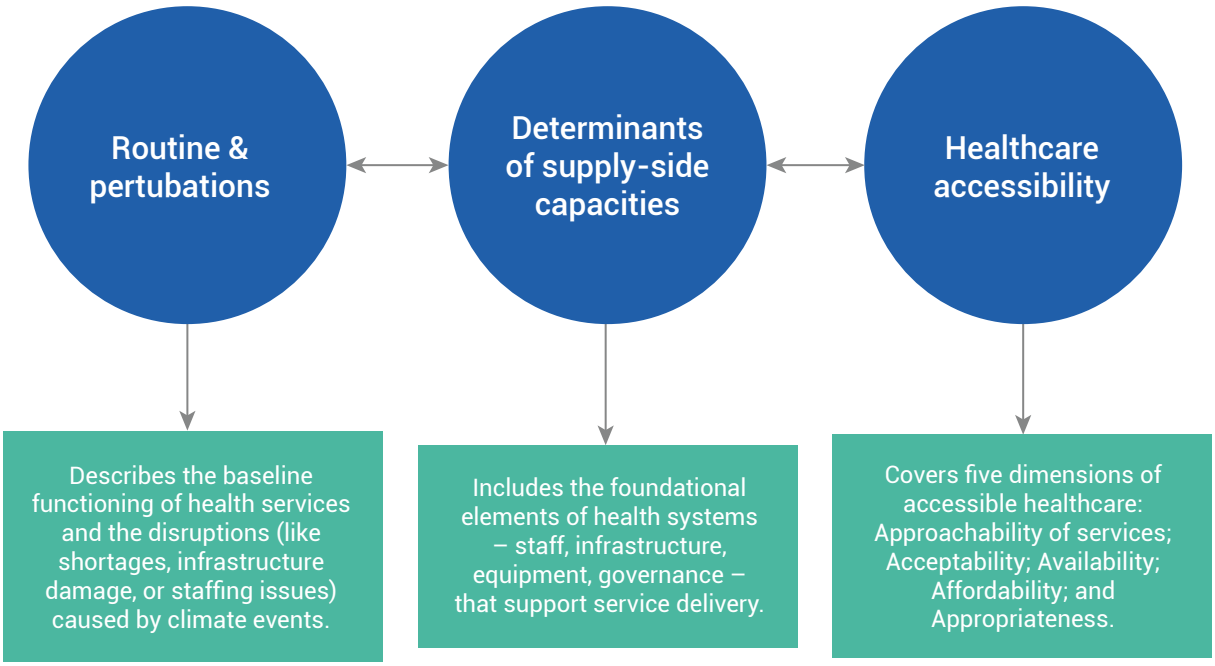
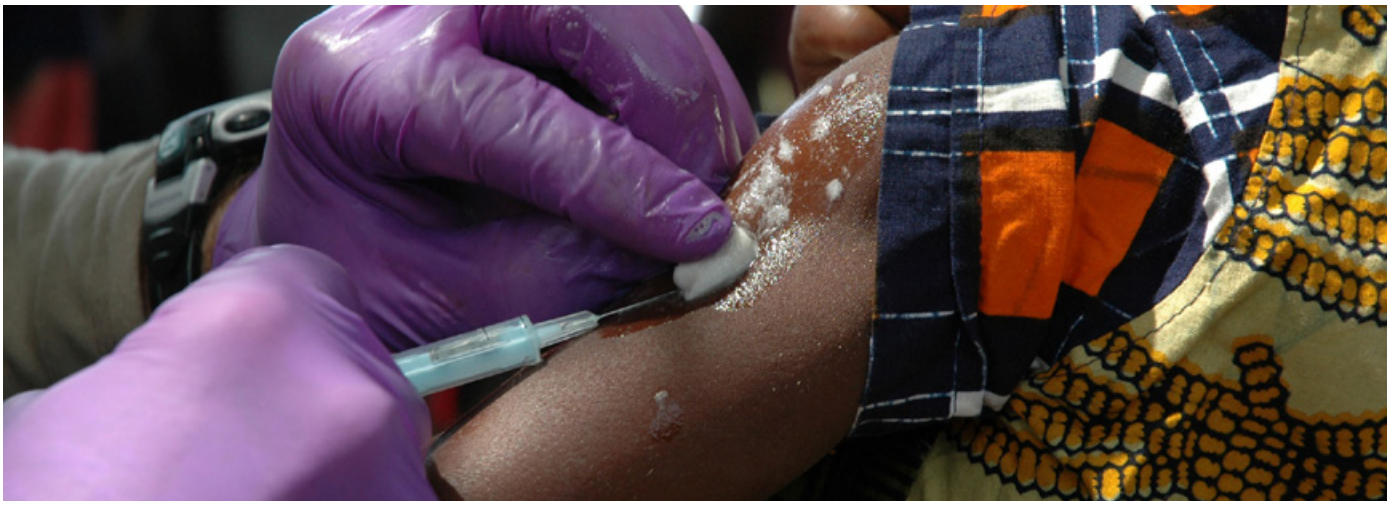


Figure 12. Supply-side determinants of health system resilience. Source: Ridde et al. (2025)

Supply-side capacities: Supply-side capacities are linked to the sensitivity to climate hazards. Overall, an increase of capacities is part of health system strengthening, and generally reduces the sensitivity to hazards and constitutes the basis for the supply side's adaptive capacity. Determinants of supply-side capacities consist of the budgetary situation and resource allocation, the cost structure, the technical and interpersonal quality, or if the building structure is climate-resilient. Against the backdrop of climate change, particularly outstanding determinants seem to be the organisational strength and autonomy of the institution or facility, the technical and interpersonal quality, and the availability of resources in times of crisis. Adaptation options therefore include drills and trainings of staff and improved coordination for extreme weather events and natural disasters, as well as measures to increase the financial and institutional sustainability of healthcare institutions and facilities.

Approachability: Approachability means that the population requiring healthcare "can actually identify that some form of services exists, can be reached, and have an impact on the health" (Levesque et al., 2013). In situations of extreme weather events or natural disasters, barriers of access include that the population might not know which facilities are functioning and providing what services, and which healthcare facilities are reachable. Suitable adaptation options include transparency of the current situation of health service provision and information and outreach activities about available treatments and services.

Acceptability: Acceptability can be understood as "cultural and social factors determining the possibility for people to accept the services" (Levesque et al., 2013). Similarly to the demand-side dimension 'ability to seek', the possibility for people to accept existing services may be disproportionally reduced for vulnerable groups as established standards for creating culturally acceptable conditions



for healthcare may be limited in times of crisis. Adaptation options include an assessment of changes in healthcare service provision during climatic events and natural disasters that may result in cultural and social unacceptability of services for certain groups, and to establish provisional measures to retain acceptability of services.

Availability & accommodation: Availability and accommodation refers to "the fact that health services […] can be reached both physically and in a timely manner" (Levesque et al., 2013). The 'availability and accommodation' can be heavily impacted by climate risks, if, for instance, a facility needs to close due to climate change impacts. Climate change related stressors and extreme weather events may therefore result in inaccessible healthcare facilities at their fixed locations or in longer travel times to reach them. An example is flooding events. As pointed out in chapter 2.2, longer climate-change related travel times or inaccessible facilities due to flooding in Nigeria can be expected. In times of extreme heat, certain times of the day may to be avoided for travelling to and from facilities. Temporary unavailability may happen due to storms or heavy rains, or the consequences thereof such as rubble or blocked roads. Adaptation options include the climate-proofing of roads and transport infrastructure, the establishment of mobile clinics, medical stands, or temporary healthcare facilities in residential areas, the strengthening of community health workers, or changed opening times during climate events, such as during heat waves (Diallo & Ridde, 2024).

Affordability: Affordability means the "economic capacity for people to spend resources and time to use appropriate services" (Levesque et al., 2013). During extreme weather events and climate change related natural disasters, the urgency and need for certain treatments increases. From the individual and public health perspective, it is essential to guarantee the affordability of these healthcare services for the population. Adaptation options therefore include public health emergency funds (either by the healthcare financing provider(s) or the government) and governmental subsidies for high priority treatments during certain climatic conditions and natural disasters.

Appropriateness: Appropriateness means "the fit between services and clients need, its timeliness, the amount of care spent in assessing health problems and determining the correct treatment and the technical and interpersonal quality of the services provided" (Levesque et al., 2013). This dimension may be impacted by climate change when the facility is damaged or staff is absent in times of crisis, delivering healthcare at lower capacity or quality. Healthcare needs and the quantity of required treatments may change through gradual climate change related changes and during extreme weather events and natural disasters, for example an increased level of cutting wounds and physical injuries during cyclones, or higher prevalence of infectious diseases during floods. Adaptation options of the health system therefore require projecting healthcare needs during these climate events and the preparation of inventories (e.g., medical stocks) and health care facilities for such changes, as well as appropriate training for health staff.

Table 6 gives an overview of adaptation options at the supply side following our application of the integrative framework of health system resilience by Ridde et al. (2025).

Table 6. Adaptation options for the supply side of healthcare access

Supply-side factors	Adaptation options
Supply side capacities	• Drills and trainings of staff and improved coordination for extreme weather events and natural disasters. • Measures to increase the financial and institutional sustainability of healthcare institutions and facilities.
Approachability	• Transparency, information, and outreach about availability of facilities and services during extreme weather events or natural disasters.
Acceptability	• Assessment of cultural and social unacceptability of services and service provision for certain (vulnerable) groups in times of climatic events and natural disasters. • Establishment of provisional measures to retain acceptability of services for all groups.
Availability & accommodation	• Climate-proofing of roads and transport infrastructure to improve access to health care facilities. • Health stands, mobile clinics or temporary healthcare facilities in residential areas and emergency shelters. • Establishing or strengthening the system of community health workers. • Changed opening times, e.g., during heat waves, and establishment of an extreme heat surveillance system.
Affordability	• Public health emergency funds for certain treatments during climatic events and natural disasters. • Governmental subsidies for high priority treatments during certain climatic conditions and natural disasters.
Appropriateness	• Projections of healthcare needs through climate-related gradual changes or extreme events. • Preparation of inventories (e.g., medical stocks) and health facilities for climate events. • Appropriate training for health staff for these climate events. • Provision of appropriate support for mental health problems related to climate change and as a result of climate-related disasters for patients and staff.

This section provided an application of a current integrative framework of health system resilience in the context of climate change, that focused on healthcare access as a metric for health for the development of adaptation strategies and policies.

4.2. Healthcare system-of-systems vulnerability and targeted adaptation

The existing approaches insufficiently capture the systemic interdependencies of healthcare systems, thereby underestimating the scope of vulnerabilities, the scale of risks, and the potential gains from integrated adaptation strategies, and, thus, may not identify the right adaptation priorities. A recent GCA and OIA report on conceptualising healthcare as system-of-system (Thacker et al., 2026) highlights how a healthcare system consists of interconnected assets and services, their dependencies, potential systemic vulnerabilities and adaptation options. This assessment, which focuses on the hard (structural/technical) dimension of health systems, elaborates on the perspective of healthcare service provision, comprising interconnected systems, from healthcare facilities, healthcare assets, the healthcare value chain, and supporting systems.

4.2.1. How is a healthcare system interconnected?

A healthcare systems characterisation (Figure 13) centres around 10 healthcare service access points. Some of these services are delivered at buildings, whilst others through transportation modes. Supporting these key service-enabling assets are other assets within the healthcare system including the healthcare materials supply chain (that use storage and transportation assets), as well as healthcare personnel supply (that use housing and transportation assets).

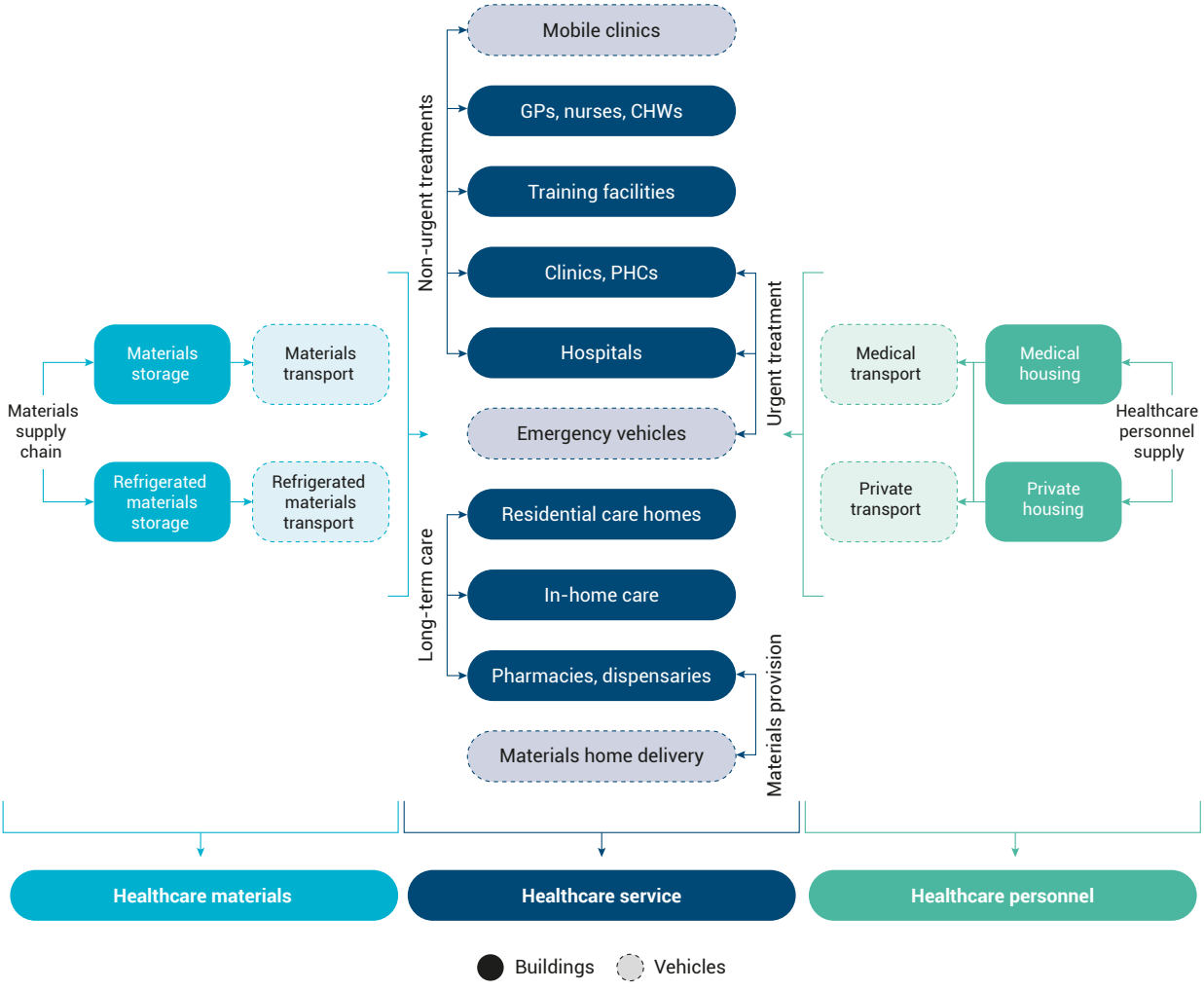
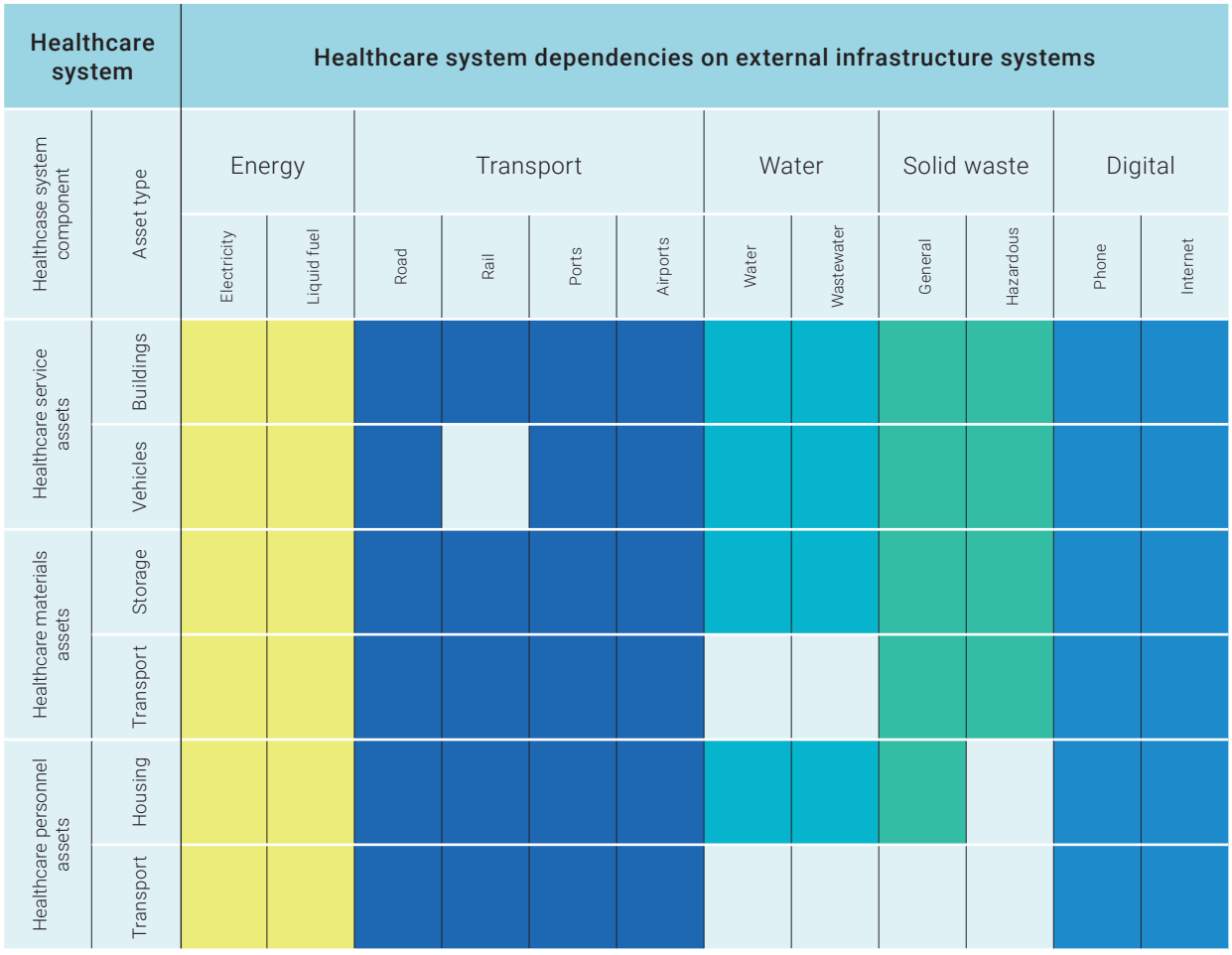


Figure 13. Generalised representation of the healthcare system, including key building and vehicle related assets and their interconnectivity.

4.2.2. What external systems support healthcare assets and services?

The healthcare system is dependent on the services provided by a broad range of external systems. These external services include those derived from infrastructure systems such as energy, transport, water, waste management and digital. Understanding healthcare's systemic vulnerabilities requires expanding analysis from a single system to a system-of-systems perspective, encompassing healthcare and its dependent external infrastructures. Figure 14 maps six key healthcare asset types and their dependencies across twelve infrastructure sub-sectors.



Note: Cell colouring represents where an infrastructure sub-sector has been identified as supporting a healthcare systems asset.

Figure 14. Generalised characterisation of the healthcare systems' dependence on a variety of infrastructure systems – creating a conceptual system-of-systems.

Infrastructure systems also depend on one another to enable their functionality. Figure 15 provides a generalised representation of the healthcare system-of-systems, based on a generalised infrastructure characterisation by (Thacker et al., 2017). At its centre is the healthcare system, with other infrastructure systems surrounding it. Each system is represented a series of interconnected assets that supply services. 3 different edge types (continuous line, dotted lines, and dashed lines) are used to showcase the connectivity within systems, dependencies of the healthcare system on infrastructure systems, and dependencies between different infrastructure systems, respectively. Such as representation provides an indication as to the complex functional relationships between sectors, that can also be considered as points of vulnerability and failure.

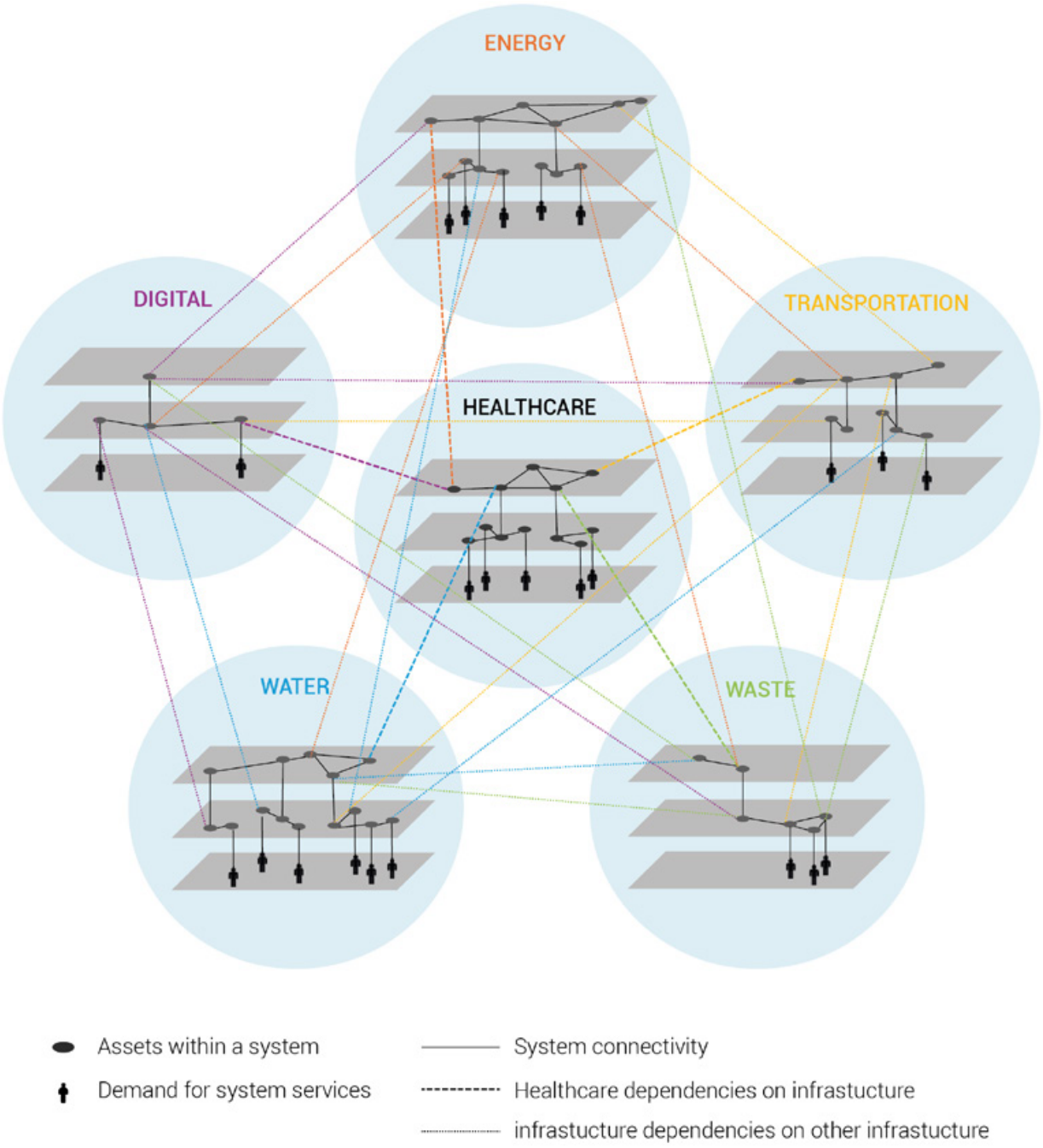


Figure 15. Generalised representation of the healthcare system-of-systems. Adapted from Thacker et al. 2017.

The 12 different sub-sectors also have dependencies on one another for core functionality. This includes where sectoral workforces require electricity, water, wastewater, waste management, digital communications and road transport to support their jobs and keep the sectors in operation. Beyond this, other specialised dependencies exist between sub-sectors, such as supply-chain related dependencies between road, rail, ports, and airports. A further example includes waste and hazardous waste dependencies from multiple sectors – that are due to the use and production of waste through their operation and maintenance.

4.2.3. What are the system climate vulnerabilities?

Connectivity and interdependence enable patients to receive a broad range of services in an array of contexts; it also introduces a multitude of systemic vulnerabilities. Systemic vulnerabilities inherent within the healthcare system-of-systems have the potential to create impacts to healthcare services at the different healthcare service access points. Disruptive events are initialised when a component within the system-of-systems is exposed to a level of intensity from a climate hazard that it cannot withstand. For example, a road asset that cannot withstand flooding of a given depth.

Figure 16 provides a generalised characterisation of the climate hazard vulnerabilities of the healthcare system-of-systems. The figure shows the disruptive potential of flooding (coastal, fluvial and pluvial), wildfires and landslides – which are found to impact all assets within the system-of-system – whether they are located above ground or are buried beneath it. Precipitation is shown to create low and moderate vulnerabilities, with moderate vulnerabilities experienced on assets that rely on road infrastructure (due to precipitation impacting driving), as well as at airports (due to take-off and landing restrictions). Precipitation is one of many drivers of flooding, and the that is considered a different category in the table. In all but the most extreme contexts, temperature similarly can impact all aspects in low and moderate ways, where moderate vulnerabilities exist in rail infrastructure (due to line buckling and rolling stock impacts), the airports (through runway blistering and the perishing of freight materials), as well as electricity (where overhead power lines have thermal operating limits). Multiple sectors have high vulnerability to extreme winds, including electricity and phones (because of the use of overhead lines), as well as healthcare vehicles and the transportation assets, whose operability is heavily impacted by winds. Droughts have high vulnerability in the water sector (due to water availability issues), and moderate vulnerabilities with electricity and wastewater systems – which rely on water provision (for thermal cooling at some electricity plants, and to produce wastewater in buildings, such as toilet flushing).

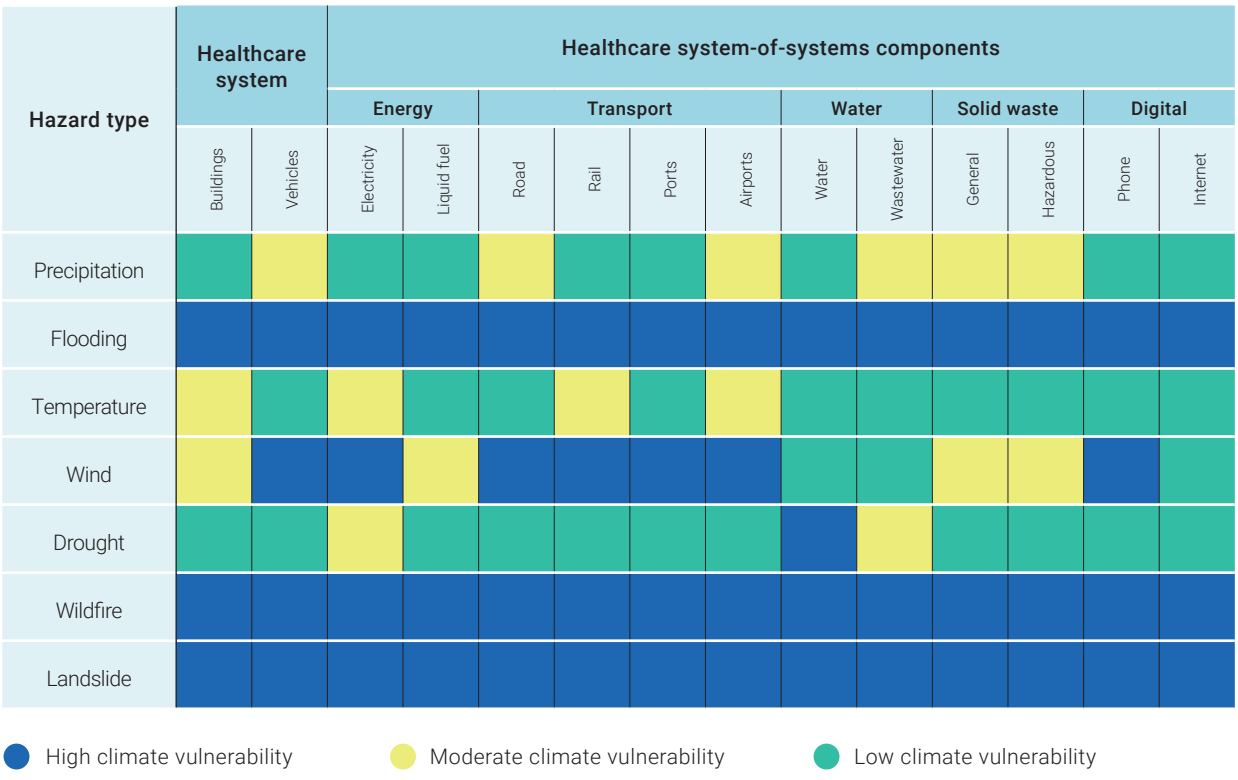


Figure 16. Generalised characterisation of the climate hazard vulnerabilities of the healthcare system-of-systems.

4.2.4. How can we adapt in a systemic way?

Healthcare system-of-systems adaptation can enhance resilience through multiple measures across infrastructure dependencies (Figure 17). For the electricity sector, this includes onsite battery storage, renewable generation, and diesel backup generators, supported by onsite liquid fuel storage (diesel, petrol, propane) for emergency use. To mitigate transport vulnerabilities, healthcare facilities can establish multiple access routes and diversify vehicle modes for service delivery, storage, and personnel transport. Alternative modes—such as port, airport, or road-based emergency vehicles—can substitute during hazard events when conditions allow. Water resilience can be improved through onsite water tanks, grey water reuse (e.g., rainwater for flushing), and stormwater management via soakaways or other nature-based systems, reducing demand on external supply and treatment networks. For waste management, both general and hazardous waste can be stored onsite or in vehicles, with onsite incineration used where feasible—particularly for hazardous waste when external capacity is limited. Finally, digital vulnerabilities (e.g., phone or internet outages) can be addressed through redundant communication systems, such as multiple devices and service providers, ensuring continued access to information and digital services.

Health-care system		Healthcare system dependencies on external infrastructure systems											
Healthcase system component	Asset type	Energy		Transport				Water		Solid waste		Digital	
		Electricity	Liquid fuel	Road	Rail	Ports	Airports	Water	Wastewater	General	Hazardous	Phone	Internet
Healthcare service assets	Buildings	Onsite generation, back-up generation and storage	Onsite fuel storage	Multiple access points				"Onsite water storage Grey-water reuse"	Onsite wastewater separation, storage and treatment	Onsite general waste storage	Onsite general waste storage and incineration	Multiple access points, and additional connection devices	Multiple access points, and additional connection devices
	Vehicles	In vehicle storage	Onsite fuel storage	Additional transport modes		Additional transport modes	Additional transport modes	In vehicle water storage	In vehicle wastewater storage	In vehicle general waste storage	In vehicle hazardous waste storage	Multiple access points, and additional connection devices	Multiple access points, and additional connection devices
Healthcare materials assets	Storage	Onsite generation, back-up generation and storage	Onsite fuel storage	Multiple access points				"Onsite water storage Grey-water reuse"	Onsite wastewater separation, storage and treatment	Onsite general waste storage	Onsite general waste storage and incineration	Multiple access points, and additional connection devices	Multiple access points, and additional connection devices
	Transport	In vehicle storage	Onsite fuel storage	Additional transport modes						In vehicle general waste storage	In vehicle hazardous waste storage	Multiple access points, and additional connection devices	Multiple access points, and additional connection devices
Healthcare personnel assets	Housing	Onsite generation, back-up generation and storage	Onsite fuel storage	Multiple access points				"Onsite water storage Grey-water reuse"	Onsite wastewater separation, storage and treatment	Onsite general waste storage		Multiple access points, and additional connection devices	Multiple access points, and additional connection devices
	Transport	In vehicle storage	Onsite fuel storage	Additional transport modes								Multiple access points, and additional connection devices	Multiple access points, and additional connection devices

Materials based services: Asset location storage, production and treatment

Access based services: Asset location access points and connection modes

Figure 17. Adaptation options for the healthcare system to address systemic external dependency vulnerabilities. Generalised between material- and access-based service delivery.

05

Adaptation insights and way forward

Adaptation insights and way forward

This Adaptation Insights report contributes to the growing body of evidence on health system resilience. It provides novel insights into how to make health systems more climate-resilient to sustain value chains and healthcare services and access to healthcare. The application and synthesis of two distinct conceptual approaches enables readers to gain new insights into how to approach health system resilience. These insights stem from two perspectives: the provision of healthcare services, comprising healthcare facilities, assets, value chains, and supporting systems, and sustained access to healthcare for patients, the population, and vulnerable groups.

The analysis has shown that good practices are emerging, that theoretical concepts of practical use are available, and that adaptation technologies and instruments exist or are emerging. Based on its systematic analysis, this Adaptation Insights report contributes a frame for implementation and gives clear recommendations on the way forward. This report is a valuable contribution to health system resilience in times of climate change deriving landmark findings from these approaches, but also, because there are fewer studies about climate change and health systems in Africa compared to other continents. A gap that needs to be further filled.

This Adaptation Insights report – grounded in systematic analysis – calls for substantially increased financing and efforts by IFIs, by African governments, and international development partners in order to make health systems climate resilient and to sustain value chains, healthcare services, and access to healthcare in the context of climate change. Evidence is striking that progress towards climate resilient health system has been slow and that climate change adaptation of health systems is fundamentally under-financed and that investments are insufficient.

This Adaptation Insights report confirms substantial adaptation finance, planning and policy, and collaboration gaps that need to be addressed through a concerted effort of all stakeholders. In its last assessment report, the IPCC warned with a high confidence that action for climate-resilient health systems between 2014 until 2022 has been slow “despite acknowledgement of the importance of health adaptation as a key component” (IPCC, 2022, p. 95).

Therefore, this Adaptation Insights emphasises that efforts and progress towards climate resilient health system need to gain momentum and require focus, actions, and investments of governments and IFIs to achieve climate-resilient health systems with sustained value chains, healthcare access and services. Drawing on these observations and our experience working with international and domestic financial institutions to catalyse adaptation through the Africa Adaptation Acceleration Program (AAAP), this section presents a set of practical recommendations to scale climate-resilient health systems. These recommendations focus on mobilising and directing finance toward system-wide resilience rather than isolated assets. Adaptation technologies, instruments, and good practices are ready for deployment, and strategic investments can deliver high economic returns and cost-efficiency. IFIs, development banks, domestic financial institutions, and private partners now have a clear opportunity to leverage dedicated climate finance, deploy de-risked investment structures,

and align funding with these actionable recommendations to accelerate tangible impact on health system resilience.

The set of insights and subsequent recommendations are tailored for IFIs, governments, development partners and domestic financial institutions are outlined below categorised into five thematic action fields to guide investment planning, project design, and financing decisions for climate-resilient health systems:

5.1. Climate risks are reducing health system capacity while increasing demand: they need to be embedded at the core of health system planning, financing, and monitoring strategies

Climate change is increasing healthcare demand and health burden. The demand for healthcare services is projected to rise because of the adverse health impacts associated with climate change, whether these are direct health impacts of climate risk events or due to gradually changing climate, or whether they are indirect or secondary impacts. Investments in climate-resilient capacity expansion, facilities, and adaptive health monitoring systems are effective in preventing system overload and mitigating downstream economic and social losses related to health-service disruptions.

At the same time, climate-driven temporary reduction in health system capacity are expected to increase in African countries, which show severe challenges across pillars of healthcare delivery. Climate change impacts are expected to increase the number of healthcare facilities, health infrastructure, and segments of the supply chain that are not operational or fully functional due to failures within or outside the health system, thereby reducing the overall health system capacity. Deterioration or system failures may be temporary, localised, or prolonged and large-scale.

Research and evaluation of climate-resilient health systems have intensified in recent years and can contribute to accelerating evidence-based health system adaptation. The body of knowledge and evidence on the effectiveness and impact of health system resilience interventions has expanded substantially, leading to a growing number of methodologies to support adaptation efforts.

The first set of recommendation therefore aims to embed climate risks and anticipate adaptation needs upfront by integrating them at the core of healthcare planning, financing and investment preparation frameworks, and national-scale health monitoring strategies:

#1: Integrate Climate Risk into Health Planning and Investment Prioritisation.

National and subnational governments can strengthen their capacity and systematise processes to integrate climate risk analysis into healthcare system planning and investment project prioritisation, in coordination with international and domestic financial institutions and development partners. By assessing and monitoring how national and localised climate impacts shift demand for healthcare , affect healthcare delivery, and (temporarily) reduce healthcare system capacity, stakeholders can identify climate-specific changes in demand patterns and channel resources efficiently to address the rising burden of communicable and non-communicable diseases.

Integrating adaptation and resilience measures upfront in planning, pipeline projects development and project prioritisation is a crucial strategy to prepare healthcare systems for increases and shifts in climate-related health risks, ensuring that current investments align with future climate-driven healthcare demands.

#2 Embed Climate Risk Screening in Investment Preparation Frameworks.

National and subnational governments, implementation agencies, and financing institutions should further integrate climate risks into investment preparation frameworks, integrating climate risks screening not as a compliance effort, but as a forward-looking methodology to safeguard investments and their socio-economic returns under future climatic conditions (GCA, 2025a).

Within investment projects preparation, assessing climate risk channels to assets and service delivery, supporting systems, and healthcare access early in the process enables cost-benefit analysis of adaptation options, allowing stakeholders to identify the set adaptation measures that can provide a cost-effective and financially viable strategy to sustain healthcare assets, services, and access under more frequent extreme events and rising climate stressors. In addition to upgrading existing health infrastructure, this includes new constructions based on the results of climate risk assessments (e.g., the selection of low-risk sites and location).

Overall, operationalising this climate risk screening and adaptation options integration into large- and medium-scale investment projects can accelerate evidence-based health system adaptation, leveraging research and applied knowledge in investment preparation processes to safeguard both direct financial returns and long-term sustainable development outcomes.

#3: Establish Climate- and Weather-Informed Information Systems for Health.

Governments, with support and in coordination with IFIs and development partners, should increase focus on establishing robust national climate- and weather-informed health information systems. These should range from local to national early warning systems and climate risk assessments for human health, enabling the projection of epidemiological patterns and healthcare needs while accounting for potential deterioration or temporary failure of health systems following natural disasters and extreme weather events.

Linking effective monitoring with strategic planning and financing frameworks can help ensure that adaptation strategies are continuously informed and adjusted, and allowing to respond to both anticipated and unforeseen impacts of changing climatic conditions on healthcare demand and service delivery capacity, increasing health system responsiveness.

5.2. Shift from asset-level resilience to system-wide and value chain approaches considering interdependencies

Resilience cannot be achieved by focusing only on individual facilities. Climate risks affect entire supply chains and interconnected systems, creating vulnerabilities across scales and sectors. This study provides a generalised demonstration of how a healthcare system is interconnected, highlighting the cascading systemic vulnerabilities which can occur from a climate hazard, causing disruptions in both services and access. The assessment of climate risks on a country's health system – with the case study of flood risks in Nigeria presented in this report – shows that physical accessibility to healthcare facilities is likely to decline in a changing climate, with certain groups or locations at risk of temporarily losing access altogether.

Effective adaptation efforts are therefore required to account for interconnectedness in climate-proofing the health system, with a target on reliable access to healthcare services. The functioning of the health care system is dependent on supporting systems, particularly on energy, transport, water, waste management and digital communications systems. These interdependencies are increasing, for example due to electrification and digitalisation. Deterioration, disruptions, and failures of supporting systems due to climate change impacts can have a negative impact on the health system. Infrastructure outside the health facility may be critical to ensure sustained services. Therefore, health policies, planning, operations and maintenance frameworks need to include more systematically detailed assessments and improved management of system interdependencies, looking at health value chain across geographical scales (from assets and local networks to the regional supply and demand area) and sectors (acknowledging underlying dependencies on supporting infrastructure).

#4 – Expand Standards for Health Systems Risks Screening and Adaptation from Facilities to Full Healthcare Value Chains.

Resilient health systems rely on supply chains and wider functions, from the local scale (facilities) to the regional scale (pharmaceuticals supply chains, logistics, workforce mobility). International and national climate change adaptation standards for health systems should evolve from asset-centric approaches toward system-wide standards. Such holistic framework can conceptualise healthcare as an interconnected system encompassing all components required for sustained delivery and equitable access, with a focus on minimising service, delivery, and access disruptions. Key aspects of these multi-scale adaptation standards may include climate-resilient facility design, operation, and maintenance standards; workforce resilience; cold-chain management; transportation and access infrastructure; and emergency response capacities.

#5 – Address Health System Dependencies, Interconnected Systems and Cross-Sector Risk Hotspots.

Climate vulnerability of healthcare systems are also closely interlinked to failures in energy, transport, water, sanitation, and digital infrastructure. Identifying interdependencies driving system deterioration or failure and hotspots of risks, where cascading disruptions are likely to affect healthcare delivery and access at scale, is critical for effective reduction of systemic vulnerability. Governments and development actors should integrate the interconnectedness of systems and the dependency of the health system into climate risk and adaptation standards.

Furthermore, health sector standards need to define methodologies how to assess and quantify physical climate risks and cascading impacts in order to design targeted and cost-effective adaptation strategies.

Beyond the health sector itself, territorial governance policies and planning processes should explicitly consider the interdependencies between health systems and supporting infrastructure. This includes assessing cross-sectoral vulnerabilities and prioritising adaptation options that address potential deterioration or failure of these supporting systems under changing climatic conditions.

5.3. Focus on sustaining access to healthcare and make health systems user-centric, locally-led, and service-oriented

Access to healthcare is central to healthcare system performance. Climate change increasingly affects access to healthcare at the supply and the demand side, leading to failing health system, as its main function – to deliver healthcare – cannot be fulfilled.

Climate impacts disproportionately affect vulnerable populations and disrupt last-mile service delivery. Prioritising access, equity, and service continuity from a user perspective directly contributes to achieving a more resilient health system, together with the inclusion of populations as active health system actors in adaptation strategies and processes.

Sustaining both demand and supply of healthcare is central for climate change adaptation efforts, through adequate policy incentives and context-specific adaptation measures. Climate change negatively impacts access to healthcare at the supply and the demand side, leading to failing health system, as its main function – to deliver healthcare – cannot be fulfilled. Climate change adaptation measures are required at the demand-side and supply-side of healthcare access, following the integrative framework of health systems resilience (section 3.1), to sustaining access.

National health adaptation planning processes (e.g., HNAPs) and healthcare system development planning could set focus on service delivery and access targets, allowing for context-specific adaptation solutions to emerge. Various context-specific adaptation options at the demand and supply side are available (Table 5, page 28 and Table 7, page 31). This was revealed by the analysis of the integrative framework of health systems resilience (section 4.1) and such methodology lays the ground for an effective, context-specific action plan.

#6 Think Health System Adaptation from the Goal to Sustain Access to Health Care.

In the context of climate change, a paradigm shift is advised to design and assess healthcare system performance with the goal to sustain and improve access to health care. Given the requirement for complex adaptation responses at the supply and demand side, the population needs to be considered as an actor in health system resilience. Current and future health and healthcare-related adaptation strategies of the population needs to be considered and supported in health system planning and management.

#7 – Strengthen Last-Mile Delivery, Physical Accessibility of Healthcare Facilities, and Users-Centred Adaptation.

Strengthening physical accessibility and decentralised service provision can ensure continuity of care during climate shocks, particularly in remote and climate-exposed areas. This involves focusing not only on health service delivery (supply side), but also on measures to ensure patients and populations have sustained access to healthcare (demand side). Physical accessibility, for example, can be strengthened by ensuring road accessibility of stationary facilities, climate-resilient health and transport infrastructure, means of transport for immobile people, or providing (temporary) health service access close to communities, including in emergency shelters.

Governments and development partners should develop evidence-based policies at the demand and supply sides to improve and sustain access to healthcare for patients and the population. Specifically, these measures and policies should safeguard both the population's ability to access care and the health system's capacity to deliver accessible, acceptable, and appropriate services, under different configurations of climate-related disruptions. This could for example integrate policy targets and incentives to:

- Increase the abilities of population to access health care, comprising the ability to perceive, the ability to seek, the ability to reach, the ability to pay, and the ability to engage (see examples of demand-side adaptation options on Table 5, page 28);

- Strengthen the capacities of the health system to provide access to health care, comprising improved approachability, acceptability, availability & accommodation, affordability, and appropriateness (see examples of supply-side adaptation options on Table 7, page 31);

- Enable equitable access to healthcare, including vulnerable and marginalised groups.

#8 – Promote Localised Solutions and Devolve Decision-Making.

Localised and context-specific solutions are essential to trigger resilience at the macro level. In line with locally led adaptation principles, decision-making should be devolved to the lowest appropriate level and contribute to adaptation actions identification, prioritisation, implementation and evaluation.

In health sector adaptation strategies and policies, IFIs, governments and development partners should consider the patients and population (including users, their associations, territorial and community actors, and vulnerable groups) as active participants of the health system through their access to and demand of healthcare services, as well as through their health-related adaptation strategies. Community involvement is required to effectively sustain healthcare access.

5.4. Build and manage adaptive, dynamic, and evidence-based health systems in the context of climate change

Successful adaptation requires recognising health systems as dynamic structures. Health systems are dynamic systems that operate in changing environments characterised by recurrent shocks and stresses and respond through evolving resilience processes – whether planned or unplanned.

The analysis of the integrative framework of health systems resilience (section 3.1) revealed that health system needs to be considered as a dynamic system that continuously goes through resilience processes of pro-active adaptation strategies, deterioration, (partial) failure, recovery, and improvement on both sides, demand side (access) and supply-side (delivery of healthcare). Static approaches to planning and management are increasingly insufficient to address evolving climate risks. This has several policy implications.

#9 – Allow for Flexible Decision-Making for Dynamic System Response.

Flexible decision-making structures can allow local actors to respond rapidly to climate-related disruptions with maximum efficiency and relevance, while maintaining coherence with national strategies.

Adaptation strategies should recognise the health system as a dynamic entity undergoing continuous processes of reaction and response, both at the level of health care supply and health care demand. Decision-making authority and adaptive capacity should therefore be built in the design and operations, to enable decision-makers to react and adapt with coherence and flexibility at all levels, including the population.

#10 – Foster Population Capacity to Manage the Impacts of Climate Change with regard to Health and Healthcare Access.

Resilient health systems depend not only on infrastructure, but also on community preparedness, risk awareness, and climate risk management strategies to reduce the health burden associated with changing climate and extreme weather events. Health sector adaptation could integrate protocol for temporary and flexible adaptation in times of extreme weather events and natural disasters, including population participation, in order to increase the reactivity of the health system.

At a broader scale, this approach would strengthen alignment between disasters risk management plans, preparedness strategies within HNAPs and health system adaptation plans.

#11 – Deploy Local Early Warning Systems and Real-Time Data Platforms.

Early warning systems and real-time data management platforms at the local level are critical to enable rapid yet informed decision-making and coordinated responses, thereby reducing service disruption and maintain healthcare access during climate events.

Health sector adaptation could integrate data-driven approaches, including localised early warning systems, extreme heat surveillance system, dynamic risk mapping, and real-time information dissemination to health actors and communities. This would enhance system responsiveness and efficiency, and strengthen the overall evidence-base and continuous-learning approaches. Reliable data are the prerequisite for the development of adaptation interventions, and also required for the assessment their effectiveness and impact.

#12 – Leverage Research, Evaluation, and Knowledge Sharing to Accelerate Evidence-Based Health System Adaptation.

Effective and efficient adaptation requires evidence-based policies. This involves rigorous impact assessments and evaluations of innovative and not well-tested health system adaptation interventions, and also requires harmonising existing frameworks of health system resilience and to take them from theory to practice. It also includes better knowledge sharing and capacity strengthening on health system adaptation and resilience with stakeholders.

5.5. Strengthen regional cooperation and mobilise finance for climate-resilient health systems

Climate risks transcend national boundaries, yet adaptation responses in the health sector remain fragmented, underfunded, and overly asset-centric. While progress has been made in developing standards, tools, and policy instruments, current approaches do not comprehensively address the systemic nature of climate risks to health systems, nor provide adequate financial resources.

Existing international guidelines provide a valuable foundation for strengthening the climate resilience of healthcare facilities and service delivery. However, they remain primarily oriented toward asset centric service delivery, with limited attention to access and systemic failures, which are equally critical as highlighted in Chapter 1. International standards offer strong frameworks for quality assurance and organisational resilience; however, no comprehensive global standard exists to guide climate change adaptation across a healthcare system. As a result, adaptation efforts are often fragmented, addressing only discrete aspects of healthcare resilience (i.e., delivery only or asset centric) rather than the full set of interdependent subsystems required for sustained and equitable healthcare provision.

National planning instruments reflect similar gaps. The assessment conducted in this Adaptation Insights report reveals various gaps in policies and planning. For example, the assessment of adaptation policy instruments in African countries revealed substantial gaps in the adaptation plans to climate-proof health systems (see Table 5 on page 28 and Table 7 on page 31). In their plans, a quarter of countries do not consider health infrastructure, about 40% of countries don't consider healthcare staff, sustainable access, and cross-sectoral coordination, respectively. A mere 60% do not consider supporting systems at all, while almost 70% don't consider adaptation for supporting systems. Thus, the gaps in policies and planning are particularly in the domains of (a) health system vulnerabilities where successful healthcare delivery depends on the function of health system subsystems and on supporting systems; (b) the consideration of the population as a health system actor that accesses healthcare and that needs to be able to express demand for healthcare services; and (c) the consideration of health system reactivity and dynamics in health system planning.

Although global evidence on climate-related health impacts is well established, implementation and financing of health adaptation policies lags behind, compared more established sectors for climate change adaptation, such as Agriculture and Water (chapter 1). Nonetheless, momentum is emerging through increased investment, regional collaboration, and the development of strategic frameworks, although with a large proportion disease prevalence focused. The strategic framework on climate change and health by the AfricaCDC could serve as a frame for collaboration (AfricaCDC, 2025). The findings of this Adaptation Insights are in line with the conclusions of the IPCC (2022, p. 95) that "building climate resilient health systems will require multi-sectoral, multi-system and collaborative efforts at all governance scales (very high confidence)."

Financing gaps for the adaptation of the health sector, as reported by several agencies, are striking and constrain progress. The IPCC, for example, concludes that "This level of investment is insufficient to protect human health and health systems from most climate-sensitive health risks

(very high confidence)" (IPCC, 2022, p. 96). Available evidence suggests that even modest, climate-informed investments, such as low-cost retrofits, can yield disproportionately high protection benefits - for example, pointed out by WHO (2009) non-structural retrofits, which comprise changes that do not require alterations to the load-bearing components of buildings, amounting to just 1% of a hospital's total value can safeguard up to 90% of its assets. However, financing continues to prioritise isolated assets rather than system-wide resilience, including workforce capacity, supporting infrastructure, surveillance systems, and equitable access mechanisms.

Addressing these structural weaknesses requires greater international coordination, stronger regional cooperation, comprehensive standards, and a significant scaling and realignment of adaptation finance toward integrated, system-level resilience. Positive examples show that when funds are available, countries can effectively strengthen their planning and implementation systems, and involve all actors. For example, Nigeria is pioneering adaptation planning of the health system as it already addresses all themes required for health system adaptation and recently announced a US$ 2.2 billion investment in the healthcare sector. Governments can use such momentum to act by strengthening implementation, and institutional framework to ensure delivery of plans, and involve all relevant actors, including the population as part of the health system.

Given the strong impact on the well-being of the population, these findings represent a wake-up call for substantial increases in healthcare system adaptation financing, with the following macro-level enablers.

#13 – Embrace Healthcare Systems' Complexity in Policies and Regional Cooperation.

Reflecting more realistically climate-health linkages in policy design and regional cooperation mechanisms (cross-border collaboration, harmonised or international standards, and knowledge exchange) can strengthen collective resilience and reduce fragmentation.

Even in the absence of a holistic international standard, governments and development partners should conceptualise healthcare as a system, encompassing the interdependent components required for sustained service delivery and equitable access, in the development of their national health planning and in their Health National Adaptation Plans (HNAPs). Policies and regional cooperation frameworks could specifically include:

- Systematic policy institutional regulatory screening (PIR) and update where gaps are identified using the key themes identified in this Adaptation Insights, which are health infrastructure, healthcare staff, sustainable access, supporting systems and cross-sectoral coordination.
- The development of case-based learning to understand the interconnectedness for the context. This would help test and refine the framework through real-world applications, historic case studies, and cross-country comparisons to generate practical insights for policymakers, populations, healthcare practitioners, and infrastructure providers.
- Built in coordination mechanisms among continental, regional, and national actors, to share and capitalise on these lessons learned in health system adaptation, best practices and challenges specific to local, national, and regional contexts.

#14 – Align and Increase Finance for Climate-Resilient Health Systems

Current levels of adaptation financing for health systems are insufficient relative to projected climate risks. Closing this gap is essential to safeguard human health and well-being, and long-term development resilience. IFIs, governments and development partners should align and expand financing toward system-wide resilience rather than isolated infrastructure investments, to maximise systemic impact and incentivise a more diverse pool of financiers.

This could include:

- Mobilising climate finance instruments, blended finance, guarantees, and private-sector participation towards healthcare systems resilience;
- Widening investment beyond facilities to workforce resilience, supporting systems, cross-border surveillance, and access mechanisms;
- Institutionalising climate change adaptation sovereign financing within health planning and budgeting processes;
- Leverage collaboration with civil society, non-profit actors, through an integrated system approach, allowing to prioritise actions and incentives where it matters the most.

Climate change poses an increasingly significant threat to health systems. On the one hand, the impacts of climate change increase the burden of disease and drives higher demand for healthcare. On the other hand, health systems themselves are increasingly exposed and affected. The increasingly complex and interconnected nature of healthcare systems means that novel solutions are required to ensure resilience in times of climate change. This Adaptation Insights' assessment of the impact of climate change on health systems and the current state of health system planning in Africa sheds light on these mounting challenges and complexity.

This Adaptation Insights report presents two novel conceptual frameworks for health system vulnerabilities and adaptation options that address this complexity, helping to overcome the challenges on the way to achieving climate-resilient health systems. The synthesised findings of this approach enable multi-layered conclusions to be drawn and actionable recommendations to be derived. The report encourages stakeholders to actively engage with the approaches and interpret them in their own contexts to develop the most effective adaptation solutions for their health systems.

Based on the evidence presented in this report, we provide 14 actionable policy recommendations for decision makers concerned with healthcare systems. These recommendations support targeted action in a range of areas and are addressed to relevant stakeholders, guiding implementation. As a collaborative effort, the findings have informed a set of actionable recommendations that are relevant in the context of African countries and developing economies drawing from experience from the first phase of the Africa Adaptation Acceleration Programme (2020–2025).

These recommendations are intended as a first step towards fostering deliberative dialogue with the perspective of shifting financial and governmental systems towards a more integrated approach to climate-resilient healthcare systems. These recommendations therefore provide a foundation for further collaborative work to establish sustained value chains, improve access to healthcare services and ultimately create climate-resilient health systems. This will help to catalyse adaptation action, supporting healthier societies and resilient economies while safeguarding the essential rights of all.

06

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07

Annexes

Annex 1. Supplementary information for chapter 1

Methodology for section 1.2

The flood exposure assessment of health facilities was conducted using the WRI Aqueduct Floods Hazard Maps at a 1 km spatial resolution (Ward et al., 2020). The analysis focused on 100-year return period (RP100) river flood scenarios for the year 2050, under both RCP 4.5 and RCP 8.5 climate projections. Health facility locations were obtained from Healthsites.io, an openly accessible global database of health service points. These facility coordinates were spatially intersected with gridded flood depth layers to determine the extent of inundation exposure.

Flood depth values were classified into the following intervals: ≤0.3 m, >0.3–0.5 m, >0.5–0.8 m, >0.8–1.0 m, >1.0–1.5 m, >1.5–2.0 m, and >2.0 m. The number of health facilities within each flood depth category was then aggregated by facility type (e.g., hospitals, clinics, pharmacies, etc.), providing a comparative estimate of exposure across service categories and climate scenarios.

Limitations: The analysis is constrained by several methodological and data-related uncertainties. Both the historical and projected flood scenarios were derived from the WRI Aqueduct Flood hazard layers. So, the historical inundation dataset represents modelled – not observed – flood extents. As such, local hydrological processes, drainage infrastructure, and smaller-scale flood variations may not be fully captured at the 1 km resolution. The health facility dataset, while extensive, may exclude unregistered, temporary, or recently constructed facilities, potentially underestimating exposure. Moreover, the analysis assumes static facility locations and does not incorporate adaptive measures, retrofitting, or new construction that may occur by 2050. Accessibility assessments, including walking and motorised travel times, are also based on static assumptions and do not reflect real-time disruptions caused by compound hazards or damaged road infrastructure during flood events. Furthermore, while flooding may not influence the walking time to the second-nearest healthcare facility, the present analysis considers only the impact on access to the nearest facility.

Table A1. Health facility types expected to be impacted by a 1-in100 year fluvial flood event in 2050 (RCP 4.5) using Aqueduct fluvial flood models. Source: Open Street Map, 2025; Russell et al., 2025; Ward et al., 2020

2050, RP 100, RCP 4.5								
Flood Depth (m)	Hospital	Clinic	Doctors	Pharmacy	Dentist	Health post	Other	Total Count
<=0.3	1251	389	691	1241	6	9	64	3651
>0.3-0.5	5	2	3	11	0	0	1	22
>0.5-0.8	4	36	17	29	1	1	0	88
>0.8-1.0	4	5	3	4	0	0	0	16
>1.0-1.5	15	14	15	19	0	0	0	63
>1.5-2.0	0	1	4	3	0	0	0	8
>2.0	4	3	10	0	0	0	0	17
Total Count	**1283**	**450**	**743**	**1307**	**7**	**10**	**65**	**3865**

Table A2. Health facility types expected to be impacted by a 1-in100 year fluvial flood event in 2050 (RCP 8.5) using Aqueduct fluvial flood models. Source: Open Street Map, 2025; Russell et al., 2025; Ward et al., 2020

2050, RP 100, RCP 8.5								
Flood Depth (m)	Hospital	Clinic	Doctors	Pharmacy	Dentist	Health post	Other	Total Count
<=0.3	1248	392	691	1245	6	9	65	3656
>0.3-0.5	3	30	5	6	1	0	0	45
>0.5-0.8	9	5	13	30	0	1	0	58
>0.8-1.0	4	5	8	6	0	0	0	23
>1.0-1.5	3	9	12	9	0	0	0	33
>1.5-2.0	8	6	5	11	0	0	0	30
>2.0	8	3	9	0	0	0	0	20
Total Count	**1283**	**450**	**743**	**1307**	**7**	**10**	**65**	**3865**

Table A3. Comparison of flood scenarios impacting hospital infrastructure using Aqueduct fluvial flood models for a 100-year return period. Source: Open Street Map, 2025; Russell et al., 2025; Ward et al., 2020

Hospitals			
Flood Depth (m)	Baseline (2020)	2050, RCP 4.5	2050, RCP 8.5
<=0.3	1255	1251	1248
>0.3-0.5	5	5	3
>0.5-0.8	1	4	9
>0.8-1.0	5	4	4
>1.0-1.5	5	15	3
>1.5-2.0	9	0	8
>2.0	3	4	8
Total	**1283**	**1283**	**1283**

Table A4. Impact of fluvial flooding scenarios on walking times to the nearest healthcare facility combining Aqueduct fluvial flood models and the analysis of Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020

Population (%)				
Walking Travel Time	Baseline* (no flood)	Baseline* (RP 100)	2050** (RP 100, RCP4.5)	2050** (RP 100, RCP8.5)
0-10 min	41.02	40.65	38.34	38.33
>10-20 min	36.36	35.82	35.49	35.44
>20-30 min	7.76	7.65	8.37	8.36
>30-40 min	5.85	5.83	6.26	6.25
>40-50 min	3.37	3.27	3.62	3.62
>50-60 min	1.73	1.72	1.92	1.92
>60-90 min	2.31	2.37	2.70	2.69
>90-120 min	0.81	0.81	0.92	0.92
>120 min (prohibitive)	0.79	0.81	0.91	0.91
No access due to flooding	**0.00**	**1.09**	**1.48**	**1.57**

*Using a 2020 population with a total of 208,252,500; **Using a 2030 population with a total of 262,490,500.

Table A5. Impact of fluvial flooding scenarios on motorised travel times to the nearest healthcare facility using Aqueduct flood models combined with the travel time analysis from Weiss et al. (2020). Source: Russell et al., 2025; Ward et al., 2020; Weiss et al., 2020.

	Population (%)			
Motorised Travel Time	Baseline* (no flood)	Baseline* (RP 100)	2050** (RP 100, RCP4.5)	2050** (RP 100, RCP8.5)
0-10 min	93.69	89.54	87.83	87.85
>10-20 min	3.65	3.62	4.29	4.27
>20-30 min	0.86	0.84	0.95	0.97
>30-40 min	0.70	0.67	0.77	0.77
>40-50 min	0.37	0.36	0.41	0.41
>50-60 min	0.21	0.20	0.24	0.23
>60-90 min	0.29	0.29	0.33	0.33
>90-120 min	0.12	0.12	0.14	0.14
>120 min (prohibitive)	0.10	0.14	0.17	0.17
No access due to flooding	**0.00**	**4.22**	**4.87**	**4.87**

*Using a 2020 population with a total of 208,252,500; **Using a 2030 population with a total of 262,490,500.

Annex 2. Supplementary information for chapter 2

Table A6 . Guidelines for climate resilient healthcare systems

WHO Guidelines	Year	Purpose
Guidance to Protect Health from Climate Change through Health Adaptation Planning (WHO, 2014)	2014	A step-by-step framework for countries to develop Health Adaptation Plans (HAPs) in response to climate change.
Operational Framework for Building Climate Resilient Health Systems (WHO, 2015)	2015	Guidance for health systems to prepare for, respond to, and adapt to health risks from climate variability and change by implementing 10 key components.
Guidance for Climate-Resilient and Environmentally Sustainable Healthcare Facilities (WHO, 2020)	2020	A framework to help healthcare facilities prepare for, respond to and recover from climate change impacts while reducing their environmental footprint.
Checklist to Assess Vulnerabilities in Health Facilities in the Context of Climate Change (WHO, 2021a)	2021	A practical tool for health facility managers, planners, and policymakers to identify vulnerabilities, risks, and resilience gaps of healthcare facilities under climate change.
Measuring the Climate Resilience of Health Systems (WHO, 2022a)	2022	An updated framework and indicators to help countries and health authorities measure, monitor, and strengthen the climate resilience of health systems, building on the WHO 2015 operational framework.
Safe, Climate-Resilient and Environmentally Sustainable Healthcare Facilities (WHO, 2024)	2024	Guidance for managers, practitioners, and policymakers to make healthcare facilities safe, climate-resilient, and environmentally sustainable, focusing on universal health coverage and high-quality care.
Other Guidelines		
Climate Change and Health Vulnerability and Adaptation Assessments: A Knowledge to Action Resource Guide (Health Canada, 2022)	2020	Canada focused tools, data sources, and case examples to assess and address the health impacts of climate change through a vulnerability and adaptation (V&A) assessment.
Climate and Health: A Guide for Cross-Sector Collaboration (CDC, 2024)	2024	U.S focused guidelines to support health department staff in conducting cross-sector outreach for climate change adaptation planning.
Climate Resilience Guidelines for BC Health Facility Planning & Design (GreenCare, 2024)	2024	Roadmap for designing, building, and operating health facilities in British Columbia to withstand current and future climate challenges.
Practical Guide for Building Climate-Resilient Health Systems (HCWH Europe, 2024)	2024	Assist health systems prepare for, adapt to, and mitigate climate change impacts using a system-wide European approach combining adaptation and decarbonisation, supported by case studies.
Climate Resilience for Healthcare Toolkit (Guenther et al., 2025)	2025	U.S focused guide that helps healthcare organisations strengthen their ability to withstand and recover from climate-related hazards through a climate risk assessment, community engagement, collaboration and planning.
Health Facility Climate Vulnerability and Capacity Assessment Manual (CAA, 2025)	2025	A method to identify and address climate and health vulnerabilities, risks, and solutions for health facilities in low- and middle-income settings.

Table A7 . Overview of how major themes are addressed across health and adaptation policies in Africa

Country	Document type	Health infrastructure	Health staff	Sustainable access to healthcare	Supporting systems	Adaptation for supporting systems	Cross-sectorial coordination	Notes
		Evaluates whether adaptation to adverse effects of climate change for hospitals, clinics, or health centres are considered.	Evaluates whether expanding health care workers' knowledge about climate change and how to adapt to possible hazards is considered.	Evaluates whether long-term adaptation allowing access to healthcare services under the adverse effects of climate change is considered.	Evaluates whether the importance of resilient supporting systems, such as water supply, energy/ electricity, sewage, waste, digital connectivity, or roads for healthcare systems is considered.	Evaluates whether suitable adaptation measures are considered for these supporting systems, to insure proper health care delivery.	Assesses whether coordination between the health sector and other vital sectors (transport, water, energy, environment, etc.) is considered in health adaptation planning.	
Algeria (UNFCCC, 2025a)	NDC (2015)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Angola (UNFCCC, 2025a)	NDC (2021)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Benin (UNFCCC, 2025a)	NDC (2021)*	Not mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Burkina Faso (Government of Burkina Faso, 2025)	PNACC (2024-2028)*	Mentioned	Mentioned	Briefly mentioned	Briefly mentioned (waste)	briefly mentioned (waste)	Mentioned	
Burundi (Republique du Burundi, 2023)	NAP(2023) *	Mentioned	Mentioned	Briefly mentioned	Briefly mentioned	briefly mentioned	Mentioned	
Cape Verde (Ministry of Health Cabo Verde, 2023)	NAPHS (2022-2026) & HNAP (2021)	Mentioned (HNAP) + mentioned (HAPHS).	Mentioned (HAPHS) + mentioned (HNAP).	Not mentioned (NAPHS) + mentioned in HNAP.	Not mentioned (NAPHS) + mentioned (HNAP)	Not mentioned (NAPHS) + mentioned (HNAP)	Not mentioned (NAPHS) + mentioned (HNAP)	
Cameroon (NAP Central, 2025)	NAP (2015)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Central African Republic (NAP Central, 2025)	NAP 2022*	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Comoros (UNFCCC, 2025a)	NDC (2021-2030) *	Briefly mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Congo (UNFCCC, 2025a)	NDC(2021)*	Briefly mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Côte d'Ivoire (UNFCCC, 2025a)	PNASS (2021-2025)*	Briefly mentioned	Briefly mentioned	Briefly mentioned	mentioned	Briefly mentioned	Mentioned	
Democratic Republic of the Congo (NAP Central, 2025)	NAPTCC (2022-2026)	Not mentioned; specifically for health care facilities.	Not mentioned	Briefly mentioned; but without actual adaptation examples.	Not mentioned	Not mentioned	Not mentioned	

Country	Document type	Health infrastructure	Health staff	Sustainable access to healthcare	Supporting systems	Adaptation for supporting systems	Cross-sectorial coordination	Notes
Eritrea (UNFCCC, 2025b)	NDC (2022)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Eswatini (Ministry of Health Ewatini, 2024)	NHSSP(2024/25-2027/28)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentions climate change, and not in enough detail to be considered an efficient climate change adaptation paper/ section.
Ethiopia (Ministry of Water, Irrigation and Energy Ethiopia, 2021)	HNAP (2024-2028)	Mentioned	Mentioned	Mentioned	Mentioned	Mentioned (HNAP)	Mentioned (HNAP)	
Egypt (Ministry of Health & Population Egypt, 2024)	NHS (2024-2030)	Slightly mentioned (NHS) - not enough adaptation measures, rather highlights need to monitor for disaster resilient health-facilities.	Mentioned	Slightly mentioned (less for infrastructure more for staff adaptations).	Slightly mentioned (more for electricity and road infrastructure).	slightly mentioned (water, sanitation only) (need more details for road infrastructure, electricity etc. in regards to access to healthcare.)	Not mentioned	
Gabon (UNFCCC, 2025a)	NDC(2022)*	Briefly mentioned	Briefly mentioned	Briefly mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Ghana (UNFCCC, 2025a)	NDC (2020-2030)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Kenya (NAP Central, 2025)	NAP (2015-2030)	Not mentioned	Mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned in relation to health care system.
Lesotho (Ministry of Health Lesotho, 2017)	NHP(2017)	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Mentions that climate change is a risk factor for health sector, but does not go into detail at all regarding its effects on any of the topics above.
Liberia (NAP Central, 2025)	NAP (2020-2030)*	Mentioned	Not mentioned	Slightly mentioned	Mentioned	Not mentioned	Not mentioned	
Madagascar (NAP Central, 2025)	NAP 2022*	Mentioned	Mentioned	Briefly mentioned	Mentioned	Briefly mentioned	Mentioned	

Country	Document type	Health infrastructure	Health staff	Sustainable access to healthcare	Supporting systems	Adaptation for supporting systems	Cross-sectorial coordination	Notes
Malawi (UNFCCC, 2025a)	NDC(2021)	Mentioned	Not mentioned	Briefly mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Mauritania (UNFCCC, 2025a)	NDC(2025)*	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Mauritius (UNFCCC, 2025a)	NDC(2025)	Mentioned	Not mentioned	Mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Morocco (NAP Central, 2025)	NAP (2022-2030) *	Mentioned	Briefly mentioned	Briefly mentioned	Briefly mentioned	Briefly mentioned	Mentioned	
Mozambique (NAP Central, 2025)	NAP(2023)	Mentioned	Mentioned	Briefly mentioned	Briefly mentioned (water and roads)	Not mentioned	Not mentioned	
Namibia (UNFCCC, 2025a)	NDC (2023)	Mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Niger (NAP Central, 2025)	NAP (2022) *	Mentioned	Mentioned	Briefly mentioned	Mentioned	Mentioned	Mentioned	
Nigeria (Government of Nigeria, 2025; Ministry of Health and Social Welfare Nigeria, 2025)	HNAP (2025-2030) and NDC(2025)	Mentioned (HNAP) + mentioned (NDC)	Mentioned (HNAP) + mentioned (NDC)	Mentioned (HNAP) + mentioned (NDC)	Mentioned (HNAP) + mentioned (NDC)	Mentioned (HNAP) + mentioned (NDC)	Mentioned (HNAP) +briefly mentioned (NDC)	
Rwanda (UNFCCC, 2025a)	NDC(2035)	Mentioned	Mentioned	Mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Senegal (UNFCCC, 2025a)	NDC(2020)*	Mentioned	Briefly mentioned	Not mentioned	Briefly mentioned	Not mentioned	Briefly mentioned	
Seychelles (Ministry of Health Seychelles, 2022)	NHSP (2022-2026)	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Somalia (NAP Central, 2025)	NAP (2026-2030)	Mentioned	Mentioned	Mentioned	Mentioned	Mentioned	Mentioned	
South Africa (Ministry of Health South Africa, 2014)	HNAP (2014-2019) & NAP (2021)	Slightly mentioned (NAP) no in depth adaptations. + mentioned in (HNAP)	Mentioned (NAP) + not mentioned HNAP	Not mentioned (NAP); only with regards to staff trainings briefly + Not mentioned (HNAP).	Not mentioned (NAP) + briefly mentioned (HNAP).	Not mentioned (NAP) + not mentioned how to adapt these supporting systems (HNAP).	Not mentioned (NAP) + Not mentioned (HNAP).	
Sudan (NAP Central, 2025)	NAP(2016)	Not mentioned	Not mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	

Country	Document type	Health infrastructure	Health staff	Sustainable access to healthcare	Supporting systems	Adaptation for supporting systems	Cross-sectorial coordination	Notes
Tanzania (Ministry of Health Tanzania, 2018)	HNAP (2018-2023)	Mentioned	Mentioned	Mentioned	Not mentioned	Not mentioned; they do not mention any adaptation plans with regard to effects of climate change on supporting systems, in relation to the health system.	Cross-sectorial coordination between health sector and other supporting systems is vague in the context of climate change resilience for health care accessibility. (slightly mentioned)	
The Gambia (Ministry of Health Gambia, 2021)	NHP(2021-2030)	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	
Togo (Ministry of Health Togo, 2018)	PNACC (2018)*	Briefly mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	Briefly mentioned	
Tunisia (UNFCCC, 2025a)	NDC (2026-2035)*	Briefly mentioned	Not mentioned	Briefly mentioned	Not mentioned	Not mentioned	Not mentioned	
Uganda (Ministry of Health Uganda, 2025)	HNAP (2025-2030)	Mentioned	Mentioned	Mentioned	Partially mentioned (electricity, energy); need to develop it further to water access, road access etc. when health system is heavily effected by climate change results.	Partially mentioned as its only applied to electricity and energy.	Slightly mentioned; need to apply to all sectors which effect health care when climate change effects are in action. (again, water/roads etc.)	
Zambia (Ministry of Health Zambia, 2017)	HNAP (2017)	Mentioned	Mentioned	Mentioned	Mentioned	Mentioned	Mentioned	
%		% = 26.2% don't, 47.6% do, 26.2% briefly do.	42.9% don't, 35.7% do, 21.4% briefly do.	45.2% don't, 21.4% do, 33.3% briefly do.	59.5% don't, 21.4% do, 19.04% briefly do.	69.04% don't, 14.3% do, 16.7% briefly do.	42.9% don't, 26.2% do, 30.9% briefly do.	

*Based on an automated translation to English.

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