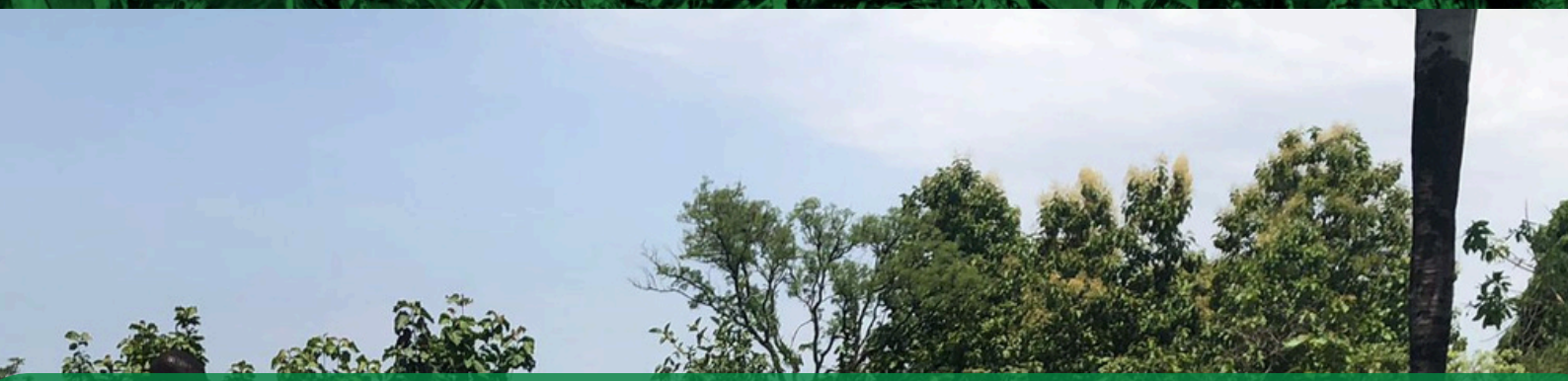
BIO4HUMAN



Policy White Paper

Bridging the gap in Solid Waste Management for Humanitarian Actions

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Damian Kuznowicz, Foundation of Education and Social Dialogue "PRO CIVIS", d.kuznowicz@procivis.org.pl
Marie Šmídová Skálová, People in Need, marie.smidova@peopleinneed.net
Anna Górska, Polish Humanitarian Action, anna.gorska@pah.org.pl
Andrea Motola, Enspire Science Ltd., andrea.ratkosova@enspire-science.com

1. Introduction

Solid Waste Management (SWM) in humanitarian settings is a critical and often overlooked challenge with far reaching consequences. Humanitarian operations (HOs) generate a significant waste footprint[1]. This accumulation of solid waste causes severe health risks, accelerates environmental degradation, and contributes to social tensions. An additional waste increases the burden on areas often lacking functional collection infrastructure. Moreover, the humanitarian sector faces massive and chronic underfunding, characterized by shrinking donor contributions and a on short-term project cycles that undermine the continuity required for impactful sustainable development. It directly impacting its ability to provide life-saving services and pursue sustainable development[2].

This financial pressure is being followed by a structural problem: SWM is often categorized as a development area rather than a humanitarian priority. While donors expect local authorities to take the responsibility, these institutions are frequently non-functional in humanitarian settings, and short-term humanitarian funding is not well suited to address such systemic governance challenges. The Water, Sanitation, and Hygiene (WASH) sector illustrates this crisis starkly. It is massively underfunded, having received only 37% of the funding required, despite its direct life-and-death impact on nearly 130 million people[3]. Compounding the problem, nearly 60% of humanitarian assistance is provided as in-kind goods, creating a massive downstream waste footprint[4], as funding to manage that waste remains insufficient[5]. Recent findings (e.g. Baharmand, 2025) demonstrate that funding gaps and insufficient training are predominant operational challenges facing the sector. Humanitarian waste management suffers from deeper structural constraints: a persistent lack of reliable data, limited investment in durable infrastructure, fragmented responsibilities between humanitarian and local actors, and reliance on short-term emergency delivery models that were never designed to manage long-term waste systems. Finally, the HO's do not operate in a void. They depend on pre-existing municipal infrastructure. In contexts where local waste systems are absent or collapsed, emergency actors cannot

[1] Baharmand, H. (2025). Exploring barriers to circularity in humanitarian supply chains. International Journal of Disaster Risk Reduction, 125, 105572

[2] Baharmand, H. (2025). Exploring barriers to circularity in humanitarian supply chains. International Journal of Disaster Risk Reduction, 125, 105572

[3] Lapegue, J., Pradat-Paz, S., & El Hattab, O. (2025, May 7). Turning point for humanitarian WASH advocacy messages: the 2025 WASH RoadMap Call To Action. The Water Diplomat (Hydropolitics News and Intelligence).

[4] Significant accumulation of solid waste and environmental byproducts generated at the final stages of relief operations (the delivery point or "downstream" end of the supply chain).

[5] Baharmand, H. (2025). Exploring barriers to circularity in humanitarian supply chains. International Journal of Disaster Risk Reduction, 125, 105572

realistically be expected to establish complex management frameworks from scratch during a crisis.

Given these pressures, a fundamental shift is required. The sector should evolve from grant-dependent delivery models towards new financing models built on data, efficiency, and the Humanitarian-Development-Peace Nexus (HDPN). Traditional sources of funding will not be sufficient to meet current or future needs. This makes the identification of new financing sources and innovative mechanisms essential[6].

2. The Findings of Bio4HUMAN Project

The Bio4HUMAN Gap Analysis Report [7], drawing on Bio4HUMAN case studies from the Democratic Republic of Congo (DRC) and South Sudan, identifies limited funding as the most severe deficiency, driven by sporadic donor support and a high dependency on short-term financing models that restrict the scale and continuity of SWM initiatives. This financial instability is compounded by a systemic absence of reliable data: information on waste generation, recycling rates, and downstream disposal is often fragmented and rarely processed consistently along supply chain stages. The absence of unified tracking systems and appropriate monitoring technologies limits the ability of organizations to formulate evidence-based strategies or effectively allocate resources for waste reduction. Furthermore, experience shows that sustainable SWM is impossible without local ownership and control, which remain difficult to establish in crisis contexts.

In the majority of settlements analysed by the Bio4HUMAN consortium, waste is typically open-dumped or burned, releasing toxic emissions and contaminating groundwater. Improper SWM represents a critical link in the chain of public health hazards, triggering cascading disease transmission mechanisms, particularly in regions with poor infrastructure. A primary threat is the physical obstruction of canals and drainage systems by uncollected waste, which leads to localized flooding during the rainy season. Water mixes with contaminants results in the pollution of the living environment and facilitating the spread of pathogens. The widespread practice of open dumping creates ideal breeding grounds for vectors such as flies, mosquitoes, and rodents, drastically increasing the risk of infectious disease transmission[8].

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[6] UNICEF Programme Division. (2016, August). Strategy for Water, Sanitation and Hygiene 2016–2030. UNICEF New York.

[7] https://bio4human.eu/wp-content/uploads/2025/03/D4.1-Bio4HUMAN_List-of-bio-based-solutions_FINAL.pdf

[8] Ekouo, J., Tague, C., Langat, A. K., & Akilimali, A. (2025). Cholera in North Kivu: Impacts of armed conflict on the resurgence of the epidemic, a narrative review. Annals of Medicine & Surgery, 87, 7381–7385, United Nations Development Programme. (n.d.). Guidance note: Municipal solid waste management in crisis and post-crisis settings. Bureau for Policy and Programme Support.

The direct link between these factors and disease outbreaks is presented by epidemiological analyses from North Kivu (DRC), which indicate that poor solid waste management, combined with stagnant wastewater, serves as a hotbed for the proliferation of *Vibrio cholerae* bacteria, directly contributing to recurring cholera epidemics in the region[9]. Moreover, it has to be highlighted that in humanitarian settings poor WASH conditions drive disease transmission, contributing significantly to mortality. It is estimated that 80% of diseases in crisis settings stem from unsafe water and inadequate sanitation[10]. In the Democratic Republic of Congo, for example, more than 20,000 cases of cholera were confirmed in 2023, with a case fatality rate that at times exceeded 2%, which is well above the acceptable threshold. Recurrent conflict, large-scale displacement, and fragile service systems have created a reinforcing cycle of instability, poverty, inadequate sanitation, and persistent disease transmission.

Despite operating under the "Do No Harm" principle, the humanitarian sector lacks robust mechanisms to assess and mitigate its environmental footprint. This is particularly evident in logistics-heavy interventions, where SWM intersects with WASH resource distribution. Water trucking, intended only as a short-term emergency measure, has been shown in some contexts to account for up to 75% of the total environmental burden of water supply operations[11]. Similar inefficiencies are observed in waste logistics, creating localized environmental and public health risks. In the Rwamwanja Refugee Settlement in Uganda, garbage trucks operating at full capacity routinely leak waste along long transport routes between the refugee settlement and surrounding host communities,[12] exacerbating environmental contamination .

3. The Connection Between Data and Funding

Although limited financial resources remain a major obstacle, Bio4HUMAN's analysis indicates that a fundamental root cause is the lack of reliable data. This void extends beyond aid operations to the crisis-affected countries themselves, where systemic dysfunction often appears before the emergency,

[9] Ekouo, J., Tague, C., Langat, A. K., & Akilimali, A. (2025). Cholera in North Kivu: Impacts of armed conflict on the resurgence of the epidemic, a narrative review. Annals of Medicine & Surgery, 87, 7381–7385.
[10] Lapegue, J., Pradat-Paz, S., & El Hattab, O. (2025, May 7). Turning point for humanitarian WASH advocacy messages: the 2025 WASH RoadMap Call To Action. The Water Diplomat (Hydropolitics News and Intelligence).
[11] Berggren, K. (2020). Measuring environmental impact in humanitarian operations: A case study of an emergency response unit for water treatment and supply from a life cycle perspective. (Degree Project in Environmental Engineering, Second Cycle, 30 Credits). KTH Royal Institute of Technology, School of Architecture and the Built Environment.
[12] UrbanEmerge, FLUSH, & Science Practice. (n.d.). Innovation Opportunities in Solid Waste Disposal in Humanitarian Settings: An exploration of problems to identify innovation opportunities in Uganda and Somalia. Report for Elrha.

making data collection nearly impossible. Furthermore, this local incapacity is followed by the overwhelming global acceleration of plastic pollution.

In the humanitarian settings, SWM is often characterized by a lack of clear institutional leadership and data scarcity, which distinguishes it from sectors perceived as directly life-saving, such as health or WASH. In crisis contexts, such as camps in Somalia, SWM is treated as a lower priority compared to healthcare or nutrition, resulting in a failure to assign responsibility and a lack of coordination between authorities and humanitarian agencies[13]. Similarly, in Juba (South Sudan), there is a lack of specialized legal frameworks and a clear division of responsibilities, and the concept of SWM as a public service is not fully established[14]. Globally, waste statistics are often inconsistent, incomparable, and underdeveloped, hindering the monitoring of policy effectiveness[15].

SWM generates real economic costs and health risks. The benefits of sound SWM, such as environmental and public health protection, as well as job creation and the generation of secondary raw materials within a circular economy, are crucial. However, realizing their full potential requires a long-term approach, capacity building and a shift in social attitudes[16].

The operational costs of SWM systems are immediate and highly visible, whereas the benefits are diffuse and materialize in the long term. Infrastructure expenditures, such as waste collection and transport, constitute a dominant share of the budget (e.g., approximately 70% of total expenditures in the Juba plan), necessitating the establishment of cost recovery systems through fees that have historically been difficult to enforce[17].

The majority of countries in the world have difficulties responding to the basic UNSD/UNEP Questionnaire on Environment Statistics, where response rates remain below 50%. Even where reporting is more consistent, data quality is frequently compromised by changes in definitions and methodologies that disrupt comparability over time. Furthermore, measuring waste flows associated with informal or illegal sectors poses an additional challenge,[18]

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[13] UrbanEmerge, FLUSH, & Science Practice. (n.d.). Innovation Opportunities in Solid Waste Disposal in Humanitarian Settings: An exploration of problems to identify innovation opportunities in Uganda and Somalia. Report for Elrha.
[14] Juba City Council, Ministry of Environment and Forestry, & Ministry of Health, Central Equatoria State. (2021). Solid Waste Management Master Plan in Juba City 2021-2030. Prepared with assistance from Japan International Cooperation Agency (JICA).
[15] Conference of European Statisticians Task Force on Waste Statistics.
[16] Conference of European Statisticians Task Force on Waste Statistics.
[17] Juba City Council, Ministry of Environment and Forestry, & Ministry of Health, Central Equatoria State. (2021). Solid Waste Management Master Plan in Juba City 2021-2030. Prepared with assistance from Japan International Cooperation Agency (JICA).
[18] Conference of European Statisticians Task Force on Waste Statistics.

leaving significant gaps in the understanding of overall waste generation and management.

Without detailed, coherent, and trustworthy data, donors cannot confidently allocate resources to the most sustainable and cost-effective solutions. As a result, the financial gap cannot be resolved until the data gap is addressed.

4. The HDPN Approach (Humanitarian-Development-Peace Nexus)

There is a crucial structural mismatch between the short-term nature of humanitarian budget cycles and the long-term operational realities of SWM. Humanitarian funding is typically short-term, crisis-driven and deployment-specific, whereas sustainable SWM infrastructure requires investments that extend far beyond immediate response periods[19]. At the same time, reductions in global development assistance brings into question the dependency of the entire humanitarian sector on institutional funding, which is inconsistent, unpredictable and often shaped by political priorities.

To bridge this gap, Bio4HUMAN supports adopting the Humanitarian-Development-Peace Nexus (HDPN approach), which emphasizes simultaneous rather than sequential engagement of humanitarian and development actors. A good example of this is UNICEF's WASH strategy, in which HDPN is established as a core programming principle[20]. Under this approach, rapid humanitarian response is aligned with longer-term solutions that strengthen community resilience and reinforce sector systems to withstand shocks and crises[21].

Investing in stronger systems during times of stability reduces both the impact and the cost of emergencies when they occur. Crucially, this is a matter of global concern: poor waste management in crisis zones has transboundary repercussions, as untreated waste contaminate shared water bodies and the atmosphere. That is why the humanitarian and development programmes must operate in a complementary manner, reinforcing rather than replacing one another. While funding gaps remain a persistent challenge, discussions

[19] Berggren, K. (2020). Measuring environmental impact in humanitarian operations: A case study of an emergency response unit for water treatment and supply from a life cycle perspective. (Degree Project in Environmental Engineering, Second Cycle, 30 Credits). KTH Royal Institute of Technology, School of Architecture and the Built Environment.
[20] UNICEF Programme Division. (2016, August). Strategy for Water, Sanitation and Hygiene 2016–2030. UNICEF New York.
[21] UNICEF Programme Division. (2016, August). Strategy for Water, Sanitation and Hygiene 2016–2030. UNICEF New York.

with experts indicate that Humanitarian Organizations (HOs) can still advance toward circularity within these existing resource constraints[22].

5. Private Sector and Income Generation

To achieve long-term sustainability, Bio4HUMAN promotes a shift in perspective from viewing waste as a liability to recognizing it as a "resource recovery" opportunity. Given that organic matter constitutes the dominant waste fraction in most humanitarian contexts, bio-based solutions offer the highest potential for cost recovery[23]. Scoped Black Soldier Fly Larvae (BSFL) technology exemplifies this approach by closing the loop between waste management and food production, transforming discarded organic matter into high-value livestock feed and biofertilizers. The economic incentives are substantial, as feed accounts for more than 70% of total production costs in agriculture and in some contexts the price of fish feed has risen by approximately 200% in a single year[24].

Financial sustainability in SWM can also be strengthened through cost-recovery mechanisms and strategic partnerships. Public-Private Partnerships (PPPs) and tariff systems provide valuable avenues for improving service delivery while offsetting operational costs. In many vulnerable communities, PPPs help bridge gaps created by limited local resources and support the long-term viability of waste services[25].

A practical example from one of Bio4HUMAN case studies comes from Juba (South Sudan), where the total projected expenditure for SWM between 2020 and 2030 is approximately 36 mln USD[26] with the largest portion allocated to waste collection and transportation. To manage these costs, in the early-stage planning Juba would like to introduce and expand a household fee collection system. While the city historically did not collect fees due to low service coverage, the city's mid-term plan indicates that fee collection for household waste will begin. The targets are ambitious: the waste collection rate for the mid-term plan (2025) in Juba was 50%, rising to 80% by 2030[27]. The Indonesia Tsunami Recovery Waste Management Programme (TRWMP) is an example of a fee system that achieved partial success. Following the 2004 tsunami, UNDP implemented a waste management programme that transitioned from emergency recovery to long-term sustainability. A key component of this

[22] Baharmand, H. (2025). Exploring barriers to circularity in humanitarian supply chains. International Journal of Disaster Risk Reduction, 125, 105572
[23] Conference of European Statisticians Task Force on Waste Statistics.
[24] Anokye, K. (2025). *Cleaner Waste Systems*, 12, 100416.
[25] Knowledge product series from the UNDP Evaluation Resource Centre (IEO).
[26] 4,718,941 thousand South Sudanese Pound (SSP)
[27] Juba City Council, Ministry of Environment and Forestry, & Ministry of Health, Central Equatoria State. (2021). *Solid Waste Management Master Plan in Juba City 2021-2030*. Prepared with assistance from Japan International Cooperation Agency (JICA).

transition was the introduction of a cost-recovery mechanism through user fees. The project succeeded in getting approximately 33% of households to pay for waste collection services[28]

These efforts illustrate how cost-recovery and private-sector engagement can support a more sustainable SWM system, even in fragile contexts.

6. Policy Recommendations

To translate these findings into action, Bio4HUMAN proposes several key policy recommendations. Given the unprecedented decrease in humanitarian funding, simply advocating for increased budgets is no longer a viable solution. Instead, the sector must adopt "out-of-the-box" financing models and integrate SWM as a cross-cutting priority essential for health, protection, and cost-efficiency.

Recommendations for Donors

Minimum actions:

1. Use SWM as a leverage point for private-sector and municipal partnerships. Humanitarian budgets alone cannot sustain SWM systems. Donors can play a catalytic role by de-risking early pilots, supporting PPP mechanisms, and incentivizing joint planning between HOs, municipalities, and private operators. This strengthens long-term service viability without increasing humanitarian expenditure.

2. Promote blended financing models. Donors should actively facilitate access to climate funds, development banks, carbon markets, and private investors to extend the impact of limited humanitarian funds.

3. Establish minimal, low-cost requirements for data. Rather than demanding complex assessments, donors should require basic waste audits or simplified LCA to create a consistent evidence base for decision-making without imposing heavy administrative burdens.

4. Climate and development donors should support SWM in crisis settings. Mismanaged waste contributes to greenhouse gases, soil and water contamination, and long-term environmental degradation. Funding SWM is not just aid but is also a climate mitigation strategy that strengthens resilience and recovery.

Advanced actions:

5. Facilitate transparency and data-sharing from private-sector actors. Donors should use their authority to promote data transparency,

[28] United Nations Development Programme. (n.d.). Guidance note: Municipal solid waste management in crisis and post-crisis settings. Bureau for Policy and Programme Support.

environmental reporting, and shared LCA standards among private suppliers, enabling better planning and improving environmental accountability across supply chains.

Recommendations for HOs

Given the sustained contraction of humanitarian funding, the following recommendations are not intended to expand the scope of humanitarian action. Instead, they focus on reallocation, substitution, and efficiency gains. Integrating SWM across sectors, investing in minimal data collection, and adopting circular approaches are proposed specifically as means to reduce downstream health costs, logistics expenditures, and recurrent emergency responses. Where new actions are recommended, they are paired with the reduction or phase-out of inefficient, logistics-heavy, and parallel systems that currently absorb a disproportionate share of limited resources.

Minimum actions:

1. Integrate SWM into core programming as a cost-reduction measure. SWM should be integrated into health, WASH, shelter, and logistics planning as a cost-reduction measure rather than an additional sector. Poor waste management drives disease outbreaks, flooding, and environmental contamination, triggering costly emergency responses. Early integration reduces repeated health interventions, WASH scale-ups, and infrastructure repairs.

2. Prioritize low-cost, circular SWM solutions. Replace logistics-heavy disposal models toward efficient, circular approaches (reuse, repair, repurposing, composting, BSF larvae) that reduce transport needs and dependence on expensive supply chains.**3. Strengthen partnerships with municipalities and local private operators.** HOs should move beyond long-term direct service delivery and focus on coordination and capacity strengthening to ensure service continuity beyond humanitarian funding and reduce parallel systems.

4. Prepare for "responsible transition" by designing SWM interventions to integrate into municipal, development, or climate-funded systems, reducing long-term future dependence on humanitarian aid.

Advanced actions:

5. Reframe SWM as a protection, health, and risk-management priority HOs should explicitly position SWM within protection and health strategies, recognizing its role in preventing disease transmission and reducing environmental hazards. This reframing supports stronger internal

prioritization and justifies resource reallocation toward preventive, lower-cost interventions.

Recommendations for Academia and Research

Minimum actions:

1. Develop methodologies for simplified LCA. Academia should lead the creation of accessible tools and simplified methodologies to generate a consistent evidence base for decision-making in resource-constrained settings.

2. Innovate for circularity. Focus research and development on efficient, low-tech circular approaches (reuse, repair, repurposing, composting, BSF larvae) that reduce dependence on expensive supply chains.

Advanced actions:

3. Promotion of data transparency and standardization. Researchers should actively promote data transparency, environmental reporting, and shared LCA standards to improve accountability across the sector.

Recommendations for the Private Sector

Minimum actions:

1. Engage in PPPs. Businesses should actively participate in PPP mechanisms and incentivize joint planning between HOs, municipalities, and private operators to ensure long-term service viability.

2. Implement circular business models. Private actors should adopt and scale efficient, circular approaches in their operations and supply chains.

3. Strengthen local partnerships. Move beyond transactional relationships by supporting and partnering with municipalities and local private operators to build capacity.

Advanced actions:

4. Invest in blended financing models. Private investors should participate in blended financing models to extend the impact of limited humanitarian funds while seeking sustainable returns.

Finally, responses must be multisectoral. SWM cannot be treated in isolation. It must be integrated into health responses to prevent cholera and other outbreaks, ensuring that health outcomes for crisis-affected populations are directly addressed through coordinated SWM and WASH interventions.

Conclusion

Sustainable Solid Waste Management is no longer a peripheral issue in humanitarian response. It is a central determinant of health, safety, and resilience for crisis-affected populations. The evidence presented through the Bio4HUMAN project highlights the urgent need to overcome longstanding data and financing gaps, shift toward integrated HDPN approaches, and embrace models that value waste as a resource.

Achieving these objectives will require coordinated action from donors, humanitarian organizations, development partners, and the private sector. By investing in data systems, enabling circular solutions, and strengthening multisectoral collaboration, the humanitarian community can build waste management systems that not only protect communities today but also strengthen resilience for the future. The tools, knowledge, and technologies already exist. What is needed now is the commitment to scale them.

The cost of inaction is too high to overlook. If SWM continues to be ignored, we accept a status quo that worsen public health crises and accelerates global pollution. By failing to address this gap, we are not only compromising the efficacy of current aid but also locking crisis-affected regions into a cycle of dependency and environmental poverty that will persist long after the emergency ends.

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