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Health system resilience to climate shocks in Mozambique: A mixed-methods study across the six WHO health system building blocks

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Abstract

Mozambique faces recurrent floods and cyclones that disrupt health services, yet little is known about how stakeholders at different levels of the health system experience these shocks. We assessed perceived impacts of climate shocks on health services, with emphasis on HIV, tuberculosis (TB) and malaria programmes, and mapped vulnerabilities across the six World Health Organization (WHO) health system building blocks.

We conducted a cross-sectional convergent mixed-methods study in Gaza, Sofala, Maputo and Cabo Delgado provinces between 18 February and 2 March 2026, immediately after major floods in southern Mozambique. Semi-structured questionnaires were administered to 25 purposively selected stakeholders (11 in Gaza): government officials and health managers (n = 7), non-governmental organization (NGO) and donor representatives (n = 4), community members (n = 6),

and health facility managers and providers (n = 8). Closed-ended items were summarised descriptively; open-ended responses were analysed with Bardin's content analysis, coded to the WHO building blocks.

Floods were rated the most impactful shock by most government (5/7) and community respondents (4/6), and all facility respondents (8/8) reported that their facility had been affected by floods. HIV services were the most frequently cited affected service: 4/6 community members chose HIV as the single most affected service, and 7/8 facility respondents listed it among affected services. Only 3/8 facility respondents reported a written contingency plan; 4/7 managers reported no formal intersectoral coordination mechanism (2/7 reported a formal, active one) and 4/7 said communities were rarely or never involved in planning. All NGO respondents described their action as exclusively reactive, and 3/4 rated financing as insufficient. Qualitative findings showed interlocking failures: warnings arriving "*in less than 8 hours*", drug losses, exhausted and unsupported health workers, ad hoc partner-dependent continuity, and governance perceived as centralised and politicised.

Climate-related vulnerabilities in Mozambique's health system appear systemic and mutually reinforcing, and participants most often traced failures to governance. Continuity of antiretroviral therapy warrants evaluation as a candidate sentinel indicator of health system climate resilience. Decentralised preparedness, people-centred early warning, protected stocks, workforce support and dedicated pre-arranged financing are priorities.

Keywords: Climate change; health system resilience; WHO health system building blocks; floods; cyclones; HIV; tuberculosis; malaria; mixed methods; Mozambique

Author summary

Mozambique is hit by floods and cyclones almost every year, and each event interrupts health care for people who depend on regular treatment, such as people living with HIV. We interviewed 25 people who experience these crises from different positions: health managers, health workers, aid organisations and community members, in four provinces, just after the 2026 floods. We organised what they told us using the six "*building blocks*" that WHO uses to describe a health system.

Floods were the most damaging event, and HIV treatment was the service most often interrupted; one patient ran out of antiretroviral pills because they had only three days' supply when the rain began. Warnings came too late to move medicines or people, health workers were left without transport, shelter or support, and continuity depended on improvised measures funded by partners. Most problems traced back to centralised decision-making, weak coordination between sectors and the exclusion of community leaders, whom managers themselves described as more trusted than the health system.

We argue that keeping people on HIV treatment during a disaster is a good test of whether the whole health system is prepared. Moving decisions, medicine stocks and funds closer to districts and communities, before the next disaster, is the main change needed.

1. Introduction

Human-induced warming has made extreme weather events more frequent and intense, and further increases are projected under all emission scenarios [1]. The health effects are direct (injury and death from storms, floods and heat), indirect (shifts in vector-borne, water-borne and nutritional disease, and mental illness) and systemic, through damage to facilities, supply chains and the health workforce [2]. WHO's operational framework for climate-resilient and low-carbon health systems therefore treats resilience as a property of the whole health system rather than of individual programmes [3]. Resilience in this sense is the capacity of health actors, institutions and populations to prepare for, absorb and adapt to shocks while maintaining core functions [4–6]. Health-system resilience therefore requires not only emergency response, but also facility-level measures that protect essential services, supplies, energy, water and sanitation before hazards occur [3-48].

Mozambique is among the countries most exposed to climate hazards. It has about 2,700 km of Indian Ocean coastline in the path of tropical cyclones and lies downstream of large transboundary river basins, including the Limpopo, Save and Zambezi, which cause recurrent flooding [7]. It ranked among the ten countries most affected by extreme weather over the past two decades [8]. Major events include the 2000 Limpopo floods (more than 700 deaths), Cyclones Idai and Kenneth in 2019 (more than 600 deaths and 1.85 million people affected by Idai alone), Cyclone Freddy in 2023, the longest-lived tropical cyclone on record, and the 2026 floods in the south, which inundated health facilities [9,10]. Exposure is compounded by poverty: Mozambique's Human Development Index was 0.461 in 2022, and about two-thirds of the population live in rural areas and depend on rain-fed agriculture, many of them in flood-prone low-lying areas [7,11].

The national health system is organised at central (Ministry of Health, MISAU), provincial (Provincial Health Directorates, DPS) and district (District Services of Health, Women and Social Action, SDSMAS) levels, with primary care delivered through health centres and posts that leave large gaps in rural coverage [12]. HIV, TB and malaria account for a large share of the disease burden and of external financing. HIV prevalence among adults aged 15 years and older was 12.5% in the 2021 population-based survey [13], with an estimated 2.2 million adults living with HIV in 2023 [14] and about 1.7 million people on antiretroviral therapy (ART) [15]; TB incidence is high with substantial HIV co-infection, and malaria is the leading cause of outpatient consultations [12].

These programmes are particularly exposed to climate shocks. They depend on continuous supply of medicines and diagnostics, which floods interrupt by cutting roads and destroying stores. ART and TB treatment require sustained adherence, and unplanned treatment interruption increases the risk of virological failure, drug resistance, onward transmission and death [16,17]. Displacement to temporary accommodation centres breaks the link between patients and their usual facility [18]. Many facilities stand in flood-prone lowlands. Floods also create breeding sites for *Anopheles* mosquitoes, so malaria transmission may rise just as services fail [19]. The risks extend beyond the Global Fund priority diseases: overcrowding in temporary accommodation centres favours TB transmission [18,46], and contaminated drinking water during floods increases the risk of waterborne diseases such as cholera and diarrhoeal illness [46,47].

Most evidence on climate and health in Mozambique describes acute disaster impacts; less attention has been given to the structural and governance determinants of vulnerability and adaptive capacity, or to how actors at different levels of the

system perceive them [20]. This gap matters because Mozambique already has a policy architecture for climate and health: the National Vulnerability and Adaptation Assessment (NVAA, 2020) identified priority districts, the National Adaptation Plan and the Health Sector Strategic Plan (PESS) present climate resilience as a central axis for service continuity, and disaster response is coordinated by INGD through the National Emergency Operations Centre (CENOE) [12,21–23]. Recent work has examined how climate data are integrated into and used by the national health system [24], and studies after Cyclones Idai and Freddy documented disruption of HIV and other services [25–27]. Whether these policies reach districts, facilities and communities during a shock remains largely unexamined. Few studies have used a whole-system framework to examine the problem from the combined perspectives of government managers, health workers, implementing partners and communities.

This study aimed to analyse how these four stakeholder groups perceive the impacts of climate shocks on health services in Mozambique, with emphasis on HIV, TB and malaria. Specifically, we sought to (i) identify the climate shocks that most affect service continuity; (ii) assess perceived resilience of infrastructure, supply chains and human resources; (iii) examine intersectoral coordination and communication between levels of the system and communities; (iv) document local adaptation and continuity strategies; and (v) identify gaps and opportunities for strengthening resilience, organised by the six WHO health system building blocks [28,29].

2. Materials and methods

2.1 Study design

We conducted an exploratory, descriptive cross-sectional study using a convergent parallel mixed-methods design [30,31]. Quantitative (closed-ended) and qualitative (open-ended) data were collected simultaneously with the same instrument, analysed separately, and integrated at interpretation. Reporting follows the Consolidated Criteria for Reporting Qualitative Research (COREQ) [32] and the Good Reporting of A Mixed Methods Study (GRAMMS) guidance [33] (S1 Checklist).

2.2 Conceptual framework

The qualitative analysis was structured by the six WHO health system building blocks [28,29]: (1) service delivery, (2) health workforce, (3) health information, (4) medical products and technologies, (5) health financing and (6) leadership and governance. For each block we defined the components relevant to climate shocks: continuity and access for service delivery; distribution, working conditions and crisis support for the workforce; early warning and communication for information; supply chains, strategic reserves and infrastructure for medical products; sufficiency, predictability and flexibility for financing; and contingency planning, intersectoral coordination, decentralisation and community participation for governance. The framework also allowed us to examine links between blocks, consistent with WHO's climate-resilient health systems framework [3].

2.3 Setting

The study took place in four provinces selected purposively for recent climate exposure and HIV burden. Gaza lies in the Limpopo basin and experienced major floods in 2000, 2013 and 2026; Sofala was the province most affected by Cyclone Idai in 2019; Maputo Province experienced floods and intense rainfall in 2026; and Cabo Delgado was struck by Cyclone Kenneth in 2019 and has a complex humanitarian context. Gaza and Maputo provinces have among the highest adult HIV prevalence in the country [13]. Coverage was uneven: Cabo Delgado contributed three participants (two NGO, one community) and no government or facility respondents, and Sofala had no community or facility respondents, so province-level comparisons were not possible.

2.4 Participants and sampling

We purposively sampled 25 stakeholders with direct experience of climate shocks in four groups (Table 1). Sample size was set before fieldwork on pragmatic grounds and judged against the principle of information power [34]: the aim was focused, participants had direct experience of the 2026 floods, and analysis was anchored in an established framework. Thematic saturation was not formally assessed, and with four to eight participants per group it is unlikely to have been reached within groups [35].

Table 1. Stakeholder groups and recruitment sites.

Group	Profile	n (%)	Recruitment sites
G1	Government officials and health managers (provincial and district)	7 (28.0)	DPS Gaza, DPS Sofala, SDSMAS Chókwè, SDSMAS Xai-Xai
G2	NGO and cooperation agency representatives	4 (16.0)	Ariel Glaser Foundation, ECHO, World Vision, local organisations
G3	Community members (patients and service users)	6 (24.0)	Health centres, resettlement centres, communities
G4	Health facility managers and providers (clinicians, nurses, managers)	8 (32.0)	CS Chiaquelane, Guijá district, Chókwè Rural Hospital, Xai-Xai City Health Centre, CS Moamba

DPS, Provincial Health Directorate; SDSMAS, District Services of Health, Women and Social Action; CS, health centre; NGO, non-governmental organisation.

2.5 Data collection instruments

Four semi-structured questionnaires, one per group, were developed from the literature and reviewed by public health and disaster management specialists. All shared six sections: (A) sociodemographic characteristics (closed, 5–7 items); (B) impacts of climate shocks (mixed, 4–6); (C) resilience of infrastructure and logistics (mixed, 3–5); (D) coordination and communication (mixed, 3–4); (E) adaptation and continuity strategies (open, 2–3); and (F) recommendations (open, 1–2). Example questions were "*How do national or provincial health policies integrate climate considerations into HIV, TB and malaria programmes?*" (G1) and "*In your community, which climate events most affected access to health care?*" (G3). The instruments are provided in S1 File.

2.6 Data collection procedures

Data were collected between 18 February and 2 March 2026, immediately after the floods in southern Mozambique. Six trained interviewers with qualitative research experience and knowledge of the Mozambican health system contacted participants in person or by telephone, read an informed consent statement, and conducted face-to-face interviews at workplaces, homes or accommodation centres. Interviews lasted 45–90 minutes and were conducted in Portuguese. Closed-ended answers were entered directly into Microsoft Excel forms; open-ended answers were recorded in narrative form by the interviewer, with notes on context. Interviews were not audio-recorded; quotations reported here are therefore near-verbatim extracts from interviewers' notes, translated from Portuguese by the authors, with the Portuguese originals provided in a supporting file [Supplemantary file 1]. Because the absence of audio recordings placed greater reliance on interviewer notes, note-taking was standardised across all six interviewers to ensure consistency in the capture and recording of data. A common note-taking template was developed prior to fieldwork, structured around the core themes of the interview guide, with designated sections for contextual observations (e.g. setting, non-verbal cues, and interview dynamics), verbatim quotations, and reflective memos. All interviewers used this identical template for every interview.

To reinforce consistency, a half-day pre-fieldwork training session was held, during which the team reviewed the template, practised note-taking using a recorded mock interview, and compared their notes to calibrate the level of detail, use of

abbreviations, and conventions for distinguishing verbatim quotes from paraphrased summaries. Discrepancies identified during this exercise were discussed and resolved, and a brief written protocol was agreed upon. After fieldwork, the study team held a debriefing focus group with the interviewers to consolidate field observations.

2.7 Data analysis

Quantitative analysis. Closed-ended responses were compiled in Microsoft Excel and summarised as frequencies and percentages of all respondents in each group, stratified by group; non-responses were retained in the denominator and are reported where they occurred. Given the exploratory aims and small sample, no inferential statistics were computed; we report counts alongside percentages throughout.

Qualitative analysis. Open-ended responses from all 25 participants (a corpus of about 12,000 words) were analysed with Bardin's three-stage content analysis [36]. In pre-analysis, the team read the corpus repeatedly and drafted initial themes. In the exploration stage, two analysts independently coded each unit of meaning to a WHO building block and to an inductively derived subcategory within it, then compared codes and resolved differences by discussion until consensus. In the interpretation stage, coded material was organised into thematic matrices by block and subcategory and interpreted in its institutional and political context. Translation of quotations from Portuguese to English was done by the authors.

Integration. Quantitative and qualitative results were merged in joint displays by building block to identify convergence, complementarity and divergence across groups and methods [31].

2.8 Trustworthiness

Credibility was supported by triangulating across four stakeholder groups and two data types, and by informal member checking. Transferability was supported by describing the setting, participants and procedures in detail. Dependability was supported by documenting coding decisions and the consensus process, and confirmability by grounding interpretations in near-verbatim extracts from interviewer notes [37]. Reflexivity: the six interviewers were one woman and five men: three clinical psychologists (one woman, two men), two public health medicine specialists and one monitoring and evaluation officer. All six were affiliated with I-TECH, and none had a prior personal, supervisory or professional relationship with any participant. The predominance of male interviewers may have influenced how some women participants responded. The study team is affiliated with I-TECH, an implementing partner that supports HIV services in some of the districts and facilities studied, so some participants may have perceived the team as linked to their funders. Interviewers explained that participation would not affect programme support and that responses would not be attributed to individuals. This positionality may have shaped responses, for example by encouraging favourable accounts of partner support, and was considered during analysis.

2.9 Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles for research involving human participants set out in the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional

Bioethics Committee for Health (Comité Institucional de Bioética para Saúde de Gaza; IRB0002657; ref. 106/CIBS/2026). Informed consent was obtained from all participants before each interview. Consent was given verbally and documented by the interviewer on the questionnaire. Verbal rather than written consent was used because the study posed no more than minimal risk to participants and post-disaster field conditions made written consent impractical; this consent procedure was approved by the ethics committee. Only adults aged 18 years or older were eligible to participate. To protect confidentiality, all personal identifiers were removed from the questionnaires and the study database, and quotations are attributed only by participant role and province.

3. Results

3.1 Participant characteristics

Of the 25 participants, 11 (44.0%) were from Gaza, 8 (32.0%) from Maputo Province and 3 (12.0%) each from Sofala and Cabo Delgado (Table 2). Most were aged 25–34 years (14, 56.0%) and male (16, 64.0%); women made up half of the NGO and facility groups.

Table 2. Sociodemographic characteristics of participants by stakeholder group (N = 25).

Characteristic	G1 (n = 7)	G2 (n = 4)	G3 (n = 6)	G4 (n = 8)	Total, n (%)
Province					
Gaza	4	0	2	5	11 (44.0)
Maputo Province	1	1	3	3	8 (32.0)
Sofala	2	1	0	0	3 (12.0)
Cabo Delgado	0	2	1	0	3 (12.0)
Age, years					
<25	0	0	1	0	1 (4.0)
25–34	4	2	2	6	14 (56.0)
35–44	2	2	2	1	7 (28.0)
45–54	1	0	1	1	3 (12.0)
Sex					
Male	6	2	4	4	16 (64.0)
Female	1	2	2	4	9 (36.0)

G1, government officials and health managers; G2, NGO and donor representatives; G3, community members; G4, health facility managers and providers.

3.2 Quantitative findings

Floods were the dominant shock: most managers (5/7) and community members (4/6) rated floods as the most impactful event, and all eight facility respondents reported that their facility had been affected by floods (Table 3). HIV testing and ART was the service most often chosen as the single most affected by community members (4/6; the other 2/6 said all services were equally affected) and was listed among affected services by 7/8 facility respondents, alongside routine consultations and maternal and child health (6/8 each).

Government managers described a system poorly prepared at the policy level. Only 2/7 considered climate to be integrated into health policies (3/7 said it was not; 2/7 did not know). Vulnerable infrastructure (3/7) and insufficient financing (2/7) were the main adaptation gaps cited. Five of seven rated supply chains as "*not at all resilient*", with severe interruptions or total collapse during shocks, and 2/7 as resilient; the item offered no intermediate option. Four of seven reported no formal intersectoral coordination mechanism, 2/7 reported a formal and active one and 1/7 did not respond. Four of seven said communities were rarely or never involved in planning, 1/7 reported systematic participatory involvement and 2/7 did not respond.

All four NGO and donor respondents described their organisations' action on climate shocks as exclusively reactive, and 3/4 rated the local health system as "*not prepared*" and current climate–health financing as insufficient. Integrating climate

data into health information systems and green infrastructure with renewable energy (3/4 each) were seen as the most promising innovations, followed by community surveillance systems and disaster health insurance (2/4 each).

Among community members, impassable roads (3/6) and closed or damaged facilities (2/6) were the main barriers to care. Only 2/6 maintained access through mobile clinics, and 4/6 received no support from community health workers during the emergency.

Table 3. Key quantitative indicators by stakeholder group.

Indicator	G1 (n = 7)	G2 (n = 4)	G3 (n = 6)	G4 (n = 8)
Floods identified as most impactful shock (G4: facility affected by floods*)	5 (71.4)	—	4 (66.7)	8 (100)*
HIV identified as most affected service (G4: listed among affected services†)	—	—	4 (66.7)	7 (87.5)†
Climate not integrated in health policy	3 (42.9)	—	—	—
Supply chains "*not at all resilient*"	5 (71.4)	—	—	—
No formal intersectoral coordination mechanism	4 (57.1)	—	—	—
Communities rarely or never involved in planning	4 (57.1)	—	—	—
Organisational action exclusively reactive	—	4 (100)	—	—
Health system "*not prepared*"	—	3 (75.0)	—	—
Current financing insufficient	—	3 (75.0)	—	—
No support from community health workers	—	—	4 (66.7)	—
Written contingency plan in place	—	—	—	3 (37.5)

Values are n (%) of all respondents in each group; non-responses are retained in the denominator. —, item not asked of this group. *G1 and G3 answered a single-choice item on the most impactful shock; G4 answered a multiple-response item on which shocks had affected the facility (floods 8/8, cyclones 2/8, heatwaves 1/8). †G3 answered a single-choice item; G4 answered a multiple-response item (see Table 4). Values in these rows are therefore not directly comparable across groups.

Health facility respondents described multiple, simultaneous disruptions (Table 4). Interruption of routine consultations (7/8), patient access difficulties (6/8) and shortages of medicines and supplies (6/8) were most common, and 3/8 reported absence of health workers. Beyond HIV, routine consultations and maternal and child health (6/8 each), malaria and laboratory services (5/8 each) and TB (4/8) were affected. Coordination with the National Institute for Disaster Risk Management and Reduction (INGD) and local authorities (7/8) was the most common immediate response. Continuity relied mainly on NGO and partner support (6/8), community mobilisation (5/8) and multi-month dispensing of medicines (4/8). Only 3/8 had written contingency plans and 1/8 an early warning system.

Table 4. Effects of climate shocks and responses reported by health facility managers and providers (G4, n = 8).

Domain	Response	n (%)
Effects on services	Interruption of routine consultations	7 (87.5)
	Patient access difficulties	6 (75.0)
	Shortage of medicines and supplies	6 (75.0)
	Infrastructure damage	5 (62.5)
	Interruption of specific programmes (HIV, TB, malaria)	5 (62.5)
	Absence of health workers	3 (37.5)
	Reduced demand for services	3 (37.5)

Domain	Response	n (%)
Services most affected	HIV (ART, testing)	7 (87.5)
	Routine consultations	6 (75.0)
	Maternal and child health	6 (75.0)
	Malaria (testing, treatment)	5 (62.5)
	Laboratory services	5 (62.5)
	TB (diagnosis, treatment)	4 (50.0)
Immediate measures	Coordination with INGD and local authorities	7 (87.5)
	Temporary relocation of services	5 (62.5)
	Community mobilisation	5 (62.5)
	Redistribution of medicines	4 (50.0)
	Mobile clinics	3 (37.5)
	Rescheduling of opening hours	3 (37.5)
Continuity mechanisms	NGO and partner support	6 (75.0)
	Community mobilisation	5 (62.5)
	Multi-month dispensing of medicines	4 (50.0)
	Referral to other facilities	4 (50.0)
Medium- and long-term strategies	Inter-facility referral plans	4 (50.0)
	Improved communication with communities	4 (50.0)
	Written contingency plans	3 (37.5)
	Infrastructure improvements	2 (25.0)
	Staff training	2 (25.0)
	Early warning systems	1 (12.5)

Multiple responses were allowed. INGD, National Institute for Disaster Risk Management and Reduction.

3.3 Qualitative findings by WHO building block

Content analysis yielded 25 subcategories (155 coded citations) across the six blocks (Table 5). Governance (34 coded citations) and service delivery (36) were the most densely coded blocks.

Table 5. Coding frame: subcategories and number of coded citations by WHO building block.

WHO building block	Subcategories (coded citations)	Total
1. Service delivery	Interruption of essential services (12); continuity strategies (10); disproportionate impact on HIV (8); most affected services (6)	36
2. Health workforce	Unsupported health workers (7); absence of staff from facilities (5); need for psychosocial support (4)	16
3. Health information	Early warning failure (9); ineffective communication between levels (6); communication with communities (5); potential of digital systems (4)	24
4. Medical products and technologies	Fragile supply chains (8); loss of medicines, and supplies (6); medicine management strategies (5); loss of technologies and innovations (4)	23
5. Health financing	Role of partners and donors (7); insufficient financing (6); reactive versus proactive approach (5); need for sustainable financing to meet recurrent replacement and reconstruction needs after cyclical destruction (4)	22
6. Leadership and governance	Centralisation and bureaucracy (8); weak intersectoral coordination, with generic rather than sector-specific responses (7); lack of planning and institutional learning (6); limited involvement of communities and front-line responders in planning and communication (5); political barriers (4); decentralisation as the way forward (4)	34

3.3.1 Block 1: Service delivery

Climate shocks disrupted both supply and demand for care, and disruption was often complete: "*There was a total interruption of health services*" (health manager, Gaza). Access was the main pathway: "*[The events] affect a lot, mainly patients' ability to come to the health facilities*" (health manager, Sofala). Respondents warned that short-term disruption became lasting loss to follow-up: patients who live far away "*become defaulters*" (health provider, Gaza). Patients who had received precautionary advance doses sometimes lost their medicines when their homes were flooded.

HIV care was the most affected service. A patient in Maputo Province reported: "*When the rain started I only had ARVs for three days, so I spent several days without pills.*" A manager in Gaza noted that recently diagnosed patients with chronic disease "*end up without medication*". Respondents linked this vulnerability to dependence on uninterrupted supply, the need for regular clinical contact, displacement away from the usual facility and HIV-related stigma in crowded accommodation centres. Disruption also extended beyond priority programmes: "*Psychiatric patients end up without their medication and … become aggressive, worsening their illness*" (clinician, Gaza).

Continuity strategies were real but improvised. They included "*quarterly dispensing under the emergency*" and "*ad hoc dispensing of medicines*" (health providers, Gaza), "*integrated mobile brigades (TB, pharmacy, PMTCT, maternal and child health)*" (health provider, Gaza), service points in resettlement centres, and DPS redeployment of staff to accommodation centres. These measures were activated after the crisis began and frequently depended on partners for transport and other logistics, and for replenishing essential emergency medicines and medical products.

3.3.2 Block 2: Health workforce

Health workers were described as both victims and responders. "*Health professionals were left helpless: there was no logistical support (transport, fuel) nor conditions for rest or accommodation, leading to physical and emotional exhaustion*" (health manager, Gaza). Many "*end up losing houses and means of transport, and some have had their access roads cut off*" (health manager). Those who reached facilities were overloaded: "*Health professionals worked to exhaustion, without any support*" (health manager, Gaza). Shift rosters became hard to maintain: with access roads cut and staff dealing with their own emergencies, workers on duty often went unrelieved across consecutive shifts. At the same time, demand rose well above normal levels, driven by trauma, disease outbreaks and the concentration of displaced people in temporary accommodation centres, while facilities lacked the equipment and supplies needed for diagnosis and treatment. Managers stressed that competence was not the problem—"*our colleagues are capable*"—but institutional support was absent: "*It is not possible to respond to an emergency with exhausted and abandoned teams*" (health provider, Gaza).

Psychosocial services operated without guidance: "*Those of us in the psychosocial area go to the field blindly and do our activities as we see fit*" (health manager, Gaza). Respondents asked for training so that teams could "*do everything in a standardised way*", and for psychosocial support for staff themselves.

3.3.3 Block 3: Health information

Early warning failed on timeliness, reach and actionability. "*The population did not receive timely alerts about the rising water ('in less than 8 hours the water entered the city'), which made any preparation impossible*" (health manager, Gaza). "*There was no prior mandate to remove medical material*" (health provider, Gaza), and information "*barely reached*" the population, which "*was left in the dark*" (health managers, Gaza). One provider summarised: "*The main lesson is that information saves lives. The lack of early warning and poor management of communication between central, district and community levels paralysed the response.*" Even where warnings arrived, neither communities nor health services had known preparedness and response protocols that an alert would activate, so information did not translate into actionable steps to protect lives and property. When telephone and internet networks failed, facilities had no alternative means, such as satellite phones or two-way radio, to restore communication.

Communication across sectors and levels was described as absent and politicised: "*Communication between sectors is non-existent, and technical information is often delayed by political factors*" (health manager, Gaza); "*[there were] political obstacles in the distribution of information*" (health provider, Gaza). Communities relied on informal networks—"*we communicate among neighbours in the community*" (patient, Cabo Delgado); "*we heard among ourselves that the Administrative Post Chief (community leaders) ordered evacuation to safe places*" (patient, Maputo Province)—and had no contact with their facility: "*while we were in our homes we had no communication with the health facility*" (patient, Maputo Province). NGO respondents saw potential in integrated climate–health data and digital systems but cautioned that oral information systems are needed "*for areas with little or no technology*" (civil society representative, Sofala). Providers proposed early warning "*with accessible language and diversified channels (radio, SMS, sound cars, community leaders)*".

3.3.4 Block 4: Medical products and technologies

Supply chains were described as fragile and externally dependent: "*[They] are not prepared; we depend a lot on support*" and "*we depend on others*" (health managers, Gaza). Respondents noted the absence of strategic reserves and robust logistics plans. Lack of warning led directly to losses—"*loss of medicines in the depot*" (health provider, Gaza)—and laboratory networks failed where specimens were "*transported by motorbike, and when it rains the road floods*" (health provider, Gaza). Emergency stock existed but was "*mobilised ad hoc*", and "*there was no efficient redistribution of supplies*" (health managers, Gaza). The situation was aggravated by the lack of pre-packed emergency kits of medicines and medical products, both kits light enough to move by canoe, helicopter, motorbike, bicycle or on foot, and kits for mobile brigades to meet urgent needs during community assessment visits. Alternative sources of electricity (rechargeable batteries or solar) for cold chain and lighting, and climate-informed logistics, were the innovations most often proposed.

3.3.5 Block 5: Health financing

Financing was seen as insufficient for adaptation—"*there is a lack of funding for integration to be done effectively*" (health manager, Sofala)—and channelled to post-disaster response rather than preparedness. Respondents expressed frustration at the repetition: "*It was expected that 25 years after the 2000 floods the province would have better capacity*"; "*If nothing changes, we will always be reacting to the disaster instead of preventing it*" (health managers, Gaza). Dependence on

partners was viewed ambivalently: "*Fortunately or unfortunately, a good part of the National Health Service is managed by partners*" (civil society representative). Proposals included a dedicated credit line for disaster-ready infrastructure, "*self-sustaining programmes*", and involving the state "*in programmes even before they start*" (civil society representatives).

3.3.6 Block 6: Leadership and governance

Participants most often traced other failures to governance. Coordination was "*centralised and not very efficient in practice*", and "*the centralisation of decisions in INGD proved ineffective, because no real support reached the facilities*" (health manager and provider, Gaza); one manager described INGD as "*a merely formal structure*". Intersectoral mechanisms were absent ("*there are no formal committees*", civil society representative; "*no, not yet*", health manager, Sofala), and political factors delayed technical information. Responses were described as generic rather than tailored to the specific needs of each priority sector, such as health or education, and front-line responders (health facilities and health workers) were not involved in planning or communication. Institutional learning was weak: "*nothing is new*"; "*there were plans prepared previously, although practical implementation failed*" (Gaza).

Managers acknowledged the value of community leaders—"*one way is to involve community leaders to mobilise the population; they have more credibility than we do*" (health manager, Gaza)—yet leaders were not part of contingency plans. Participants proposed decentralising the response, "*training health facilities and communities to act locally*", forming local emergency coordination teams, and integrating community health workers and alternative channels (sound cars, community radio) into contingency plans. This would mean decentralising command and control to health-facility level through plans, protocols and standard operating procedures, and delegating the authority to activate them to district health services and health facilities.

3.4 Integration across blocks

Because closed-ended items differed by group in wording and response format (single choice or multiple response), we treat agreement between data sources as qualitative rather than numeric. Quantitative and qualitative data agreed on five points: floods as the dominant shock (G1, G3, G4); HIV as a prominently affected service (single choice in G3; listed among several affected services in G4, although only 5/8 G4 respondents reported interruption of specific programmes, a partial discordance); fragile supply chains (G1 ratings and G4 reports of shortages); weak coordination and planning (G1 reports of absent mechanisms and G4's low proportion of written plans); and community disconnection (G1 reports of low involvement and G3 reports of no CHW support). Table 6 is a joint display showing, for each block, the relevant quantitative item, the qualitative theme and the resulting meta-inference (convergent, complementary or discordant).

Table 6. Joint display of quantitative items, qualitative themes and meta-inferences by WHO building block.

WHO building block	Quantitative item (group, n/N)	Qualitative theme	Meta-inference
1. Service delivery	HIV listed among most affected services (G4, 7/8); HIV most affected service, single choice (G3, 4/6); interruption of specific programmes (G4, 5/8)	Total service interruption; HIV care most affected; ad hoc continuity	Convergent, with partial discordance (programme

WHO building block	Quantitative item (group, n/N)	Qualitative theme	Meta-inference
			interruption reported by only 5/8 G4)
2. Health workforce	Absence of health workers (G4, 3/8)	Staff without transport, shelter or support; exhaustion	Complementary: qualitative accounts explain the reported staff absence
3. Health information	Early warning systems cited as a medium- or long-term strategy (G4, 1/8)	Warnings <8 hours before flooding; politicised, delayed information; no facility–community link	Convergent (indirect quantitative evidence)
4. Medical products and technologies	Supply chains "not at all resilient" (G1, 5/7); shortage of medicines and supplies (G4, 6/8)	Stock losses; single-mode specimen transport	Convergent
5. Health financing	Current financing insufficient (G2, 3/4); organisational action exclusively reactive (G2, 4/4); NGO and partner support as continuity mechanism (G4, 6/8)	Partner dependence	Convergent
6. Leadership and governance	No formal intersectoral coordination mechanism (G1, 4/7); written contingency plan in place (G4, 3/8); communities rarely or never involved in planning (G1, 4/7); no support from CHWs (G3, 4/6)	Centralised response; weak coordination and planning; community disconnection	Convergent

4. Discussion

This mixed-methods study, conducted weeks after the 2026 floods, found that climate shocks expose vulnerabilities in every WHO building block of Mozambique's health system, and that these vulnerabilities reinforce one another. Floods were the dominant shock, HIV services were the most disrupted, and continuity depended on improvised, partner-funded measures rather than plans. Most failures reported in service delivery, workforce, information, supplies and financing traced back to governance: centralised decision-making, absent intersectoral mechanisms, politicised information flows and exclusion of communities.

4.1 Vulnerabilities as interlocking cycles

The building-block lens shows that weaknesses do not occur in isolation. From participants' accounts we propose three self-reinforcing cycles as an interpretive model, to be tested rather than taken as demonstrated pathways. In a fragility cycle, vulnerable infrastructure and unprotected stocks (block 4) leave health workers without the means to work (block 2), services stop (block 1), and the recovery bill competes with scarce budgets (block 5), so infrastructure remains fragile. In a coordination cycle, centralised and politicised governance (block 6) delays warnings (block 3), people and medicines are caught unprepared, losses follow, and the absence of after-action learning leaves governance unchanged. In a dependency cycle, insufficient domestic financing (block 5) leads to reliance on partners, who fund ad hoc continuity measures (block 1) that lapse when emergency funding ends. These cycles echo the observation that resilience is a property of interactions between system components rather than of any single component [3–5,38], and they may help explain why the same complaints recur: a health manager in Gaza observed that, 25 years after the 2000 floods, the province "*was expected to have built better capacity*", and a health professional in Gaza summarised: "*nothing is new*". A recent situational analysis by our group places this recurrence in a longer arc: Mozambique experienced 27 cyclones over the past two decades, and the national vulnerability assessment classifies more than 30% of the territory and 24% of the population as highly vulnerable in health terms, with 51 districts of low and 63 of very low adaptive capacity [21,45]. Six of the most affected districts are in Gaza and five in Maputo Province, the two provinces that contributed most participants here, which suggests that the cycles we describe are structural features of the setting rather than artefacts of a single event.

4.2 HIV as a sentinel of system resilience

HIV services were the most disrupted by both providers' and users' accounts. ART continuity depends on every building block at once: functioning facilities and outreach, available staff, timely information to patients, protected stock, financing for reserves, and contingency plans that include ART. A patient left "*several days without pills*" therefore signals failure across the system, not only within the HIV programme. Treatment interruption carries known risks of viral rebound, resistance and mortality [16,17], and Mozambique's large ART cohort means that each flood season threatens gains achieved over two decades. We propose that ART continuity during and after climate shocks be monitored as a sentinel indicator of climate resilience, for example the proportion of ART patients with at least three months of medicines at the start of the cyclone and flood season, or the proportion who miss a refill during an event. Such indicators could be derived from ART refill records in the national electronic patient tracking system (EPTS) [39], from which refill dates can be extracted by

district and event period, although they were not tested in this study and require validation against routine data; if feasible, they would operationalise the monitoring component of WHO's framework [3].

Multi-month dispensing, used ad hoc by facilities in this study, is already recommended in WHO differentiated service delivery guidance [17]. Making pre-season extended dispensing a standard protocol in flood-prone districts would be a low-cost first step. The same logic applies to TB treatment, maternal health and mental health; respondents described psychiatric patients deteriorating without medication. The situational analysis similarly recommends contingency stocks of antiretrovirals, anti-TB drugs, antimalarials, antibiotics and obstetric kits, packed in sealed, waterproof modular kits and held in safe, elevated sites close to high-risk zones [45]. Kits should be designed for the transport realities of a flood, light enough to be carried by canoe, motorbike, bicycle or on foot when roads are cut, and mobile-brigade kits should allow teams visiting affected communities to replace lost doses for people on TB or HIV treatment, test and treat malaria during outbreaks, and distribute water purification tablets for community water sources. Designing and pre-positioning such kits is among the most important preparedness measures for restoring health services quickly during a crisis. It also documents the destruction of paper records and computers during floods, leaving patients without clinical histories [45]; offline data capture with later synchronisation, and backup of EPTS data at provincial and national levels, would protect both continuity of care and the sentinel indicators proposed above.

Evidence from people living with HIV indicates that multi-month dispensing is associated with higher viral suppression than standard-of-care refills, supporting its use as a preparedness measure where clinically appropriate and compatible with national guidance [49].

4.3 Governance as a perceived central constraint

Participants located the root of many problems in leadership and governance. INGD was described as "*a merely formal structure*", support did not reach facilities, and most managers did not recognise a functional formal coordination mechanism, although 2/7 reported one. One possible explanation, which our data cannot confirm, is that district-level operational managers are not members of the district crisis committees, which in our experience are largely composed of political and administrative officials; if so, these committees are failing to inform and guide the staff who implement the response. Committee membership and communication flows should be verified in future work. Reports that technical information was "*delayed by political factors*" align with work on disaster politics showing how control of information shapes who is protected [40]. Decentralised and collaborative decision-making is generally associated with faster, more context-sensitive response [41], and participants consistently proposed it: district intersectoral committees that include health, INGD, public works, civil protection and community representatives; written, tested facility contingency plans; and pre-positioned district stocks. These proposals mirror gaps identified in the situational analysis, which found that most current normative instruments do not explicitly address climate risk and that health facilities lack internal emergency protocols defining tasks, responsibilities and activation mechanisms [45]; the low proportion of facility respondents reporting a written contingency plan (3/8) is consistent with this.

Early warning illustrates the governance problem. A people-centred warning system requires risk knowledge, monitoring, dissemination and response capability [42]. In this study, warning reached communities "*in less than 8 hours*", through informal channels, without instructions for health facilities to move stock or patients. Improving forecasts alone will not close this gap; the link from forecast to facility and household via community radio, SMS, sound cars and trusted leaders, in local languages must be designed and rehearsed. An alert is only as effective as the preparedness and response protocols it activates: without known protocols, communities and health services that receive a warning cannot turn it into an actionable plan to prevent and reduce harm to lives and to personal and public property. These protocols must be known in advance and tested, either in real events or in simulation exercises that closely reproduce crisis conditions. Communication also needs redundancy. Cyclone Idai disrupted communications alongside power and water supply [47], yet health facilities had no satellite or two-way radio backup to coordinate the emergency response once telephone and internet networks failed.

Consistent with the four pillars of effective early warning systems, namely risk knowledge, monitoring and forecasting, dissemination and communication, and preparedness to respond, the findings suggest that investment should extend beyond forecasting to rehearsed, facility- and community-level response protocols [42-50].

4.4 Communities as untapped social capital

A striking paradox was that managers described community leaders as having "*more credibility than we do*", yet communities were rarely involved in planning and most community members received no support from community health workers during the floods. Social capital, understood as networks of trust and reciprocity, is one of the strongest predictors of disaster recovery [43,44], and communities in this study were already relaying evacuation information among neighbours. Formally integrating community leaders and health workers into contingency plans, early warning relays and medicine distribution in accommodation centres is a feasible, low-cost lever. The situational analysis proposes a concrete vehicle: community-based epidemiological surveillance through community health committees, using simple tools such as SMS, community radio and visual checklists to report outbreaks and treatment interruptions, followed by post-event reviews [45].

4.5 Financing and partner dependence

All NGO respondents described exclusively reactive action, and facility continuity rested mainly on partner support. Partner capacity is a strength in the acute phase, but dependence on post-event funding sustains the cycles described above. A case study from South Africa suggests that adaptation advances when the health sector holds dedicated budget lines and clear mandates [20]. Pre-arranged financing and climate-resilient infrastructure are also central components of WHO's operational framework, which identifies anticipatory risk management, resilient facilities and supply chains, and sustainable financing as system-wide requirements for climate resilience [3-48]. Participants proposed a dedicated climate-adaptation line in the health budget, a rapid-disbursement emergency fund, financing for disaster-resilient infrastructure and parametric insurance. These proposals correspond to the climate-informed financing component of the WHO framework [3]. The situational analysis adds that reconstruction and restocking after each event divert resources from HIV, TB and malaria programmes, and that shifts in donor priorities or delays in disbursement expose the system to discontinuity [45]. It

recommends district and provincial contingency funds, climate scenarios in medium-term budget planning and participatory local budgets, which would give lower levels immediate access to resources while strengthening accountability [45].

4.6 Implications for policy and practice

Five priorities follow from these findings: (1) reform early warning and risk communication so that alerts are timely, understandable and effective to trigger clear tested and actionable plans and protocols at facility and household level, rehearsed through simulation exercises and backed by redundant communication (satellite or two-way radio) for health facilities when telephone and internet networks fail; (2) decentralise disaster health response to provinces and districts, with written, tested facility contingency plans, district strategic stocks in safe locations, pre-positioned portable emergency and mobile-brigade kits, and local emergency teams; (3) invest in climate-resilient infrastructure, including siting new facilities outside flood zones, solar power for cold chain and lighting, and resilient water and sanitation; (4) integrate community leaders and community health workers into planning, warning and service continuity; and (5) shift financing from post-disaster response to pre-arranged, flexible and domestically anchored preparedness funding. S2 Table details recommended actions, responsible institutions and timeframes by building block, and Section 5 sets out specific recommendations.

4.7 Strengths and limitations

The study's strengths include data collection within weeks of a major flood, when experiences were fresh; the inclusion of four stakeholder groups that rarely appear together, from policy makers to service users; and analysis anchored in an internationally recognised framework, which supports comparison with other settings.

Several limitations apply. First, the sample of 25 is appropriate for qualitative depth but small for quantitative description, and percentages from groups of four to eight respondents should be read as indicative rather than representative. Second, purposive sampling may have favoured informants with stronger views; Gaza was over-represented (11/25), Sofala and Cabo Delgado contributed three participants each with no facility respondents, and provinces such as Zambezia, Nampula and Tete were not included. The eight facility respondents came from five sites, one of them a district directorate, so their answers are not independent facility-level observations. Third, interviews were not audio-recorded; responses were noted by interviewers, which may have lost nuance and introduced interviewer interpretation, although the interviewer debriefing partly mitigated this. Fourth, questionnaires differed by group, so not all indicators can be compared across groups. Fifth, social desirability and the recency of a traumatic event may have shaped responses in either direction. Finally, perceptions were not triangulated with routine service data, such as ART refill or stock-out records, which future studies should add.

5. Recommendations

Drawing on the findings of this study and on the national situational analysis [45], we recommend the following actions, organised by WHO building block and distinguishing measures that can be taken before the next cyclone and flood season from medium- and long-term investments.

Service delivery. Before each season, provide multi-month dispensing of ART, TB and other chronic medicines to patients in flood-prone districts; pre-identify mobile teams and service points in accommodation centres; and designate referral facilities able to absorb patients when peripheral units fail [17,45].

Health workforce. Train facility and district teams in emergency management, safeguarding of supplies and rapid response; establish mobile rapid-response and pharmacy teams that can be redeployed to affected areas; plan transport, accommodation and food for staff when roads are cut; and provide psychosocial support and post-event follow-up, with incentives to retain staff in high-risk areas [45].

Health information. Link forecasts to facilities and households through people-centred, multichannel warnings in local languages, using community radio, SMS and trusted leaders; install servers in elevated, protected sites, back up data at national and provincial levels and use offline devices with later synchronization; and monitor ART continuity as a sentinel indicator using EPTS refill data [39,42,45].

Medical products and technologies. Raise shelving above flood level, store critical medicines in sealed, waterproof modular kits and distribute stocks across several regional depots; pre-position WHO Interagency Emergency Health Kits and contingency stocks of antiretrovirals, anti-TB drugs, antimalarials and obstetric supplies near high-risk zones; and map and test alternative land, river and air routes before the season. Over the medium term, site new facilities and warehouses above historical flood levels, apply climate-resilient building standards and install solar power, facility-level resilience should be assessed using a structured vulnerability-and-adaptation approach covering workforce protection; water, sanitation, hygiene and waste management; reliable and preferably renewable energy; and protected infrastructure, technologies and products [45].

Health financing. Create a dedicated climate-adaptation line in the health budget and district and provincial contingency funds with rapid-disbursement rules; finance pre-positioning, mobile brigades and preventive maintenance before rather than after events; incorporate climate scenarios into medium-term planning; and diversify sources beyond external partners, including domestic resources and parametric insurance [3,45].

Leadership and governance. Institutionalise rapid-response protocols that automatically authorise the mobilisation of kits and supplies once an emergency is declared; delegate decision-making to provinces and districts; ensure that district health managers are represented on district crisis committees alongside INGD, public works, civil protection and community representatives; require written, tested contingency plans for every facility; and conduct after-action reviews that feed back into planning [45].

Communities. Integrate community leaders, co-management committees and community health workers into contingency planning, warning relays, community-based surveillance and medicine distribution in accommodation centres, and involve them in participatory budgeting for preparedness [43,45].

These recommendations derive from stakeholder perceptions and a situational analysis; their feasibility, costs and effects should be assessed with the Ministry of Health and INGD before scale-up.

6. Conclusions

Climate shocks in Mozambique interrupt health services across all six WHO building blocks, and the resulting vulnerabilities appear systemic and mutually reinforcing, and participants most often traced failures to governance. HIV treatment emerged as a highly exposed service, and its continuity warrants evaluation as a sentinel indicator of whether the health system is climate-resilient. The lessons are not new to those who live them; what is missing is the shift from a reactive, centralised and partner-dependent model to one in which districts, facilities and communities are prepared, resourced and empowered before the next flood or cyclone arrives. Operationalizing these priorities will require facility-level vulnerability assessment, pre-arranged financing and tested protocols that link meteorological warnings to concrete actions by health facilities, households and communities.

Declarations

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Ethics approval and consent to participate. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Bioethics Committee for Health (Comité Institucional de Bioética para Saúde de Gaza; IRB0002657; ref. 106/CIBS/2026). Informed consent was obtained from all participants before data collection. Consent was given verbally and documented by the interviewer on the questionnaire; the ethics committee approved this verbal consent procedure because the study posed no more than minimal risk and post-disaster field conditions made written consent impractical. All participants were adults aged 18 years or older.

Consent for publication. Not applicable. The manuscript contains no images or personal or clinical details that could identify any individual participant; quotations are attributed only by participant role and province.

Data availability statement. *The de-identified quantitative dataset and the coded qualitative extracts underlying the findings are provided as Supporting Information. Full interview notes cannot be shared publicly because they contain potentially identifying information about participants in small communities; these are available from the corresponding author on reasonable request.*

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