

Climate-Resilient WASH: Evaluating Adaptation Strategies, and Sustainability in Disaster-Prone Communities of Cabo Delgado, Mozambique

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doi.org/10.64643/JATIRV2I6-140651

Abstract— *This study examines the role of climate-resilient water, sanitation, and hygiene (WASH) intervention in strengthening community resilience in two disaster-prone districts of Cabo Delgado province, Mozambique: Mecufi and Metuge. Climate-related hazards, cyclones, floods, droughts, and conflict-induced displacement, place considerable strain on water, sanitation, and hygiene (WASH) systems throughout Cabo Delgado Province, Mozambique. The study used a convergent mixed-methods design that combines a household survey of 350 respondents with 30 key informant interviews, four focus group discussions with women, men, youth, and community health worker, WASH committee representatives, and direct field observation of WASH facilities. The study assessed water access, sanitation infrastructure, hygiene practices, health outcomes, household and community disaster preparedness, and the governance structures supporting WASH service sustainability. Findings indicate that climate-resilient WASH interventions including elevated and flood-protected water points, durable latrine construction, and community-based WASH committees were associated with statistically meaningful improvements in water source functionality during climatic shocks, reductions in self-reported diarrhoeal morbidity, and stronger household-level disaster preparedness relative to non-intervention comparators within the same districts. Nonetheless, the study identifies persistent governance and financing gaps that threaten the long-term sustainability of these gains, including inconsistent user-fee collection, delayed repairs, and uneven engagement of local authorities. The study concludes with recommendations for strengthening the institutional, financial, and gender-inclusive foundations of climate-resilient WASH programming in Cabo Delgado and comparable disaster-prone settings across Mozambique.*

Index Terms— *climate-resilient WASH, community resilience, disaster preparedness, water and sanitation, sustainability, Cabo Delgado*

I. INTRODUCTION

Mozambique ranks among the countries most exposed to climate-related hazards in sub-Saharan Africa, and Cabo Delgado province exemplifies this exposure in its most acute form. Tropical cyclones, seasonal flooding, recurrent drought, and conflict-induced displacement converge in this province to produce a compounded crisis environment in which water, sanitation, and hygiene (WASH) systems are simultaneously a precondition for community health and one of the most climate-vulnerable elements of local infrastructure. When a borehole is damaged by flooding, when a latrine collapses in a cyclone, or when a water source runs dry during drought, the consequences cascade rapidly into disease outbreaks, malnutrition, and the erosion of the basic dignity and stability on which community resilience depends Instituto Nacional de Gestão e Redução do Risco de Desastres [INGD], 2022; World Bank, 2022).

The Intergovernmental Panel on Climate Change does not soften this point in its most recent assessment: Africa has contributed almost nothing to the emissions driving global warming, yet it is already absorbing climate losses in water availability, food production, and economic growth, with coastal and low-lying communities like those in Cabo Delgado bearing some of the heaviest exposure on the continent (Trisos et al., 2022). Cyclones come in off the Indian Ocean more often than they used to, the rains bring floods, the dry months bring drought, and a long-running conflict has forced tens of thousands of people out of their homes and into communities that were never built to hold them (UN Office for the Coordination of Humanitarian Affairs [OCHA], 2025). These hazards rarely occur independently; instead, they often overlap and reinforce one another, creating complex and cascading risks.

Consequently, water, sanitation, and hygiene (WASH) systems are situated at the nexus of these intersecting challenges, serving not only as an essential foundation for community health but also as one of the most exposed and fragile forms of infrastructure that district authorities are required to sustain under increasingly adverse conditions (Bartram & Cairncross, 2010). These challenges are not merely theoretical concerns; they are realities that communities confront every day. When a flood submerges a borehole, a cyclone tears the roof from a latrine block, or a shallow well runs dry before the end of the dry season, the consequences extend far beyond the loss of physical infrastructure. Communities face reduced access to safe water, increased health risks, and greater vulnerability to disease outbreaks. Following severe weather events, local health facilities often experience a rise in diarrhoeal and other waterborne diseases, placing additional strain on already overstretched health systems. This illustrates how vulnerable WASH systems directly affect public health, community well-being, and resilience in disaster-prone settings.

Mozambique has already lived through exactly this scenario, on a national scale. When Cyclone Idai tore through the centre of the country in March 2019, the water infrastructure it destroyed and the sources it contaminated, led to outbreak of cholera epidemic that infected thousands of people in a matter of weeks, brought under control only by an emergency WASH taskforce and a fast-moving oral cholera vaccination campaign (Lequechane et al., 2020). Something similar, on a

smaller and more local scale, turned up again closer to the districts this study looks at: a 2022 survey of internally displaced people and host residents in Cabo Delgado's resettlement sites found real gaps in cholera knowledge and inconsistent WASH practices, leaving displaced households more exposed to outbreak risk than their neighbours (Di Gennaro et al., 2023). None of this is ancient history. It is the backdrop any honest assessment of climate-resilient WASH programming in Mecufi and Metuge has to reckon with.

The conflict in Cabo Delgado has tightened the pressure on WASH systems. A wave of attacks that began in December 2023 displaced more than 100,000 people in just three months, and the escalation that followed between January and June 2024 displaced nearly five times as many people as the whole of 2023 pushing the total number of people displaced across the province past half a million by the second half of that year (International Organization for Migration [IOM], 2024; OCHA, 2024). A 2024 community-based study of conflict survivors in Cabo Delgado found substantial rates of post-traumatic stress, depression, and anxiety among displaced residents, a reminder that the WASH systems this study examines do not operate in a vacuum, but inside a wider climate of trauma and instability that shapes how households experience, and recover from, every additional shock (Manafe et al., 2024). It is this stacking of climatic, epidemiological, and conflict-driven stress that has pushed global WASH actors to start treating climate resilience as something infrastructure simply has to have, not an upgrade to bolt on once funding allows (UNICEF, 2020; World Health Organization [WHO], 2022).

For a long stretch of its recent history, WASH intervention in fragile, disaster-prone settings has treated climate resilience as an afterthought rather than a starting assumption. There has always been pressure to expand basic coverage fast, get more people to any water source, any latrine and that pressure has tended to crowd out the harder, more expensive question of whether the infrastructure will still be standing after the next major shock (Lockwood & Smits, 2011). Climate-resilient WASH intervention exists to correct that: elevated, flood-protected water points; water sources built to survive drought; stronger construction materials; and, just as critically, governance arrangements that can actually finance and coordinate repairs when something breaks, the same qualities the disaster risk reduction literature treats as defining features of a genuinely resilient community (Twigg, 2009). Even so, recent sector reviews are not especially reassuring on this front, noting that adaptation across the WASH sector remains patchy, with public health and water utility actors still only loosely engaged in climate-resilient design despite a growing sense of how much is at stake (Marcus, 2023).

This study was carried out in two of Cabo Delgado's districts, Mecufi and Metuge, chosen precisely because they share much of that hazard exposure while pulling apart sharply on geography and demographic pressure. Both have weathered cyclones and flooding. Metuge, on top of that, has absorbed a large share of the people displaced by the regional conflict, which puts a different kind of strain on its WASH systems altogether (OCHA, 2025). The question driving the research is simple to state and harder to answer with confidence: does climate-resilient WASH interventions actually deliver better water access, better health, and stronger community resilience in practice

and if it does, what does it take to keep those gains alive once construction wraps up and the slower, less visible work of maintenance and governance begins? To give both districts an equal and statistically comparable say in that answer, the study deliberately split its quantitative and qualitative samples evenly between Mecufi and Metuge, a design choice the Methodology section takes up in more detail.

II. METHODOLOGY

This study was organised around the main objective and five specific objectives, and together they shaped both the data collection tools and the results. Each objective was deliberately tied to established resilience and disaster-risk-reduction thinking (Cannon, 2008; Twigg, 2009), so that what actually got measured in the household survey, the key informant interviews, and the focus group discussions would speak to recognised dimensions of community resilience, not just to WASH coverage in isolation.

Main objective was to evaluate how effective, health-protective, and sustainable climate-resilient WASH interventions has been at strengthening community resilience to climatic and disaster-related shocks in Mecufi and Metuge districts, Cabo Delgado province, Mozambique.

Specific objectives:

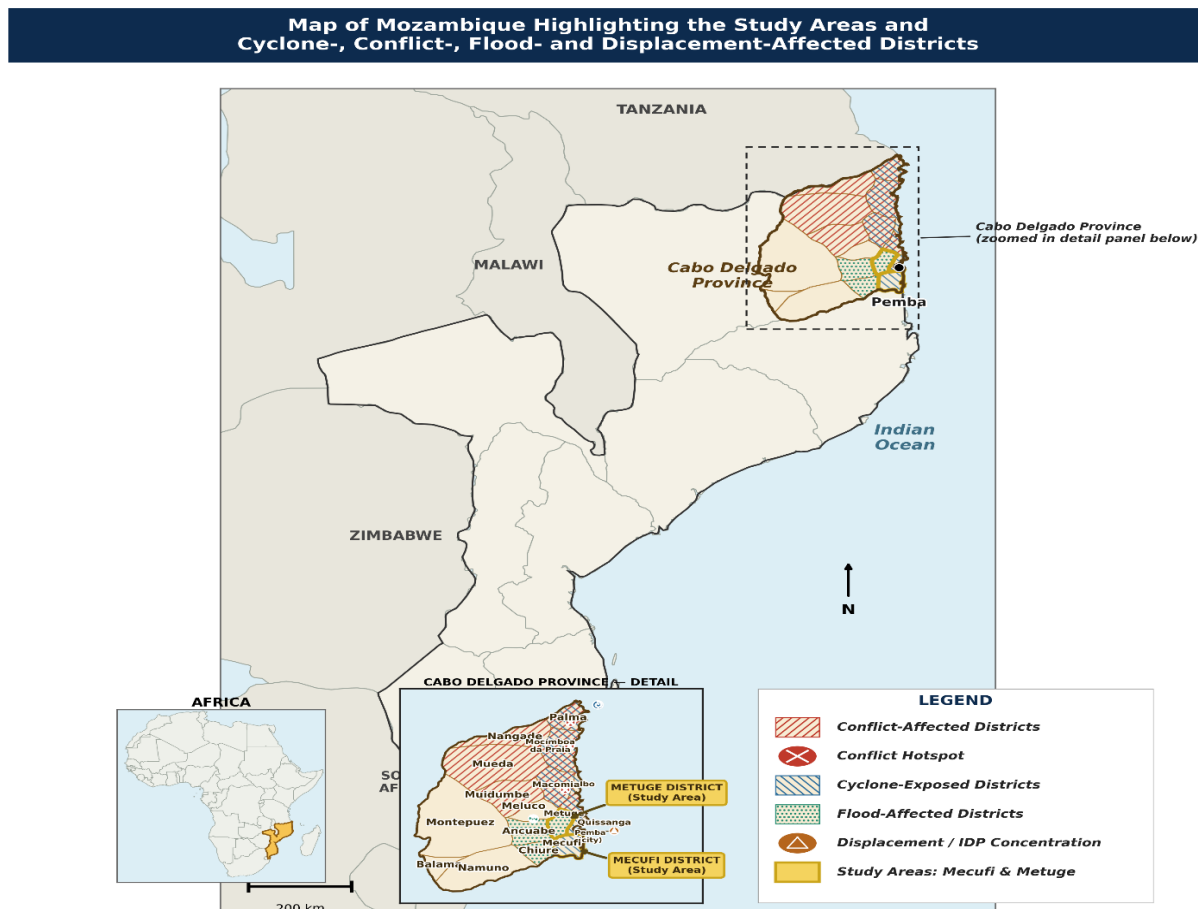
1. Assess how far climate-resilient WASH infrastructure i.e. water points and sanitation facilities, keeps functioning during and after climatic shocks, relative to conventional infrastructure.
2. Examine household hygiene practices and the channels that actually carry hygiene-promotion information into communities.
3. Determine whether climate-resilient WASH access is associated with self-reported health outcomes, including diarrhoeal morbidity and cholera incidence.
4. Evaluate household- and community-level disaster preparedness such as emergency planning, early warning access, evacuation knowledge in relation to exposure to WASH intervention.
5. Assess the governance and financing arrangements, including WASH committees, user fees, and repair systems, that underpin whether climate-resilient WASH services last.

Study Area

Mecufi and Metuge are both districts of Cabo Delgado province in northern Mozambique. Both were chosen because they face much of the same climatic hazard and have been priority sites for humanitarian and development partners delivering climate-resilient WASH interventions between 2021 and 2025 with elevated, flood-protected boreholes; durable, gender-segregated latrines; and community-based WASH committees responsible for day-to-day operations and maintenance.

Mecufi runs along the coast, south of the provincial capital, Pemba. People here make their living mostly through artisanal fishing and smallholder farming, and the district's position on the Indian Ocean leaves it open to storm surge, cyclone-driven flooding, and a slow creep of saline intrusion into shallow water sources (INGD, 2022; Trisos et al., 2022). Several of the major cyclones that have battered Cabo Delgado over the past decade have hit Mecufi directly or nearly so, and its sandy coastal soils make it a genuinely difficult place to build a latrine that is still standing and structurally sound a year on.

Metuge district sitting inland right next to Pemba City has become one of the main destinations for people displaced by the conflict that has unsettled northern Cabo Delgado since 2017 (OCHA, 2025), a conflict that kept generating fresh displacement well into 2024 even as some earlier IDPs began returning to their original home (IOM, 2024; Manafe et al., 2024). Some of the province's largest resettlement sites are in Metuge district, and that influx has put real strain on water and sanitation systems that were never engineered for this kind of population density. Where Mecufi's hazard profile is dominated by the sea, Metuge is dominated by its river drainage systems, seasonal flooding made worse by settlements that have grown up quickly, and often with limited planning, in exactly the area's most prone to flooding, a dynamic also highlighted as a constraint on the province's broader economic stabilisation (World Bank, 2022).



Research Design

The study adopted a convergent parallel mixed-methods design, in which quantitative and qualitative data were collected concurrently, analysed separately, and integrated during the interpretation stage (Creswell & Plano Clark, 2018). This approach was particularly appropriate because the study sought to answer different but complementary types of questions. Some questions focused on measurable outcomes and relationships, for example, whether water sources in intervention communities were more likely to remain functional during droughts. Such questions required the statistical strength and representativeness provided by household survey data. Also, the study aimed to understand the underlying processes and experiences that shape these outcomes. For instance, why are some WASH committees able to mobilise resources and sustain services effectively, while others struggle under seemingly similar conditions? Addressing such questions required the contextual insights that emerge through interviews and focus group discussions. By collecting both forms of data simultaneously, the study was able to capture not only what was happening, but also why it was happening. This approach enabled a more comprehensive understanding of climate resilience and WASH governance while making efficient use of the available fieldwork period (Hailu et al., 2024). The qualitative component was further informed by contemporary principles of rigorous applied qualitative research, emphasizing context, participant perspectives, and the practical realities of implementation in real-world settings (Lim, 2024).

Sampling Strategy

The household survey sample of 350 respondents was drawn using a multi-stage stratified random sampling approach. In the first stage, communities within Mecufi and Metuge were stratified by intervention status (climate-resilient WASH intervention present versus comparison community without recent upgrades) and by displacement status (host community versus IDP resettlement site, applicable primarily in Metuge). In the second stage, a proportionate number of communities were randomly selected within each stratum. In the third stage, households within selected communities were enumerated and a simple random sample was drawn using community household lists maintained by local leadership, supplemented by a random-walk method where lists were unavailable or incomplete. The final achieved sample comprised 350 households, distributed equally as 175 in Mecufi and 175 in Metuge.

Key informant interviews targeted 30 individuals purposively selected for their institutional role in WASH service delivery, climate adaptation, or disaster management, including district government officials, representatives of the Serviço Distrital de Planeamento e Infraestrutura (SDPI) and the Serviço Distrital de Saúde, Mulher e Acção Social (SDSMAS), health facility managers, NGO programme staff, WASH committee leaders, community health workers (CHWs), and disaster management officers. Purposive sampling ensured representation across all relevant institutional categories and both districts. Four focus group discussions were conducted, one each with women, men, youth, and a combined group of community health workers and WASH

committee members, with 8 to 12 participants per group, selected in collaboration with community leaders to ensure diversity of age, livelihood, and (where relevant) displacement status within each group.

Data Collection Methods

Data collection was conducted in April 2026, using four distinct instruments, each tied to a specific element of the convergent parallel research design. The household questionnaire covered eight sections including demographic information, climate and disaster exposure, water access, sanitation, hygiene practices, health outcomes, community resilience, and governance and sustainability with several modules adapted from established humanitarian WASH standards (Sphere Association, 2018). Enumerators were trained for 2 days covering survey administration, ethical protocols, and the digital platform use, and before the survey went into full deployment, it was piloted with 20 households in a community outside the study area. The trained enumerators administered it face to face, in Portuguese, and translated to Makua depending on what the respondent preferred, recording answers on a digital platform (Kobo collect) configured to work offline, a necessity given how patchy connectivity is across both districts and an approach consistent with how comparable interviewer-administered instruments have been conducted elsewhere in Cabo Delgado's resettlement sites (Di Gennaro et al., 2023).

The key informant interview (KII) guide structured 30 semi-structured conversations (15 per district). Target participants were district government officials, SDPI and SDSMAS representatives, health facility managers, NGO staff, WASH committee leaders, community health workers, and disaster management officers. An approach to pairing institutional perspective with household-level data that shows how recent convergent mixed-methods studies in similarly resource-constrained public health settings have combined structured surveys with key informant interviews to build a full picture of how a programme is actually performing (Hailu et al., 2024).

The focus group discussion (FGD) guide shaped four 90-minute sessions, two per district, working through 12 discussion questions covering hazard exposure, changes in water and sanitation services, which interventions participants found most useful, shifts in health outcomes, improvements in preparedness, women's role in WASH decision-making, how effective WASH committees actually are, what challenges remain, how services might be sustained once project support ends, and what community health workers contribute to hygiene and health promotion. Throughout, particular attention went to how experiences differed by gender and to the role WASH committees and community health workers play in building on the kind of community-based qualitative work into displacement-affected WASH and health experiences already established in this same province (Manafe et al., 2024).

The field observation checklist was applied directly by the research team at 64 water points and sanitation facilities across both districts, organised into five domains i.e. water infrastructure, sanitation facilities, hygiene conditions, climate resilience features, and governance and

sustainability were each scored simply as yes or no, with room for a narrative comment. This instrument picked up first-hand observational data on infrastructure functionality, climate-resilience features such as elevation and flood protection, hygiene conditions including soap availability and waste disposal, and tangible signs of governance activity such as maintenance logs and community notice boards, letting the team check what households reported against what enumerators actually saw with their own eyes.

Data Analysis

Quantitative data were analysed using descriptive statistics such as frequencies, percentages, means, and standard deviations to summarize household characteristics and key variables (Schwitter, 2025). Cross-tabulations and comparative tables examined differences between Climate-Resilient WASH and traditional WASH interventions, and with how similarly convergent-design public health studies have paired structured survey data with formal statistical testing to draw conclusions about satisfaction and service outcomes (Hailu et al., 2024). Interview and focus group transcripts were translated into both Portuguese and English, and analysed thematically using the framework approach (Ritchie & Spencer, 1994), a method well suited to applied policy research of this nature since it allows themes to emerge organically from the data while keeping the analysis anchored to the study's original objectives.

Qualitative data were analysed thematically through systematic coding of KIIs and FGDs to identify recurring patterns related to hazard exposure, changes in water and sanitation services, most useful WASH interventions, health outcomes, improvements in preparedness, women's role in WASH decision-making, effectiveness of WASH committee, WASH challenges, WASH sustainability, and contribution of community health workers to hygiene and health promotion in conflict-displaced settings (Farias et al., 2025; MAXQDA, 2026). This practice of independent double-coding followed by a formal reliability check mirrors current methodological guidance on what distinguishes rigorous qualitative analysis from a more impressionistic reading of transcripts (Lim, 2024). Observational data collected in the field were tabulated separately and then cross-referenced against survey responses from the same communities, allowing the research team to weigh what households reported against what enumerators directly observed on the ground.

Validity and Reliability

Validity was ensured through pre-testing of research instruments covering hygiene knowledge, preparedness, and governance perception in Metuge and Mecufi district, districts commonly affected by regular climate shocks and displacement. Reliability was strengthened through standardized data collection procedures, enumerator training, and consistency checks (Okoko, 2024). Triangulating of quantitative and qualitative data sources across household survey, key informant interviews, focus groups, and field observation gave an additional safeguard against any single source enhanced the credibility of the findings.

Ethical Considerations

Ethical standards were maintained throughout the study. Informed consent was obtained from all participants, and participation was voluntary. An approach consistent with guidance on adapting consent processes to local language and literacy realities rather than leaning on a single standardised written form (Thomson et al., 2024). Enumerators were trained to handle disclosures with care and to refer respondents to appropriate health or psychosocial support where needed, in keeping with established protection and dignity principles for research involving displaced populations (Sphere Association, 2018) and with mounting evidence that conflict-displaced residents of Cabo Delgado carry a real burden of psychological distress that interview protocols need to anticipate (Manafe et al., 2024). There was also a deliberate step taken to keep the research process safe from causing harm or distress, in line with ethical frameworks built specifically for disaster research carried out amid ongoing conflict (Mena & Hilhorst, 2022). In Metuge's IDP resettlement sites, the team was careful never to imply that the study would lead to any material assistance, mindful of the well-documented power imbalances that can otherwise distort participation and consent in research involving displaced and resettled communities (Pincock & Bakunzi, 2021). Community leaders at every sampled site were consulted and gave their permission before data collection began, and enumerators were told to pause or end an interview immediately if a respondent showed signs of distress, whatever stage of the questionnaire they had reached.

Limitations of the Study

First, the cross-sectional design means data were collected at a single point in time, so reported associations between climate-resilient WASH access and outcomes such as health and disaster preparedness are correlational rather than causal, a constraint shared by comparable surveys in the province.

Second, several policy-relevant indicators, including diarrhoeal illness, cholera incidence, and water source functionality during drought, rely on self-reported data, which is susceptible to recall bias and social desirability bias (Bispo Júnior, 2022); no health facility surveillance records were available for cross-checking, and recent multi-country research has similarly flagged self-reported functionality data as a source of measurement uncertainty even after triangulation.

Third, key informant interviews and focus group discussions used purposive rather than random sampling, well suited to capturing institutional and group-level perspectives but limiting generalisability beyond those consulted, a constraint also noted in comparable qualitative research on displacement-affected populations in Cabo Delgado.

Although the equal-allocation sampling design gave both districts comparable statistical weight, it does not fully correct for the demographic asymmetry between the largely host-community district of Mecufi and Metuge, which absorbs a substantial IDP population, warranting caution when extrapolating district-level findings to either population as a whole.

Despite these limitations, the use of a mixed-methods approach combining household surveys, focus group discussions, key informant interviews, and field observations strengthened the credibility of the findings through methodological triangulation. The study therefore provides a robust evidence base for understanding how interacting climate and conflict risks shape WASH service continuity, adaptive capacity, and public health outcomes, while highlighting the opportunities and constraints associated with resilience-building in fragile and conflict-affected contexts.

III. RESULTS AND FINDINGS

This section works through what the data actually showed, across nine areas, bringing together the household survey (N = 350, split evenly between Mecufi and Metuge at 175 households apiece) with evidence from 30 key informant interviews (15 per district) and four focus group discussions (two per district), checked against field observation data gathered at 64 sites (32 per district). On balance, the picture that comes through is an encouraging one though not a simple one, and the qualitative material in particular adds texture the tables alone cannot.

Demographic and Socioeconomic Profile

Table 1. Demographic and Socioeconomic Profile of Respondents (N = 350)

Characteristic	Mecufi (n=175)	Metuge (n=175)	Total (N=350)
Sex of Respondent			
Female	102 (58.3%)	99 (56.6%)	201 (57.4%)
Male	73 (41.7%)	76 (43.4%)	149 (42.6%)
Age Group			
18–29 years	47 (26.9%)	54 (30.9%)	101 (28.9%)
30–44 years	65 (37.1%)	62 (35.4%)	127 (36.3%)
45–59 years	43 (24.6%)	40 (22.9%)	83 (23.7%)
60+ years	20 (11.4%)	19 (10.9%)	39 (11.1%)
Marital Status			
Married	117 (66.9%)	103 (58.9%)	220 (62.9%)
Single	27 (15.4%)	34 (19.4%)	61 (17.4%)
Widowed	21 (12.0%)	24 (13.7%)	45 (12.9%)
Divorced	10 (5.7%)	14 (8.0%)	24 (6.8%)

Characteristic	Mecufi (n=175)	Metuge (n=175)	Total (N=350)
Educational Attainment			
None	51 (29.1%)	62 (35.4%)	113 (32.3%)
Primary	78 (44.6%)	71 (40.6%)	149 (42.6%)
Secondary	37 (21.1%)	34 (19.4%)	71 (20.3%)
Technical/Vocational	6 (3.4%)	5 (2.9%)	11 (3.1%)
University	3 (1.7%)	3 (1.7%)	6 (1.7%)
Main Occupation			
Farming	61 (34.9%)	85 (48.6%)	146 (41.7%)
Fishing	70 (40.0%)	6 (3.4%)	76 (21.7%)
Petty trade	27 (15.4%)	46 (26.3%)	73 (20.8%)
Casual labour	12 (6.9%)	26 (14.9%)	38 (10.9%)
Formal employment	5 (2.9%)	12 (6.9%)	17 (4.9%)
Household Size			
1–4 members	42 (24.0%)	40 (22.9%)	82 (23.4%)
5–7 members	85 (48.6%)	79 (45.1%)	164 (46.9%)
8–10 members	37 (21.1%)	42 (24.0%)	79 (22.6%)
Above 10 members	11 (6.3%)	14 (8.0%)	25 (7.1%)
Displacement Status			
Host community	163 (93.1%)	99 (56.6%)	262 (74.9%)
IDP	8 (4.6%)	63 (36.0%)	71 (20.3%)
Returnee	4 (2.3%)	13 (7.4%)	17 (4.8%)

Source: Author's Field Survey (2026)

The 350 respondents, divided evenly across Mecufi and Metuge, look fairly similar on most basic demographics. Women make up a clear majority in both districts (58.3% and 56.6% respectively), consistent with their traditional role managing household water and sanitation in rural Mozambique, and age, household size, and marital status all track closely between the two sites, with married respondents and households of 5 to 7 members the norm everywhere. Education is low across the board, as expected in a rural province like Cabo Delgado, though Metuge runs

slightly behind Mecufi, with more residents reporting no formal schooling this is due to the fact that most of the respondents were IDPs in resettlement sites in 25 de Juno and Namuapala.

Where the two districts genuinely differ are occupation and displacement, and the two are clearly connected in household size. Mecufi's economy is built around the coast, with fishing the leading occupation at 40.0% against just 3.4% in Metuge. Metuge leans heavily on farming instead (48.6% versus Mecufi's 34.9%), along with more petty trade and casual labour, the kind of work people often fall back on when they lack land, fishing grounds, or established livelihoods. That pattern lines up almost exactly with displacement status: Mecufi's sample is overwhelmingly host community (93.1%), while in Metuge only 56.6% are host residents, with 36.0% identifying as IDPs and another 7.4% as returnees. In short, Metuge is carrying a much heavier displacement burden, and that fact alone explains a good deal of the weaker economic and livelihood sources seen there. It also sets up something the report keeps coming back to: Metuge's WASH systems aren't just serving a poorer or less settled population, they're serving one still absorbing the shock of displacement, which is part of why the strain on those systems shows up so clearly in the later findings.

Climate and Disaster Exposure

Almost no household in either district came through the past five years without some kind of climate or disaster shock, though which hazard hit hardest tracked geography closely, mirroring the compound-hazard profile already documented at the provincial level (INGD, 2022).

Table 2. Climate and Disaster Exposure, Past Five Years (N = 350/175 per district))

Indicator	Mecufi (%)	Metuge (%)	Total (%)
Hazard Types Experienced (multiple response)			
Cyclones	86.5	71.5	79.0
Floods	58.4	77.3	67.9
Droughts	49.4	61.0	55.2
Disease outbreaks	33.1	41.3	37.2
Conflict-related displacement	7.9	58.1	33.0
Frequency of Household Impact			
Once	18.5	14.5	16.5
2–3 times	41.6	38.4	40.0
More than 3 times	39.9	47.1	43.5
Most Serious Impact Reported			

Indicator	Mecufi (%)	Metuge (%)	Total (%)
Loss of crops	29.2	38.4	33.8
Water shortages	24.7	19.8	22.3
Damage to infrastructure	21.3	17.4	19.4
Disease outbreaks	12.4	11.0	11.7
Displacement	5.1	9.9	7.5
Loss of livestock	7.3	3.5	5.4

Source: Author's Field Survey (2026)

The numbers in Table 2 show two districts facing very different mixes of hazards, despite both being hit hard and often. Mecufi, sitting right on the coast, is dominated by cyclones (86.5%) and lists water shortages as its top concern, which makes sense given how exposed its water infrastructure is to storm damage. Metuge looks almost like a mirror image: floods (77.3%) and droughts (61.0%) lead the way, crop loss is the most commonly cited serious impact, and conflict-related displacement sits at an outstanding 58.1%, against just 7.9% in Mecufi, relating with the displacement figures already seen in Table 1, underscoring that this is fundamentally a different vulnerability profile, tied closely to the wider displacement dynamics tracked across the province (OCHA, 2025).

Mecufi's hazard is on cyclones and the water-system damage that follows, while Metuge's hazards experienced are floods, drought, and the strain of displacement. That's a meaningful distinction, and it suggests climate-resilient WASH intervention probably shouldn't look identical in the two districts. Households in both districts had typically been hit by a climate or disaster shock more than once in the preceding five years, and 43.5% had weathered more than three separate impacts, fitting the broader, well-documented picture of compounded, cyclical hazard exposure across Cabo Delgado (Cannon, 2008). The disease-outbreak numbers in this table shows a now-familiar regional pattern, too: cyclone-driven infrastructure damage in Mozambique has repeatedly come before cholera outbreaks, from the nationally significant epidemic that followed Cyclone Idai in 2019 (Lequechane et al., 2020) to the more localised cholera risk identified a few years later among displaced households in Cabo Delgado's own resettlement sites (Di Gennaro et al., 2023).

Water Access

Table 3. Water Point Access (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)
Main Water Source		

Indicator	Mecufi (%)	Metuge (%)
Borehole	56.5%	30.9%
Protected well	21.5%	18.4%
Piped system	12.1%	4.4%
Surface water	3.7%	26.5%
Rainwater harvesting	6.2%	19.8%
Distance and Availability		
Less than 500m to source	68.7%	41.9%
Water available year-round ('Always')	74.3%	38.2%
Source remains functional during drought	81.8%	47.8%
Water quality satisfaction (1–5 scale, mean)	4.1 (0.8)	3.0 (1.1)

Source: Author's Field Survey (2026)

Table 3 makes the gap between the two districts very concrete. Mecufi relies mainly on boreholes (56.5%) and 21.5% protected wells, sources that hold up reasonably well under stress. While Metuge relies more on surface water (26.5%) and rainwater harvesting (19.8%), both far more exposed to contamination and seasonal failure, with boreholes serving under a third of households in Metuge district showing exactly the shift toward improved water sources that global monitoring frameworks treat as the foundation of safe water access (UNICEF/WHO Joint Monitoring Programme, 2023). Fewer Metuge households live close to their water source (41.9% within 500m, versus 68.7% in Mecufi), fewer households in Metuge have year-round availability (38.2% versus 74.3%), and fewer can count on their source surviving a drought (47.8% versus 81.8% in Mecufi). Satisfaction scores follow the same pattern, with Mecufi households rating water quality considerably higher and more consistently (4.1 out of 5) than Metuge's lower, more variable scores (3.0). This isn't just a matter of perception, but the field team's own observations, of cleaner water points and properly functioning drainage at most of the intervention sites visited, point the same way, and this kind of independent corroboration between self-report and direct observation is precisely what structured WASH risk-assessment tools, now being piloted in other climate-vulnerable African settings, are designed to standardise (Kapwata et al., 2022).

In short, Metuge is not struggling with water access in some unclear or unexplained way, but it's struggling because it depends more heavily on water sources that simply aren't built to withstand the climate pressures both districts face. This gap is mainly rooted in infrastructure type commonly used in Metuge district. This single comparison captures the entire logic behind climate-resilient design that infrastructures built to anticipate stress keeps working at exactly the moment ordinary infrastructure tends to give out, delivering the kind of reliable service quantity and quality long

identified as central to health protection (Howard & Bartram, 2003), and lining up with recent multi-country evidence that age, technology type, and management arrangements are not just how well something was built in the first place but a drive whether a rural water point keeps functioning over time (Murray et al., 2024).

Sanitation Infrastructures

Table 4. Sanitation Infrastructures (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)
Type of Sanitation Facility		
Improved latrine	61.2%	37.2%
Traditional latrine	29.0%	47.8%
Shared latrine	7.9%	16.2%
No facility	1.9%	8.8%
Climate Resilience Features		
Flood-resistant construction	54.2%	11.0%
Elevated structure	48.6%	8.1%
Durable construction materials	59.8%	19.9%
Inclusion and Access		
Accessible to persons with disabilities	38.3%	22.5%
Gender-segregated facility	66.4%	33.8%

Source: Author's Field Survey (2026)

Sanitation findings track the water findings closely. Improved latrines were more than twice as common in Mecufi (61.2 %) as in Metuge (27.2%), a gap that the global sanitation ladder treats as decisive for health protection (UNICEF/WHO Joint Monitoring Programme, 2023), while open defecation, the "no facility" category, affected 8.8 of Metuge households against just 1.9% in Mecufi. The sharpest contrast of all appears in the climate-resilience features built directly into the infrastructure itself. Flood-resistant construction was nearly five times more common in Mecufi (54.2% versus 11.0 in Metuge), and field observers directly confirmed elevated latrine platforms and reinforced superstructures at most of the intervention sites they inspected in Mecufi, giving real weight to what respondents reported rather than leaving it as self-report alone. Gender-segregated facilities, which matter enormously for the safety and dignity of women and girls and sit at the heart of minimum humanitarian WASH standards (Sphere Association, 2018), were present at 66.4% in Mecufi compared with 33.8% in Metuge. That said, as recent scoping reviews

of WASH-related gender-based violence caution, having a segregated facility is only a starting point and says little on its own about whether women and girls actually feel safe using it (Nunbogu & Elliott, 2022; Ray, 2022). Disability accessibility, at 38.3% in Mecufi against 22.5% in Metuge, remains the weakest dimension of sanitation infrastructure in both districts.

Hygiene Practices

Table 5. Hygiene Practices and Knowledge (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)	Total (Average %)
Handwashing Infrastructure and Supplies			
Has a handwashing facility	72.0%	33.8%	56.6%
Soap always available	54.2%	20.6%	40.6%
Soap never available	8.4%	29.4%	16.9%
Correct Handwashing Knowledge (≥ 3 of 5 critical times identified)			
After toilet use	91.6%	79.4%	86.6%
Before preparing food	74.3%	55.1%	66.6%
Before eating	81.3%	63.2%	74.0%
Before feeding children	68.7%	47.1%	60.0%
After handling waste	59.3%	38.2%	50.6%
Hygiene Promotion Exposure			
Received hygiene promotion message (past year)	79.0%	47.8%	66.0%
Source: Community Health Worker	44.9%	27.9%	36.4%
Source: WASH Committee	29.4%	18.8%	24.1%
Source: Radio	34.0%	33.8%	33.9%
Source: NGO	48.4%	69.1%	58.8%
Source: School	3.3%	10.3%	6.8%

Source: Author's Field Survey (2026)

Hygiene practice findings favoured Mecufi over Metuge across every measure, and the widest gap appeared on the most basic infrastructure question, where 72.0% of Mecufi households reported having a handwashing facility, against just 33.8% in Metuge, a meaningful difference given that

handwashing infrastructure is consistently identified as one of the simplest, most cost-effective health interventions available to a household (Bartram & Cairncross, 2010). Soap availability followed the same pattern: 29.4% of Metuge households reported that soap was never available, compared with only 8.4% in Mecufi, a gap worth dwelling on because it speaks to whether handwashing is even physically possible in the household, separate from how much a household knows about it or chooses to practise it.

Unprompted recall of the correct moments to wash hands was higher in Mecufi than in Metuge across all five critical times asked about, with the widest knowledge gap concerning handwashing before feeding children (68.7% in Mecufi versus 47.1% in Metuge). This broadly echoes a 2022 survey of cholera-related knowledge and hygiene practice among displaced and host populations elsewhere in Cabo Delgado, which likewise found hygiene knowledge gaps tied to education level and access to basic supplies (Di Gennaro et al., 2023).

One detail worth pausing on is the channel through which hygiene messages actually reached people. Community health workers and WASH committees were the dominant source in Mecufi, while NGO outreach carried more weight in Metuge, reflecting the heavier NGO presence there given the district's large population of IDPs and resettlement sites. This suggests that the community-based governance structures built alongside climate-resilient infrastructure are doing double duty not simply overseeing infrastructure, but functioning as an effective channel for hygiene communication in their own right.

Health Outcomes

Table 6. Health Outcomes Status (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)
Diarrhoea in household, past two weeks	9.8%	23.5%
Cholera cases in community, past 12 months	3.7%	11.8%
Perceived improvement in family health attributable to WASH (Agree/Strongly agree)	77.6%	41.9%

Source: Author's Field Survey (2026)

Of everything this study found, the health data may carry the most direct policy weight. Diarrhoea in the two weeks preceding the survey was reported by less than half as many households in Mecufi (9.8%) as in Metuge (23.5%), a difference that is both substantial and statistically significant, and broadly consistent with the global evidence base linking improved WASH access to reduced childhood diarrhoeal disease (Wolf et al., 2018). Community-level cholera incidence over the previous twelve months followed the same pattern, reported by 3.7% of respondents in Mecufi against 11.8% in Metuge, a gap consistent in direction, if not in scale, with the much larger national cholera epidemic that followed the destruction of water infrastructure during Cyclone Idai

(Lequechane et al., 2020) and with the elevated cholera risk already documented among IDPs in Cabo Delgado's own resettlement sites (Di Gennaro et al., 2023).

These figures are self-reported, and the study could not cross-check them against health facility surveillance records, a limitation acknowledged in this report. Even so, the consistency of the pattern across both indicators, together with corroborating accounts from health facility managers, gives reasonable confidence to the broader conclusion that climate-resilient WASH access tracks with better health outcomes in these two districts (Bartram & Cairncross, 2010).

Community Resilience and Preparedness

Table 7. Community Resilience and Disaster Preparedness (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)	Total
Household has emergency preparedness plan	41.6%	19.9%	33.1%
Can identify evacuation routes	58.9%	33.1%	48.9%
Receives early warning information	63.6%	36.0%	52.6%
Household keeps emergency supplies	35.5%	16.2%	27.7%
Early Warning Source (among those receiving warnings)			
Community leaders	38.7%	44.9%	41.9%
Radio	27.2%	32.7%	30.0%
Government	16.1%	10.2%	13.1%
Community health workers	12.4%	6.1%	9.3%
SMS	5.6%	6.1%	5.7%
Mean household recovery ability (1–5 scale)	3.4 (1.0)	2.4 (1.1)	3.0 (1.1)

Note. Household recovery ability is a self-rated single-item measure (1 = very low, 5 = very high).

Source: Author's Field Survey (2026)

What stands out in Table 7 is that exposure to climate-resilient WASH intervention appears to go hand in hand with broader gains in disaster preparedness, well beyond water and sanitation narrowly defined. Households in Mecufi communities were more than twice as likely to have a

formal emergency plan (41.6% versus 19.9% in Metuge) and to keep emergency supplies on hand (35.5% versus 16.2% in Metuge), gains that map closely onto the household-level traits of disaster-resilient communities described in the wider preparedness literature (Twigg, 2009). The most plausible explanation, and one this report returns to elsewhere, is that climate-resilient WASH interventions in these districts were typically rushed together with broader community engagement and disaster risk reduction sensitisation, delivered through the same WASH committees and community health worker networks, in line with the multi-stakeholder early warning principles set out in the Sendai Framework (United Nations Office for Disaster Risk Reduction, 2015). Self-rated recovery ability after a disaster was also marked higher in Mecufi communities (mean 3.4 versus 2.4 in Metuge on a 5-point scale), hinting at a resilience dividend that reaches well past the WASH sector itself.

Governance and Sustainability

Table 8. WASH Governance and Sustainability (N = 350/175 per district)

Indicator	Mecufi (%)	Metuge (%)	Total
WASH committee exists in community	89.7%	27.2%	65.4%
Committee meets regularly (among those with a committee)	68.2%	32.4%	60.2%
User fees collected	57.9%	14.0%	40.6%
Repairs carried out promptly	61.7%	19.1%	44.6%
Local authorities support WASH services (Agree/Strongly agree)	64.0%	27.9%	49.4%

Note. 'Committee meets regularly' is calculated as a percentage of households reporting that a WASH committee exists in their community.

Source: Author's Field Survey (2026)

According to Table 8, WASH committees existed in 89.7% of Mecufi communities, against only 27.2% in Metuge, clear evidence that governance structures were built deliberately alongside the physical infrastructure rather than left to emerge on their own, particularly in Mecufi, a district with greater exposure to cyclones and flooding than Metuge. Yet even within Mecufi communities, only 57.9% of households said user fees were actually being collected, and just 61.7% said repairs happened promptly when something broke on the boreholes. What this suggests is that building the infrastructure and standing up a committee turned out to be the easier part in Mecufi. Getting the financing and maintenance side of that committee's mandate to function consistently is where the model still runs into trouble, a pattern that echoes the broader service-delivery critique levelled at donor-funded rural water programming (Lockwood & Smits, 2011) and that lines up closely

with recent multi-country evidence showing that financial management and access to outside support, not just construction quality, are among the strongest predictors of whether a rural water point keeps working years after it was built (Murray et al., 2024). This is a finding the report returns to repeatedly in the Discussion and Recommendations, since it may well be the single biggest challenge facing climate-resilient WASH interventions in these districts going forward.

Key Informant Interviews and Focus Group Discussions

The qualitative study comprised 30 key informant interviews, 15 per district, and four focus group discussions involving women, men, youth, community health workers, and WASH committee members across Mecufi and Metuge. Taken together, the findings shed useful light on the effectiveness, challenges, and sustainability of climate-resilient WASH interventions in both districts. Participants in both districts pointed to cyclones and flooding as the dominant climate hazards bearing down on WASH infrastructure, though their experiences diverged from there. In Mecufi, respondents spoke positively about climate-resilient boreholes, several of which stayed operational through the 2024 cyclone season while traditional wells nearby were damaged or contaminated. In Metuge, by contrast, stakeholders described rapid population growth driven by conflict-related displacement placing real strain on existing infrastructure, with some facilities now serving two to three times the population they were built for.

Health facility managers in both districts perceived a reduction in diarrhoeal disease among communities served by climate-resilient water systems, though they were careful to note that limited health data made this difficult to verify with precision. Government officials and NGO staff converged on inadequate financing and maintenance budgets as the principal threat to the infrastructure's long-term sustainability. WASH committee members described real difficulty collecting user fees given the depth of poverty in the communities they serve, including among internally displaced households. Many committees quietly waived fees for the poorest families out of genuine solidarity, a humane response that nonetheless chips away at the financial sustainability the formal model depends on. Community health workers, meanwhile, were consistently seen, by themselves and others, as a trusted and effective channel for hygiene promotion, though limited incentives constrained how much outreach they could realistically sustain.

In Mecufi, women's focus group participants valued climate-resilient water points chiefly for the time and physical burden they relieved, especially during the dry season, but raised a concern not well captured elsewhere: whether sanitation facilities actually felt safe to use at night, given questions around lighting, functioning locks, and how close facilities sat to people's homes. Men in the same district focused more on reliable water access for fishing-related livelihoods and called for greater transparency in how WASH committees managed user fees. In Metuge, youth participants showed a strong grasp of climate risks and the health challenges that follow, but felt sidelined from WASH governance structures, and suggested young people could take on a larger

role in early-warning dissemination and community awareness, particularly given their comfort with mobile technology.

The combined focus group of community health workers and WASH committee members in the same district pointed to spare-parts shortages and long supplier distances as the main drivers of repair delays, and proposed community-based spare-parts depots as a practical, low-cost way to make WASH services more sustainable and responsive. The qualitative findings reinforce the quantitative results, confirming that climate-resilient WASH interventions have genuinely improved water access and public health outcomes, while also surfacing governance, financing, gender, and sustainability challenges that still need attention.

IV. DISCUSSION

The findings offer strong evidence that climate-resilient WASH interventions meaningfully improve service continuity, public health, and community resilience in Cabo Delgado. The most notable result is the gap in water source functionality during drought, considerably higher in Mecufi (81.8%) than in Metuge (47.8%), underscoring just how much it matters to design infrastructure capable of withstanding climate-related shocks (Howard & Bartram, 2003). The widespread adoption of elevated, flood-resistant sanitation facilities tells a similar story, confirming the value of disaster-resilient infrastructure approaches consistent with established humanitarian standards (Sphere Association, 2018; Kapwata et al., 2022).

Health outcomes are encouraging as well. Intervention communities reported substantially lower levels of diarrhoeal disease and cholera than non-intervention areas, in line with the broader global evidence linking improved WASH services to better public health outcomes (Bartram & Cairncross, 2010; Wolf et al., 2018), though the study's cross-sectional design and reliance on self-reported health data limit how confidently a direct causal claim can be made.

One finding worth dwelling on is the governance gap affecting the long-term sustainability of WASH services. Infrastructure construction and the establishment of WASH committees were generally successful, but fee collection, maintenance financing, and timely repairs continued to undermine functionality over time. The qualitative findings add useful texture here: WASH committees often quietly waived user fees for vulnerable households, including women-headed households and internally displaced families, a practice that reflects genuine local solidarity even as it weakens the financial sustainability of the systems. Repair delays, meanwhile, were attributed less to any lack of community commitment or technical capacity than to shortages of spare parts and long distances to suppliers, which points to a fairly practical fix: pooled, community-based spare-parts depots.

The study also found that resilience benefits extend well beyond physical infrastructure. Community health workers and WASH committees played an important role in promoting hygiene

awareness, disaster preparedness, and early-warning communication, and these social and institutional networks appear to strengthen community resilience and disaster risk reduction in ways consistent with the Sendai Framework and the broader community resilience literature (UNDRR, 2015; Twigg, 2009).

Gender and social inclusion issues also came through strongly in the qualitative data. Women valued climate-resilient water points mainly for the time and physical burden they relieved, but raised lingering concerns about the safety of sanitation facilities at night, even where gender-segregated latrines were available. Men placed more weight on water access for livelihoods, particularly fishing, and called for greater transparency in how user fees were managed. Youth participants, for their part, expressed a clear desire for greater involvement in WASH governance and pointed to the potential of mobile technology for disaster communication and early-warning dissemination.

Finally, the comparison between Mecufi and Metuge illustrates just how much local context shapes intervention outcomes. Both districts benefited from climate-resilient WASH interventions, but Metuge faced the added pressure of rapid population growth driven by conflict-related displacement, which placed greater strain on both infrastructure and governance systems. This suggests that climate-resilient WASH models designed with relatively stable populations in mind may need further adaptation in displacement-affected settings, in both infrastructure capacity and governance arrangements, to remain effective under conditions of heightened demand.

Generally, the study demonstrates that climate-resilient WASH interventions can meaningfully strengthen water security, public health, and community resilience. Long-term success, however, depends not only on resilient infrastructure but also on stronger governance systems, sustainable financing mechanisms, inclusive participation, and the institutional capacity to manage growing climate- and displacement-related pressures.

V. CONCLUSION

This study evaluated the effectiveness, health impacts, and sustainability of climate-resilient WASH interventions in Mecufi and Metuge districts of Cabo Delgado Province, Mozambique, drawing on 350 household surveys, 30 key informant interviews, and four focus group discussions. The findings show that climate-resilient WASH infrastructure performs considerably better than conventional systems during droughts and floods, and this holds up in the health data too, with lower rates of self-reported diarrhoeal disease (Wolf et al., 2018) and reduced cholera incidence consistent with Mozambique's broader post-disaster disease trends (Lequechane et al., 2020; Di Gennaro et al., 2023). The interventions also appear to have strengthened household disaster preparedness and resilience in ways that reach well beyond the WASH sector itself (Twigg, 2009).

The study also surfaced governance and financing challenges that threaten the long-term sustainability of these gains. WASH committees are now widely established, but their

effectiveness on the ground remains uneven, with low rates of user-fee collection and persistent repair delays driven by weak spare-parts supply chains. This lines up with existing evidence that inadequate financial management and maintenance systems, more than construction quality itself, are the major drivers of rural water point failure (Murray et al., 2024), and it leaves governance and financing as the most pressing unresolved challenge for sustaining climate-resilient WASH services in Cabo Delgado going forward (Lockwood & Smits, 2011).

The comparison between Mecufi and Metuge reinforces a broader point: climate-resilient WASH interventions need to be adapted to local conditions rather than rolled out uniformly. Different hazard profiles, population pressures, and displacement dynamics call for genuinely context-specific approaches (Cannon, 2008; INGD, 2022; Trisos et al., 2022), a point that matters especially in Metuge, where rapid population growth driven by ongoing conflict and displacement continues to strain both infrastructure and governance systems (IOM, 2024; OCHA, 2024, 2025). Taken together, the study concludes that climate-resilient WASH interventions can meaningfully improve service reliability, public health, and community resilience, but that their long-term success ultimately hinges on resolving governance, financing, and contextual implementation challenges.

VI. IMPLICATIONS OF THE STUDY

This study carries meaningful implications for the evidence base, programme design, financing, and resilience-building within climate-resilient WASH intervention. It adds to the still-limited body of research examining these interventions in complex, multi-hazard environments where cyclones, floods, droughts, and conflict-induced displacement overlap, as they do in Cabo Delgado Province. The comparison between Mecufi and Metuge makes clear that climate-resilient WASH interventions can't rely on a one-size-fits-all approach; they need to be adapted to the specific hazard profile and demographic pressures of each setting (Cannon, 2008), and the study offers useful evidence for designing that kind of context-specific intervention in fragile settings.

For programme design and financing, the findings point to a real "governance lag" between building infrastructure and putting in place the systems needed to sustain it. WASH committees were present in Mecufi showing 89.7%, yet only 61.7% reported timely repairs, confirming that governance, financing, and maintenance gaps continue to undermine long-term sustainability. This fits with evidence showing that financial management and institutional support often matter more than construction quality in determining whether rural water systems keep functioning over time. The study also surfaces a genuine tension between community solidarity practices, such as informal fee waivers for vulnerable households, and the formal financial sustainability models these systems are built on, pointing to a need for more flexible and equitable financing approaches going forward.

The findings also show that climate-resilient WASH interventions contribute to community resilience well beyond water and sanitation improvements alone. Intervention communities reported stronger disaster preparedness, better access to early warning information, and greater confidence in their ability to recover from shocks, supporting the view that WASH programmes can function as a platform for broader resilience-building rather than a narrowly technical fix. This reinforces recent calls for climate-resilient WASH programming to be woven into broader community resilience and adaptation strategies rather than treated as a stand-alone intervention. Altogether, the study underscores that lasting development outcomes depend on pairing resilient infrastructure with strong governance systems, sustainable financing mechanisms, and genuine community engagement, not infrastructure alone.

VII. RECOMMENDATIONS

The findings from Mecufi and Metuge make clear that climate-resilient WASH outcomes depend on far more than infrastructure availability alone; they hinge on the long-term capacity to operate, maintain, and govern water and sanitation systems under mounting climate stress, displacement pressure, and institutional constraint. Investments in boreholes, water systems, and sanitation facilities have genuinely improved access in several communities, yet sustainability remains fragile, undermined by weak maintenance arrangements, limited repair financing, uneven governance capacity among WASH committees, and the additional strain that climate shocks and population movement place on districts such as Metuge. Strengthening climate-resilient WASH going forward will require coordinated action across government, development partners, communities, and research systems alike, so that infrastructure translates into service delivery that is both sustained and equitable. The recommendations below are offered with that in mind.

District authorities in both Mecufi and Metuge have a clear opening to strengthen operation, maintenance, and financing systems at the local level. The study suggests that WASH systems tend to fail not because of flawed initial design, but because maintenance structures are inadequate and repairs come too slowly. Dedicated budget lines for WASH operation and maintenance would give routine repairs and post-shock rehabilitation the predictable funding they currently lack, while stronger technical supervision of WASH committees and decentralised maintenance arrangements, shared spare-parts depots serving clusters of communities rather than each settlement managing alone, would meaningfully reduce water-point downtime and improve reliability across both districts.

At the community level, WASH governance and accountability structures need reinforcing. WASH committees remain central to service continuity, yet their effectiveness is held back by limited training, weak accountability mechanisms, and financial management gaps. Formalising transparent financial reporting, improving record-keeping, and setting clear guidelines for fee collection and expenditure would go some way toward addressing this, while structured support mechanisms, rather than informal exemptions, would allow vulnerable households to be protected

without abandoning cost recovery altogether. Community health workers, given their existing trust within communities, are also well placed for more systematic integration into WASH governance, strengthening hygiene promotion, disease prevention, and climate-related health messaging in the process.

Closely related is the need to improve capacity and incentives for the community health workers and WASH committee members who carry a disproportionate share of day-to-day service delivery, often with little in the way of incentive or logistical support. Regular training on climate-resilient WASH management, outbreak preparedness, and risk communication, paired with modest but consistent incentives, financial or in-kind, would help with both retention and performance, and there is a genuine opportunity here to bring more youth and women into WASH leadership roles, which would support sustainability, innovation, and a deeper sense of community ownership.

Climate risk also needs to be built into WASH infrastructure design and expansion from the outset rather than treated as an afterthought. Given how frequently floods, droughts, and extreme weather now affect Cabo Delgado, infrastructure planning in Mecufi and Metuge must move beyond basic service provision toward genuinely climate-proofed systems, incorporating flood protection, elevated boreholes where appropriate, improved drainage, and climate-resilient siting. In Metuge specifically, where displacement continues to drive population growth, planning should account explicitly for future demographic pressure to avoid the kind of chronic system overloading already evident in this study.

None of this can be achieved through the WASH sector alone, which is why stronger intersectoral coordination matters. Climate resilience in WASH is bound up with health, disaster management, environmental, and planning sectors, and district governments would benefit from tighter coordination across these institutions, linking early warning systems with WASH contingency planning, coordinating emergency water supply during disasters, and aligning public health interventions with WASH infrastructure expansion. Better coordination across sectors would improve preparedness and reduce service disruption when climate shocks do occur.

Financing also needs to become more flexible and inclusive if sustainability is to hold. Financial constraints, at both the household and system level, remain a major barrier, and development partners and NGOs could usefully support community-managed revolving funds, targeted subsidies for vulnerable households, and contingency financing for climate emergencies, designed carefully enough to protect long-term cost recovery while still ensuring equitable access. Displaced populations in Metuge and low-income households in Mecufi, both disproportionately affected by affordability constraints, deserve particular attention here.

Monitoring, learning, and evidence systems for climate-resilient WASH also warrant strengthening. What is needed goes beyond simply tracking whether infrastructure exists, toward capturing functionality, reliability, safety, and user experience, with district and national monitoring frameworks routinely tracking system uptime, repair response times, water quality, and

user satisfaction, and paying particular attention to gendered safety concerns around sanitation access. Researchers and implementing partners alike would benefit from investing in longitudinal studies and better integration with health facility data, which would help clarify the causal links between WASH interventions, climate resilience, and health outcomes in both districts with more confidence than this study's design alone permits.

Finally, donors are well positioned to support longer-term, more flexible engagement with resilient systems. Funding cycles need to reflect the time it actually takes to build and sustain climate-resilient WASH, since short-term, project-based funding limits institutional learning and undermines maintenance systems. Funding approaches that build in flexibility to respond to climate shocks, displacement events, and infrastructure failures, alongside greater harmonisation across WASH, health, and disaster risk reduction funding streams, would reduce duplication and meaningfully improve the efficiency of resilience-building efforts across both Mecufi and Metuge.

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