

Evaluating the Environmental Footprint of Emergency WASH Programming and Eco-Innovation in Conflict-Affected Settings: A Case of Cabo Delgado, Northern Mozambique

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Abstract:

This study examines the environmental impacts of emergency Water, Sanitation, and Hygiene (WASH) interventions in conflict-affected settings and explores how eco-innovative practices can improve the environmental sustainability of humanitarian responses in Cabo Delgado Province, Northern Mozambique. Emergency WASH programmes are critical for preventing disease outbreaks and ensuring access to safe water and sanitation during humanitarian crises. However, these interventions are often implemented under urgent timelines with limited environmental assessment, which can unintentionally contribute to ecological degradation, including groundwater depletion, sanitation-related contamination, deforestation, and plastic waste accumulation in displacement settings. The study employed a qualitative case study approach grounded in resilience thinking and political ecology frameworks. Data were collected through key informant interviews, focus group discussions, field observations, and document analysis across five districts in Cabo Delgado: Pemba, Metuge, Montepuez, Mocimboa da Praia, and Quissanga. A purposive sample of humanitarian practitioners, government officials, and internally displaced community members was selected to provide context-specific insights into WASH implementation practices and environmental outcomes. Findings indicate that emergency WASH interventions significantly improved access to safe water and sanitation services but also generated unintended environmental pressures. Intensive borehole drilling contributed to declining groundwater yields; poorly sited sanitation facilities increased the risk of soil and groundwater contamination; and plastic-based hygiene kits contributed to waste accumulation in internally displaced persons (IDP) settlements. Operational factors such as compressed donor timelines, limited environmental screening, and weak coordination with local authorities further amplified these impacts. The study concludes that environmental sustainability should be integrated into humanitarian WASH programming. Strengthening environmental screening, incorporating ecological indicators into monitoring systems, and promoting eco-innovative technologies such as solar-powered water systems and reusable hygiene materials can help balance life-saving humanitarian objectives with long-term environmental resilience.

Keywords — *Emergency WASH, environmental sustainability, eco-innovation, humanitarian response, conflict-affected settings, Cabo Delgado.*

1.0 INTRODUCTION

The study examined the environmental impact and eco-innovation in emergency Water, Sanitation, and Hygiene (WASH) interventions, which are a central pillar of humanitarian response in contexts affected by armed conflict, natural disasters, and large-scale displacement. Globally, emergency WASH

programmes aim to ensure access to safe drinking water, adequate sanitation, and appropriate hygiene practices in order to prevent disease outbreaks and uphold human dignity (Sphere, 2018). Over the past decade, the humanitarian WASH sector has expanded significantly in scale and scope due to the increasing frequency and protracted nature of global crises. Coordination has been strengthened through the humanitarian cluster system, with UNICEF leading the Global WASH Cluster to provide technical guidance, operational standards, and resource mobilisation among humanitarian actors (Global WASH Cluster, 2021). In 2022 alone, humanitarian WASH programmes reportedly reached more than 125 million people worldwide, highlighting both the scale of need and the critical role of WASH in emergency response (UNICEF, 2023). Despite this progress, limited empirical evidence exists on the environmental footprint of emergency WASH interventions, particularly in conflict-affected African contexts. While global policy frameworks increasingly emphasise sustainability and resilience, practical mechanisms for integrating eco-innovation into emergency WASH programming remain underdeveloped. This study, therefore, contributes to an emerging interdisciplinary field linking humanitarian WASH, environmental management, and innovation studies.

The theoretical foundation of this research draws primarily on resilience thinking, which examines how WASH systems absorb shocks, adapt to disruptions, and continue to function under crisis conditions. Contemporary resilience scholarship emphasises not only recovery but also the capacity of systems to reorganise, learn, and operate within ecological limits during disturbances such as armed conflict, climate stress, and large-scale displacement (Folke, 2016; Zhang et al., 2025). Applying a resilience lens allows this study to move beyond viewing emergency WASH responses as short-term technical fixes and instead assess their potential contributions to long-term environmental sustainability, social cohesion, and institutional strengthening in fragile contexts.

The study also engages with political ecology, which highlights how environmental outcomes are shaped by power relations, governance

arrangements, and crisis-driven decision-making (Perreault et al., 2022). Within humanitarian WASH, emergency imperatives, donor priorities, and fragmented institutional authority can influence infrastructure siting, groundwater extraction, sanitation practices, and waste management systems. By combining resilience thinking with political ecology, the study provides a more comprehensive framework for analysing how emergency WASH interventions interact with environmental systems and governance structures in vulnerable settings.

Conceptually, the study examines emergency WASH interventions through the lens of environmental sustainability and eco-innovation. It focuses on the environmental footprint of humanitarian WASH operations, including resource extraction, waste generation, and energy use, and explores opportunities for resource-efficient, environmentally responsible technologies. These issues are particularly pronounced in sub-Saharan Africa, where armed conflict, climate variability, rapid population growth, and structural poverty converge to intensify vulnerability. Damage to water infrastructure, population displacement, and sanitation disruption frequently increase the risk of waterborne diseases, especially among children and other vulnerable groups (WHO, 2022; UNICEF, 2023). Although humanitarian WASH programmes play a critical role in mitigating these risks, operational constraints such as insecurity, poor infrastructure, and logistical challenges often prioritise speed and scale over long-term environmental sustainability (Luke & Walters, 2022).

Cabo Delgado Province in northern Mozambique represents a particularly acute example of these dynamics. Since the escalation of armed conflict in 2017, more than 1.3 million people have been displaced, placing significant strain on already fragile WASH systems (UNICEF, 2024). The humanitarian situation has been further exacerbated by recurrent climate-related shocks, including cyclones and droughts, which have damaged infrastructure and contaminated water sources (OCHA, 2021; UNICEF, 2024). Humanitarian actors such as UNICEF, Médecins Sans Frontières,

and the International Committee of the Red Cross have implemented various emergency WASH interventions, including borehole drilling, water trucking, hygiene kit distribution, and solar-powered water systems (ICRC, 2016; MSF, 2024; ReliefWeb, 2022).

1.1 Statement of the Problem

Emergency Water, Sanitation, and Hygiene (WASH) interventions are widely recognized as essential for saving lives, protecting public health and human dignity during humanitarian crises, with international frameworks such as the Sphere Handbook and Global WASH Cluster guidelines providing clear strategic and operational direction (Sphere, 2018; Global WASH Cluster, 2021). Despite these established standards and substantial investments, a critical concern persists regarding the extent to which environmental sustainability is meaningfully integrated into emergency WASH programming, particularly in conflict-affected and environmentally fragile settings. This raises an important interrogation: how can emergency WASH interventions achieve their life-saving objectives without undermining the environmental systems upon which affected communities depend for long-term recovery and resilience? Although humanitarian policies increasingly acknowledge sustainability, emergency WASH initiatives are frequently implemented without comprehensive Environmental Impact Assessments (EIAs), leaving the long-term ecological consequences insufficiently examined and addressed (Yates, 2023). Sustainability planning remains limited, with many interventions designed as short-term solutions that deteriorate or are abandoned once external support ceases, resulting in unsatisfactory outcomes for both communities and ecosystems (UNICEF, 2024).

A further issue of concern is the imbalance between the urgency of emergency response and the need for environmental protection. Common emergency practices, including reliance on fossil fuel-powered pumps and generators, large-scale distribution of single-use plastic hygiene kits, and construction of pit latrines without adequate waste treatment, prioritize immediate service delivery but often

impose significant environmental costs (Sanderson, 2020; Haverkort et al., 2019). These approaches contribute to groundwater depletion, surface water pollution, deforestation, and solid waste accumulation, particularly within fragile ecosystems already under stress (Walden et al., 2022; UNEP/OCHA, 2020). At the same time, limited community involvement in programme design and management reduces contextual appropriateness and environmental compatibility, further weakening long-term effectiveness (Yates, 2023).

There is also a missing link between humanitarian policy commitments and operational practice. Although environmental sustainability and eco-innovation are increasingly emphasized within humanitarian discourse, especially in response to climate change and protracted displacement, their practical application in emergency WASH remains inconsistent and poorly documented (Oxfam, 2023; IRC, 2022; UNHCR, 2021; Global Humanitarian Overview, 2023). Many humanitarian actors lack systematic environmental monitoring mechanisms during WASH implementation, limiting their ability to identify negative impacts, adopt corrective measures, or strengthen resilience over time (Sphere, 2022). This represents a significant technological and institutional challenge in translating sustainability principles into effective, scalable solutions.

These challenges are particularly evident in Cabo Delgado Province in northern Mozambique, where prolonged armed conflict since 2017 and recurrent climate-related disasters have resulted in large-scale displacement and heightened dependence on emergency WASH services. Rapid population influxes into resettlement sites have intensified pressure on limited water resources, increasing the risk of groundwater over-extraction (Ballard Brief, 2020; UNICEF, 2022), while overstretched sanitation and waste management systems have contributed to open defecation, environmental contamination, and elevated public health risks (UNDP, 2022; UNICEF, 2024). Seasonal flooding and poorly constructed sanitation facilities have further exacerbated water pollution, with 29.6% of water sources reported to be contaminated with

faecal matter (BallardBrief, 2020). Despite growing recognition that environmental sustainability is integral to effective humanitarian response, a question remains about how eco-innovative approaches can be systematically integrated into emergency WASH programming without compromising life-saving objectives. Humanitarian guidance increasingly calls for environmental considerations to be embedded from the outset of WASH programme planning, including the identification of environmental risks, establishment of environmental performance objectives, and implementation of mitigation measures (UN-IASC, 2023). However, empirical evidence on how such approaches can be operationalized in conflict-affected settings remains limited. This study addresses this gap by examining the environmental impacts of emergency WASH interventions in Cabo Delgado Province and exploring eco-innovative pathways to strengthen environmentally sustainable and resilient humanitarian WASH programming.

1.2 Research Objectives

The study examines the environmental impacts of emergency Water, Sanitation, and Hygiene (WASH) interventions and explores eco-innovative approaches to enhance the environmental sustainability of humanitarian WASH programming in conflict-affected settings, using Cabo Delgado Province in northern Mozambique as a case study, and the specific objectives were:

1. To identify and describe the prevailing emergency Water, Sanitation, and Hygiene (WASH) programming practices implemented in conflict-affected areas of Cabo Delgado Province.
2. To evaluate the environmental impacts of emergency WASH interventions, with particular attention to water resource use, sanitation infrastructure, waste generation, and energy consumption.
3. To determine the operational components and implementation practices that contribute most significantly to the environmental footprint of humanitarian WASH programmes.
4. To examine existing and emerging eco-innovative approaches that can reduce

environmental harm while maintaining the effectiveness of emergency WASH responses.

5. To develop context-appropriate recommendations for integrating environmental sustainability into emergency WASH programming in conflict-affected settings.

1.3 Research Questions

This study was guided by the research questions listed below:

1. What types of emergency WASH programming practices are implemented in conflict-affected areas of Cabo Delgado?
2. What environmental impacts are associated with these emergency WASH practices in Cabo Delgado, particularly in relation to water resources, sanitation, waste, and energy use?
3. Which operational practices contribute most significantly to the environmental footprint of emergency WASH interventions in Cabo Delgado?
4. What existing or potential eco-innovative approaches could reduce the environmental footprint of humanitarian WASH programming in this conflict-affected context?
5. How can environmental sustainability be effectively integrated into emergency WASH programming in conflict-affected settings such as Cabo Delgado?

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

Theoretical perspectives such as resilience thinking and political ecology have been applied to understand the environmental dynamics of humanitarian WASH interventions. Resilience thinking emphasises the capacity of socio-ecological systems to absorb shocks, adapt, and transform in response to crises, highlighting the importance of interventions that address immediate needs while strengthening long-term environmental and institutional resilience (Folke, 2016). In humanitarian contexts, resilience thinking encourages programming that not only delivers life-

saving services but also ensures that natural resources and ecosystems remain capable of sustaining communities over time.

Political ecology, in contrast, examines the influence of power, governance, and institutional arrangements on resource access and environmental outcomes (Perreault et al., 2022). This perspective highlights how donor priorities, governance constraints, and crisis-driven decision-making influence environmental outcomes in humanitarian responses. Within emergency WASH programming, these dynamics can shape decisions regarding water extraction practices, sanitation infrastructure siting, waste management systems, and resource allocation.

Together, resilience thinking and political ecology provide a useful analytical lens for understanding how emergency WASH interventions interact with socio-ecological systems in fragile and conflict-affected settings. These theoretical perspectives help explain why humanitarian responses that prioritise rapid service delivery may inadvertently contribute to environmental degradation, and identify pathways for integrating sustainability and resilience into humanitarian programming.

2.2 Empirical Review

Water, Sanitation, and Hygiene (WASH) interventions are a core component of humanitarian response, particularly in emergencies and conflict-affected settings where service breakdowns increase public health risks. Access to safe water, sanitation facilities, and hygiene promotion is essential for preventing communicable diseases and reducing mortality during crises (Sphere Association, 2018). Emergency WASH programmes are typically designed for rapid, large-scale delivery, prioritising speed, coverage, and cost-efficiency in response to donor timelines, security constraints, and urgent disease prevention needs (Manaktala, 2024; Luke & Walters, 2022).

Common interventions include water trucking, emergency borehole drilling, temporary latrine construction, hygiene kit distribution, and short-term water treatment solutions. While these interventions are critical for life-saving outcomes, they are frequently implemented under operational

pressure with limited environmental assessment, particularly in fragile and conflict-affected contexts (Yates, 2023). Weak governance, damaged infrastructure, and limited technical oversight constrain the integration of environmental safeguards into programme design and implementation (UNICEF, 2023; WHO, 2022), often relegating environmental considerations to later recovery phases (Global WASH Cluster, 2021).

A growing literature highlights the environmental externalities associated with emergency WASH operations. Rapid groundwater abstraction from boreholes can contribute to aquifer depletion, while poorly sited temporary latrines may contaminate soil and water sources (Ballard Brief, 2020; Samantha & Frances, 2020; UNHCR, 2024). Inadequate faecal sludge management, combined with widespread distribution of single-use plastics in hygiene kits and water containers, exacerbates solid waste accumulation and pollution in settings with weak waste management systems (Sanderson, 2020; UNDP, 2022; Global WASH Cluster, 2021).

Conflict and displacement further complicate the environmental dynamics of WASH interventions. Armed conflict often damages water infrastructure, disrupts sanitation services, and restricts access to natural resources, increasing dependence on humanitarian assistance (UNEP/OCHA, 2020). Some scholars argue that WASH interventions in fragile contexts inadvertently reinforce cycles of environmental degradation and vulnerability, especially where temporary settlements exert pressure on water, fuel, and land resources, leading to deforestation, soil erosion, and water contamination (Perreault et al., 2022; UNICEF, 2024). Others highlight that careful planning, integration of local knowledge, and community participation can mitigate these effects, although operational constraints often prevent systematic implementation of such measures (Luke & Walters, 2022).

In response to these challenges, a subset of studies has examined the potential of eco-innovation to improve environmental outcomes in humanitarian WASH programming. Solar-powered water systems, ecological sanitation technologies, rainwater

harvesting, water reuse, and circular waste management models are increasingly proposed as strategies to reduce environmental impacts while maintaining operational effectiveness (UNHCR, 2024; Global WASH Cluster, 2021). Evidence suggests that solar-powered water systems can reduce reliance on fossil fuels, operational costs, and greenhouse gas emissions in remote humanitarian settings (ReliefWeb, 2022), while ecological sanitation can mitigate contamination risks and improve waste management when properly implemented (WHO, 2022). However, adoption remains limited due to high upfront costs, technical complexity, donor risk aversion, and perceptions that sustainable approaches conflict with rapid response imperatives (Manaktala, 2024).

Despite the growing recognition of sustainability in humanitarian WASH, several key points emerge from the literature. First, there is broad agreement that emergency interventions are life-saving but environmentally costly. Second, there is consensus that eco-innovation offers potential solutions; however, debates persist regarding the feasibility, scalability, and operational integration of these innovations in conflict-affected contexts. Third, scholars consistently highlight the importance of local participation, governance, and institutional coordination, yet these factors are rarely fully realised in practice due to security, logistical, and funding constraints.

The empirical evidence examining the environmental impacts of emergency WASH interventions in conflict-affected African contexts is limited. Most studies focus on immediate health outcomes rather than ecological consequences, and few assess the practical integration of eco-innovative solutions under operational constraints. Furthermore, the perspectives of frontline practitioners and affected communities are underrepresented, limiting understanding of context-specific challenges and locally driven solutions.

2.3 Conceptual Framework

The conceptual framework of this study is grounded in the relationships among emergency WASH interventions, environmental impacts, and eco-

innovative solutions in conflict-affected humanitarian contexts. Emergency WASH interventions such as borehole drilling, water trucking, hygiene kit distribution, and temporary sanitation infrastructure are implemented to address urgent humanitarian needs. However, these interventions can generate unintended environmental pressures, including groundwater depletion, soil and water contamination, deforestation, and plastic waste accumulation. These environmental impacts are often intensified by governance constraints, operational pressures, limited environmental assessments, and weak coordination mechanisms. Eco-innovation represents a potential pathway for reducing the environmental footprint of humanitarian WASH programming while maintaining life-saving service delivery. Innovations such as solar-powered water systems, reusable hygiene materials, rainwater harvesting, ecological sanitation technologies, and circular waste management models aim to balance humanitarian objectives with environmental sustainability.

Cabo Delgado Province in northern Mozambique exemplifies these dynamics. Since the escalation of conflict in 2017, over 1.3 million people have been displaced, straining already fragile WASH systems (UNICEF, 2024). Recurrent climate-related shocks, including cyclones and droughts, have further damaged infrastructure and contaminated water sources (OCHA, 2021; UNICEF, 2024). Humanitarian actors have implemented emergency WASH interventions, including borehole drilling, water trucking, hygiene kit distribution, and solar-powered water systems (ICRC, 2016; MSF, 2024; ReliefWeb, 2022). While essential for immediate survival, these operations have raised environmental concerns, including the accumulation of plastic waste, pressure on soil and water resources, and poorly sited temporary sanitation facilities (Sanderson, 2020; UNDP, 2022). Water contamination remains a pressing issue, with 29.6% of water sources reported to contain faecal matter (Ballard Brief, 2020), highlighting the persistent nexus between environmental degradation, public health, and vulnerability in emergency settings.

This study, therefore, seeks to address these gaps by providing a qualitative analysis of emergency WASH interventions in Cabo Delgado, focusing on environmental impacts and the feasibility of integrating eco-innovative practices within humanitarian response operations. By combining insights from resilience thinking and political ecology, the study aims to inform strategies that reconcile rapid life-saving objectives with environmental sustainability and long-term resilience.

3.0 RESEARCH METHODOLOGY

3.1 Study Area

This study utilized a qualitative case study design to examine the environmental impacts of emergency Water, Sanitation, and Hygiene (WASH) interventions and the potential for eco-innovative practices in conflict-affected settings. Grounded in a pragmatic philosophical framework, the research analyzes WASH operations within the complex socio-political and ecological landscape of Cabo Delgado, Mozambique, a region defined by protracted conflict and large-scale displacement (see **Figure 1**). Ontologically, the study views environmental outcomes not as isolated technical phenomena, but as products of intricate socio-ecological and institutional systems. This perspective justifies a qualitative approach to generate nuanced, context-sensitive insights into the realities of humanitarian aid (Yin, 2018).

Source: Google Maps, Cabo Delgado Province, Mozambique, accessed October 12, 2025.

3.2 Data Collection

A qualitative case study framework facilitated detailed exploration of WASH interventions in real-world humanitarian contexts where operational, environmental, and governance factors intersect (Yin, 2018). Data were collected over a four-month period between October 2025 and January 2026, ensuring temporal relevance and capturing both operational dynamics and environmental conditions across the study sites.

Data collection employed a mixed qualitative strategy combining primary and secondary sources to enhance analytical depth and rigor. Primary data collection methods included semi-structured interviews, key informant interviews (KIIs), focus group discussions (FGDs), and field-based environmental observations. Semi-structured interviews were conducted with NGO and UN humanitarian practitioners, including WASH coordinators, engineers, hygiene promoters, and programme managers, to capture operational perspectives. In contrast, KIIs were specifically used to engage government officials and institutional stakeholders, allowing for deeper insights into governance, regulatory frameworks, and coordination mechanisms. FGDs were conducted with community members in internally displaced persons (IDP) settlements to capture lived experiences and community-level perspectives on WASH interventions and environmental impacts (Miles et al., 2014).

In total, 15 individual interviews were conducted, comprising 11 semi-structured interviews with NGO and UN personnel and 4 KIIs with government and coordination actors. Additionally, 2 FGDs were conducted in Metuge District at the Namuapala and 25 de Junho IDP camps, involving 24 and 14 participants respectively, with representation from community leaders, women's groups, youth volunteers, and hygiene promoters. This multi-level data collection approach ensured representation across institutional, operational, and

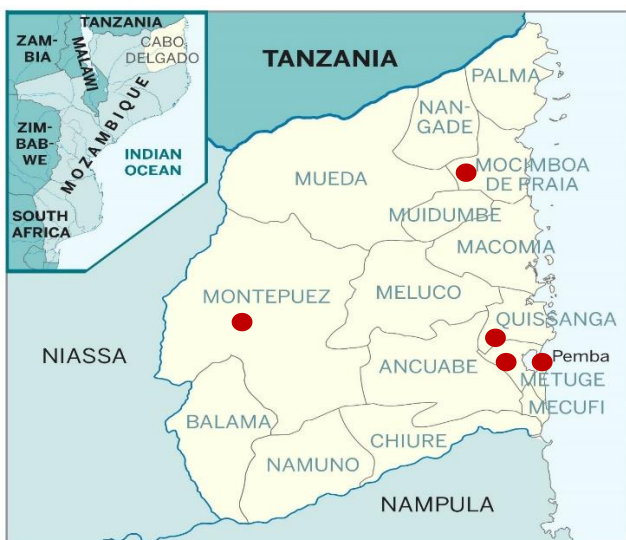


Figure 1: Map of Cabo Delgado Province showing the districts of study

community levels, strengthening the validity and triangulation of findings.

Secondary data were drawn from a purposively selected set of approximately 15–20 documents, including humanitarian project reports, environmental assessments, donor guidelines, national WASH policies, and international humanitarian standards. Documents were selected based on their relevance to emergency WASH programming and environmental management in conflict-affected settings, with priority given to materials from Cabo Delgado and comparable humanitarian contexts. Document analysis was conducted using a thematic content analysis approach, allowing for the identification of recurring patterns related to environmental impacts, operational practices, and sustainability considerations.

A sample of research participants was selected using a combination of purposive, stratified, and simple random sampling strategies. Participant selection prioritized analytical relevance and expertise in humanitarian WASH programming over statistical representativeness, consistent with qualitative case study principles that emphasize depth, interpretive understanding, and contextual sensitivity (Kothari, 2019; Creswell & Creswell, 2020). The study sought information-rich cases to elucidate the relationships between emergency WASH delivery practices and environmental consequences (Bouncken et al., 2025). Participants included UN and NGO WASH personnel engaged in coordination, engineering, hygiene promotion, and programme management; provincial and district-level government authorities; and community members residing in IDP settlements across Pemba, Metuge, Montepuez, Quissanga, and Mocimboa da Praia (OCHA, 2023).

Sample size decisions were guided by principles of thematic saturation, prioritizing analytical depth over statistical representation. Data collection proceeded iteratively and concluded when saturation was achieved, ensuring methodological rigor while remaining responsive to contextual dynamics (Hennink & Kaiser, 2022).

Table 1: Summary of Data Collection Methods

Method	Participants	Number	Locations	Purpose
Semi-structured Interviews	NGO & UN WASH personnel	11	Pemba, Metuge, Montepuez	Operational insights
Key Informant Interviews (KIIs)	Government & coordination actors	4	Pemba, Quissanga, Montepuez, Provincial	Governance & policy insights
Focus Group Discussions (FGDs)	Community members (IDPs)	2	Metuge (Namuapala & 25 de Junho camps)	Community perspectives
FGD Participants	Community members	38	Metuge IDP camps	Lived experiences
Document Analysis	Reports, policies, guidelines	15–20	Various (Cabo Delgado & global)	Contextual & policy analysis

3.3 Data Analysis

Data analysis employed thematic analysis to identify recurring patterns related to environmental impacts, governance dynamics, and eco-innovative practices. The analytical process involved transcription, coding, categorization, and theme development, supported by qualitative data analysis software to enhance transparency, reliability, and interpretive rigor (Jowsey et al., 2021; Miles et al., 2014; Miraz et al., 2025).

4.0 RESULTS AND DISCUSSIONS

Drawing on rich qualitative data from 11 semi-structured interviews, 4 key informant interviews (KIIs), and 2 focus group discussions (FGDs) with humanitarian practitioners, government officials, and community members, this study synthesizes diverse perspectives on the environmental impacts of WASH interventions and opportunities for sustainable practices in Cabo Delgado. The analysis integrates community experiences with institutional insights to explore how environmental accountability can be embedded within humanitarian programming in fragile, conflict-affected settings. Participants included WASH Cluster Coordinators, engineers, program managers, and hygiene promoters from organizations such as UNICEF, UNOPS, MSF-OCB, Solidarités International, World Vision Mozambique, and Johanniter International Assistance, as well as representatives from relevant government institutions, including SPI and SDPI. Respondents were predominantly aged 20–40, with 2–10 years of

professional experience, while some government officials reported over 20 years of institutional experience. The data captured multi-level perspectives spanning operational, institutional, and community dimensions of humanitarian WASH programming.

These qualitative insights are supported by available quantitative evidence from Mozambique and Cabo Delgado, which highlights the scale of environmental and public health pressures associated with WASH systems. For instance, approximately 60% of the population relies on groundwater for drinking water, raising concerns about over-abstraction and sustainability in high-demand humanitarian settings (IGRAC, 2023). At the same time, 29.6% of water sources tested in Mozambique have been found to contain faecal contamination, indicating significant risks associated with sanitation practices and water quality (Ballard Brief, 2020). In conflict-affected areas such as Cabo Delgado, these pressures are further intensified, with cholera outbreaks exceeding 6,400 reported cases between 2025 and early 2026, largely linked to contaminated water and inadequate sanitation (ACAPS, 2026). Additionally, national data show that 63% of the population lacks access to basic sanitation services, while 27% still practice open defecation, further exacerbating environmental contamination pathways (UNICEF, 2022).

Two FGDs were conducted in Metuge District at the 25 de Junho and Namuapala IDP camps. The 25 de Junho FGD included 14 participants (4 female, 10 male), while the Namuapala session involved 24 participants (14 female, including 3 breastfeeding mothers). Participants comprised community leaders, women's representatives, youth volunteers, hygiene promoters, and other community members. Although individual biodata was not collected to ensure confidentiality, the discussions revealed diverse perspectives on environmental degradation, hygiene practices, and WASH facility management, grounding technical findings in lived experience.

Field observations, interviews, focus groups, and document analyses across Pemba, Metuge, Montepuez, Mocímboa da Praia, and Quissanga

indicate that emergency WASH interventions were critical for public health but generated systematic environmental pressures shaped by operational practices, donor frameworks, and governance dynamics. The document analysis component drew on a purposively selected set of approximately 15–20 documents, including humanitarian project reports, environmental assessments, donor guidelines, national WASH policies, and international humanitarian standards relevant to Cabo Delgado and comparable contexts. These documents were selected based on their direct relevance to emergency WASH implementation and environmental management and were analysed using a thematic content analysis approach to identify recurring patterns related to environmental impacts, operational practices, and sustainability considerations. Rapid deployment and standardized designs followed a “life-saving first” logic, with interventions such as solar-powered boreholes in Pemba and rainwater systems in Metuge providing adaptive solutions under resource constraints (Sphere Association, 2018; UNICEF, 2022; Global WASH Cluster, 2021).

Observed environmental impacts included declining groundwater levels in Metuge and Montepuez due to intensive borehole drilling without hydrogeological assessments; poorly sited latrines in Pemba and Quissanga contributing to soil erosion and groundwater contamination; stagnant wastewater around water points in the 25 de Junho camp creating breeding grounds for vectors; and deforestation for latrine and shelter construction. Additionally, plastic waste from hygiene kits and NFIs accumulated due to a lack of structured disposal or recycling mechanisms. These findings underscore the tension between rapid, life-saving interventions and environmental sustainability in fragile humanitarian contexts (UNEP/OCHA, 2020; Samantha & Frances, 2020; Manaktala, 2024).



Figure 2: Stagnant wastewater from a water point within the IDP resettlement camp

Source: Photo taken during data collection at 25 de Junho IDP resettlement camps, Metuge District, (2025).



Figure 3: Emergency latrines constructed using bamboo in the IDP resettlement Camp

Source: Photo taken during field survey in Namuapala IDP resettlement camp, Metuge district, (2025).



Figure 4: Accumulated waste from the distributed WASH hygiene kits in the 25 de junho IDP resettlement camp

Source: Photo taken during data collection at 25 de Junho IDP resettlement camps, Metuge District, (2025).

Respondents across districts attributed environmental degradation in WASH interventions primarily to operational and institutional factors rather than technical ignorance. Donor timelines and reporting systems prioritized coverage indicators, such as the number of boreholes or latrines, while environmental performance metrics were largely absent. NGO staff in Pemba noted that environmental assessments were often treated as optional due to compressed funding cycles (NGO-Pemba-2, Appendix II). Weak coordination between NGOs and district authorities (SDPI) contributed to borehole duplication and poorly sited facilities, with government officials in Quissanga reporting limited involvement in site selection (GOV-Quissanga-1, Appendix IV). Capacity constraints, including limited training in eco-sanitation and groundwater monitoring, further exacerbated environmental pressures. These dynamics align with political ecology perspectives

highlighting how institutional structures and resource allocation shape environmental outcomes (Perreault et al., 2022; Robbins, 2021).

4.1 Emergence of Eco-Innovations

Despite these challenges, several eco-innovative practices were observed. Solar-powered water systems in Montepuez and Metuge reduced reliance on diesel, while women's cooperatives in Mocímboa da Praia and Metuge produced reusable menstrual hygiene kits, reducing plastic waste and supporting livelihoods. Pilot EcoSan toilets and greywater reuse initiatives were introduced in Pemba, alongside the use of alternative construction materials in some districts. Such initiatives were most effective where community participation and institutional support converged, consistent with resilience thinking principles (Folke, 2016; Oxfam, 2023).

4.2 Governance and Environmental Outcomes

Governance capacity strongly influenced environmental performance. Limited technical expertise and financial resources constrained SDPI oversight, although advocacy and training in Pemba and Montepuez demonstrated incremental progress. Cluster coordinators emphasized the need for sustainability benchmarks, noting that donor frameworks often prioritize coverage over ecological outcomes (Cluster Coordinator, Appendix II). Overall, environmental impacts in Cabo Delgado emerged from the intersection of operational urgency, donor priorities, and governance capacity, while eco-innovations highlighted opportunities to strengthen environmentally responsible WASH programming (UNEP/OCHA, 2020; UNDP, 2022; Inter-Agency Standing Committee, 2023).

4.3 District-Specific Evidence

Groundwater depletion in Montepuez, latrine contamination in Pemba and Quissanga, deforestation in Metuge, and waste accumulation in IDP camps reflected structural consequences of humanitarian decision-making. Conversely, localized eco-innovations illustrated resilience pathways where community ownership and institutional support converged, underscoring the need to transition emergency WASH programming

from reactive relief to environmentally accountable practice (Sphere Association, 2018; UNICEF, 2024; Oxfam, 2023).

4.4 Contribution of the Study

While this study is grounded in the specific socio-political and environmental context of Cabo Delgado, it is important to distinguish between context-specific findings and those with broader applicability. Environmental pressures such as groundwater depletion linked to intensive borehole drilling, plastic waste accumulation from hygiene kits, and sanitation-related contamination are strongly influenced by local factors including hydrogeological conditions, displacement patterns, and governance capacity in Cabo Delgado. However, several operational drivers identified in this study, such as compressed donor timelines, limited environmental screening, and output-focused monitoring frameworks, are not unique to this context. These systemic characteristics are widely documented across humanitarian WASH responses in other conflict-affected settings. Similarly, the potential of eco-innovative approaches, including solar-powered water systems, reusable hygiene materials, and community-led sanitation, represents transferable strategies that can be adapted to comparable fragile environments. Therefore, while the environmental manifestations may vary geographically, the underlying institutional and operational dynamics, as well as the pathways for sustainable intervention, offer broader relevance for humanitarian WASH programming globally.

This study advances empirical, theoretical, and practice-oriented knowledge on the environmental dimensions of emergency WASH programming in conflict-affected settings. It documents how interventions generate recurring environmental pressures, declining borehole yields, aquifer stress, sanitation-related contamination, and plastic waste accumulation while identifying operational drivers such as rapid infrastructure deployment, standardized designs, and output-focused monitoring frameworks (Sphere Association, 2018; UNICEF, 2021; UNEP, 2021).

Importantly, the study highlights eco-innovative practices such as solar-powered water systems, reusable menstrual hygiene kits, and community-led sanitation initiatives that mitigate environmental impacts without compromising emergency service delivery, thereby supporting resilience through local ownership and adaptive learning (Folke, 2016; Oxfam, 2023).

Theoretically, the study reframes emergency WASH as a socio-ecological system shaped by donor priorities, institutional authority, and coordination dynamics (Robbins, 2021; Perreault et al., 2022), while extending resilience thinking by demonstrating that adaptive governance and eco-innovation can enable sustainable humanitarian responses even in conflict settings (Zhang et al., 2025).

From a policy perspective, findings underscore practical entry points for environmental accountability, including mandatory environmental screening, integration of ecological indicators into monitoring systems, and stronger district-level oversight. Evidence from Cabo Delgado offers a transferable framework for embedding sustainability into humanitarian WASH programming, strengthening the emerging field of green humanitarianism, and advancing global commitments under SDG 6, 12, and 13 (UN General Assembly, 2015).

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study examined emergency WASH programming in conflict-affected Cabo Delgado Province, focusing on environmental impacts, operational drivers of degradation, and opportunities for eco-innovative practices within humanitarian response. Drawing on qualitative evidence from field assessments, interviews, focus group discussions, and document review, the research demonstrates that humanitarian WASH interventions can generate significant environmental consequences if ecological considerations are not systematically integrated into programming.

Findings show that emergency WASH interventions often produced cumulative environmental pressures. Intensive borehole drilling in districts such as Metuge and Montepuez contributed to declining groundwater yields, while poorly sited latrines in flood-prone areas of Pemba and Quissanga increased the risk of soil instability and groundwater contamination. Plastic-heavy hygiene kit distributions also contributed to the persistent accumulation of solid waste. These impacts were largely driven by compressed implementation timelines, standardized technical approaches, and donor-driven output targets that limited environmental screening and monitoring.

At the same time, the study identified promising eco-innovations that demonstrate the compatibility of emergency response and environmental sustainability. Solar-powered water systems reduced reliance on diesel fuel, community-led sanitation improved maintenance and reduced open defecation, and locally produced reusable hygiene materials helped reduce plastic waste while supporting livelihoods.

The research also highlights the importance of governance and coordination in shaping environmental outcomes. Weak oversight and limited technical capacity at the district level constrained systematic environmental management, while stronger coordination between humanitarian actors and government institutions showed potential for improved accountability.

Overall, the study concludes that environmental sustainability should be treated as a core component of humanitarian WASH programming. Integrating environmental screening and monitoring, and strengthening institutional coordination, can help ensure that emergency interventions meet immediate humanitarian needs while safeguarding fragile ecosystems in conflict-affected settings.

5.1 RECOMMENDATIONS

Building on empirical findings, this study proposes a set of recommendations to enhance environmental accountability, operational sustainability, and governance capacity in emergency WASH programming in conflict-affected settings such as

Cabo Delgado. These recommendations are context-specific but transferable to other fragile humanitarian environments.

Evidence from Metuge and Montepuez, where clustered borehole drilling caused aquifer stress and seasonal failure, underscores the need for mandatory hydrogeological assessments prior to water infrastructure deployment. Tools such as NEAT+, inconsistently applied in early emergency phases, should be institutionalized as non-negotiable requirements within project design and donor frameworks. Environmental indicators must be integrated into routine monitoring systems to ensure ecological risks are systematically tracked alongside coverage metrics. District-level institutions, such as SDPI, should be resourced and empowered to enforce siting standards and abstraction controls, reducing duplication and unregulated groundwater extraction.

Findings from Pemba and Quissanga show that sanitation-related contamination stemmed from compressed timelines and donor-driven output indicators. Donor frameworks should therefore go beyond coverage metrics to include environmental performance benchmarks, such as safe latrine siting, waste segregation, and sludge management.

The WASH Cluster in Cabo Delgado should adopt a provincial Green Humanitarian Standard, aligning interventions with Sphere guidelines and national environmental regulations. This would ensure humanitarian actors are evaluated not only on speed and scale but also on their capacity to safeguard fragile ecosystems.

Eco-innovations observed in Montepuez, Metuge, and Mocímboa da Praia—such as solar-powered water systems, community-led sanitation, and reusable menstrual hygiene kits demonstrate that environmentally responsible practices are feasible within emergency timelines. Their success, however, depends on local ownership and adaptive learning.

To scale these practices, agencies should invest in local artisan training for eco-construction, support women's cooperatives producing reusable hygiene

items, and allocate dedicated budget lines for renewable energy integration. Embedding eco-innovation targets into provincial WASH strategies would help mainstream these practices beyond pilot initiatives.

Weak coordination between NGOs and SDPI, particularly in Quissanga, revealed governance gaps amplifying environmental risks. Strengthening these interfaces requires investment in district-level technical capacity, including training in groundwater monitoring, eco-sanitation, and waste management.

Formalized inter-agency coordination mechanisms would prevent borehole duplication and ensure compliance with hydrogeological standards. Incremental reforms in Pemba and Montepuez, such as environmental monitoring advocacy and technician training, should be consolidated into provincial policy frameworks, embedding environmental accountability into routine governance structures.

The Cabo Delgado case demonstrates that environmentally responsible humanitarian action is achievable when institutional incentives, operational practices, and governance structures are deliberately aligned. Future WASH programming should explicitly integrate commitments under SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) into project cycles. This requires enforceable operational standards, including mandatory environmental impact assessments, ecological monitoring indicators, and green logistics pilots. By embedding sustainability into humanitarian performance frameworks, emergency WASH can evolve from short-term service delivery to integrated socio-ecological approaches that safeguard both human survival and environmental integrity.

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