



Working paper:
**Overcoming the non-technical
barriers for effective
implementation of bio-based
solutions in humanitarian
settings**

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November 2025

1. Context and aims of Bio4HUMAN Project

The Bio4HUMAN EU-funded project aims to identify bio-based solutions for solid waste management (SWM) applicable to humanitarian sector, drawing on case studies of existing SWM practices in the Democratic Republic of Congo (DRC) and South Sudan. The aim of this working paper is to present the findings from the [Gap Analysis Report](#) related to recommendations for overcoming non-technical barriers to implementing bio-based solutions in humanitarian actions (HA). This paper also aims to inform a wider audience and key stakeholders in the context of humanitarian aid: NGOs, donors and policymakers, but also academia and bio-based industries. These stakeholders would be particularly interested in the outcomes, because they can effectively contribute to enhancing the sustainability and efficiency of humanitarian operations:

- NGOs stand to gain from practical solutions for waste management that align with their environmental commitments and improve living conditions in affected areas;
- Donors and policymakers will find value in evidence-based recommendations that can guide funding decisions and policy development towards more environmentally responsible and effective aid delivery;
- Academia can leverage the report's findings for further research and innovation in bio-based solutions for challenging environments;
- Finally, bio-based industries can identify new markets and opportunities for their technologies within the humanitarian sector, contributing to both their growth and global humanitarian efforts.

2. Breakdown of the Gap Analysis Report

The Gap Analysis Report is structured into six chapters to provide a clear and logical progression of findings and recommendations. The introductory chapter sets the stage, providing the essential context for the gap analysis and outlining the overarching aim of the Bio4HUMAN project and its scoping exercise. Chapter 2 dives into the methodology, which is presented briefly above. Chapter 3 provides a comprehensive overview of existing SWM practices in humanitarian contexts, detailing the types of waste generated, current management techniques, and specific challenges encountered at various supply chain stages, with particular reference to real-world examples from Bio4HUMAN's case studies - the DRC and South Sudan. Chapter 4 outlines the desired state of SWM in HA. This chapter defines a potentially ideal SWM system for HAs, which effectively incorporates sustainable, bio-

based solutions and infrastructure, based on the identified stakeholder needs. Chapter 5 then describes the differences between the current and desired SWM states, analysing needs and challenges for SWM in the humanitarian contexts through a structured gap analysis. Finally, Chapter 6 presents concrete actions and strategies to address the identified SWM gaps, focusing on critical areas such as governance, technology adoption and effective stakeholder engagement. This chapter aims to serve as a roadmap for bridging these gaps. It also outlines a communication strategy, recognizing its vital role in successfully implementing the proposed changes.

This report builds upon work previously done in the project which aimed to identify environmentally friendly bio-based innovative solutions and systems applicable within diverse humanitarian contexts. It synthesizes findings from multiple crucial sources to address the challenges and opportunities in Humanitarian Supply Chains (HSC), with a specific focus on SWM.

The foundation for this analysis was the [Humanitarian Sector Needs Assessment Report](#) developed by humanitarian project partners of the Bio4HUMAN consortium - [People in Need \(PIN\)](#) and [Polish Humanitarian Action \(PAH\)](#). The report identified the most pressing needs within the humanitarian sector connected to implementing SWM: limited SWM capacities in the country, lack of funding, no coordinated SWM plans of the humanitarian sector, reluctance to give SWM priority, and a lack of efficient enforcement of SWM policies on a local government level. The data was based on field assessments conducted between March and July 2024 in the DRC and South Sudan. Both organizations have long-standing operations in Central and East Africa, providing critical aid in conflict-affected regions. PIN has been active in the DRC since 2008 and its efforts are concentrated in the conflict-affected South Kivu province, where it works directly with local communities. PAH has been operating in South Sudan since 2006, making it one of its long-term missions. Their activities primarily focus on providing access to clean water, sanitation, and hygiene (WASH). In 2024 alone, their work in this African country benefited nearly 70,000 people.

The next important activity in the project was the development of the [List of Bio-Based Solutions](#). This report played a crucial role by scoping and listing sustainable bio-based solutions specifically designed to enhance humanitarian operations and SWM. These solutions were not only potentially applicable within humanitarian contexts for SWM, but also could contribute to a more circular bioeconomy, offering functional properties comparable to their fossil-based substitutes. The report was enriched by the insights from a task aimed at identification of Supply Chain Gaps in the SWM System for HA. It highlighted gaps in supply chains supporting humanitarian efforts by

comprehensive analysis of the links, management techniques and solid waste technologies already being used. This was developed by a multi-level approach consisted of literature review, in-depth interviews with supply chain leaders, comprehensive data collection on management tools and techniques used in humanitarian interventions and detailed supply chain mapping across nine distinct supply chain stages¹. Afterwards, the areas for innovation and existing gaps in those stages were identified by using tailored dimensions, point scales, a common data extraction sheet and a rating scheme based on priorities of humanitarian aid providers. By integrating these efforts, the report presents a holistic view of both the challenges and the potential for innovation within HSC and SWM.

One of the aims of Bio4HUMANis to develop a replication roadmap that will contribute to the future replicability of the solutions identified. It is meant to provide practical tools and strategies for addressing waste management and related issues across a diverse range of humanitarian aid contexts. Its development will aim to facilitate the pathway towards future replicability of the bio-based solutions identified within the project. This paper has the ambition to focus on non-technical barriers to implementing these bio-based solutions; the technical feasibility alone is insufficient for successful adoption in complex humanitarian environments, and non-technical barriers encompass a wide range of challenges. By identifying and addressing these enablers of solutions, the project acknowledges that sustainable integration requires more than just innovative technology. It requires an effort to overcome the human, organizational, and systemic obstacles that often hold progress in humanitarian contexts.

3. Tackling the non-technical barriers to put bio-based solutions into action

The successful integration of bio-based solutions into humanitarian SWM should be based not only on technological innovation, but also significantly on overcoming a range of non-technical barriers. Within the Bio4HUMAN project, the identification of these non-technical barriers was part of the Gap Analysis Report. Key findings from this comprehensive study were based on the real-life research conducted in the DRC and South Sudan, but also on other investigated humanitarian settings. The following critical gaps related to non-technical domains were identified. **Insufficient financial resources** points to a lack of adequate funding specifically allocated for SWM initiatives,

¹ Based on major phases of crisis management, we identified 9 HSC stages, taking into account specific type of actions required for implementation, intensity and scale of used tools, techniques and technologies, external staffing and local human resources involvement, and finally, the scale and type of solid waste generated.

including financial contributions from public bodies and donors supporting the implementation of new bio-based technologies. **Shortage of human resources** refers to the limited trained personnel with the necessary expertise in SWM and particularly in managing bio-based processes. It negatively affects the operational capabilities related to SWM. **Weak policy framework and enforcement** leads to inadequate or unimplemented policies at national and international levels, which creates an unstable environment for sustainable SWM practices and the introduction of new bio-based approaches. **Lack of strategic planning** is understood as the absence of long-term, integrated planning for SWM, eventually leading towards efforts that are often reactive rather than proactive, failing to match the needs of bio-based solutions. This refers to the integration of circular economy principles and adherence to the SWM hierarchy (prioritizing avoidance, reduction, reuse, and recycling over disposal). The major barrier encountered during the investigation was **insufficient data and inconsistent monitoring**. Without reliable data on waste generation, its composition and current management practices, it becomes difficult to accurately assess needs, measure the impact of interventions, and justify investments in these sustainable solutions. Significant challenges lie in **sustainable procurement and planning**. Humanitarian organizations (HOs) often face difficulties in sourcing and planning for bio-based products and materials within their existing procurement systems, which limits the wider adoption of these alternatives. Furthermore, another barrier identified was **limited awareness and education on sustainable waste management**. A lack of understanding among affected populations, humanitarian staff, and local authorities regarding effective SWM practices and the benefits of bio-based solutions has a significantly impeding effect on their acceptance and proper utilization by not transforming waste into useful products or resources. **Lack of coordination among facilities** involved in the waste management chain also presents a significant barrier. When collection, transport, processing, and disposal facilities and actors do not work together efficiently, it creates inefficiencies and operational bottlenecks that affect the establishment of integrated bio-based systems. Finally, even with the introduction of bio-based solutions earlier in the process, **inadequate waste management at the end of the supply chain** can affect their overall positive impact. If waste is not properly managed at its final stages of disposal or recycling, the benefits of using bio-based materials are significantly reduced.

These non-technical barriers were further evaluated through a structured gap analysis across six key dimensions², defined in consultation with the

² **Resource availability:** Pertains to the non-financial resources, including materials, infrastructure, and human capacity. / **Technology for SWM in humanitarian contexts:** While technology itself is technical, its adoption and suitability are influenced by non-technical factors like user acceptance, training, and

representatives of HOs (World Food Programme, International Committee of Red Cross) and project partners - PAH and PIN. These dimensions underscore the multi-faceted nature of non-technical challenges. Each dimension was rated on a 5-point scale, where '5' indicated a "Critical Gap" requiring immediate action and '1' represented a "Minimal Gap." The analysis highlighted that "Insufficient financial resources" and "Lack of coordination among facilities" emerged as the most significant non-technical barriers. This underscores their profound impact on operational viability, the high dependency on funding, and the systemic challenges in inter-organizational relationships. "Weak policy framework and enforcement" also prominently featured, emphasizing the critical need for engaging local governments and institutions to strengthen policy alignment and regulatory enforcement. Dimension-wise, "Supply chain efficiency" and "Environmental sustainability and policy alignment" were identified as the most critical categories. This clearly indicates that systemic setbacks within the supply chain and a lack of alignment in environmental policies are major non-technical barriers that significantly hinder the overall performance of HOs in adopting and implementing bio-based SWM solutions. Addressing these deeply ingrained non-technical barriers is therefore paramount for the successful and sustainable deployment of bio-based innovations in humanitarian aid.

4. Enablers to overcome non-technical barriers

To effectively address the above-mentioned non-technical barriers affecting the implementation of bio-based solutions in humanitarian SWM, the Gap Analysis Report identifies a number of strategic enablers and supporting actions. These enablers are tailored to various target groups, recognizing that **a multi-stakeholder approach** is essential for fostering a conducive environment for sustainable SWM practices. The value of such a multi-stakeholder approach is also validated by the collaborative structure of the Bio4HUMAN project team itself, which successfully integrates humanitarian and technical expertise. By targeting specific actors: policymakers, bio-based industries, academia, and HOs, the report outlines how collaborative efforts can dismantle existing obstacles and pave the way for successful integration of bio-based solutions. This is strategically aligned with the outcomes of the project's [stakeholder mapping](#). The outlined enabling actions are designed to

maintenance capacity. / **Supply chain and operational efficiency:** Focuses on the effectiveness of logistical and management processes rather than just the physical movement of goods. / **Stakeholder engagement:** Addresses the critical need for collaboration, communication, and buy-in from all relevant parties, including local communities, governments, and NGOs. / **Environmental sustainability and policy alignment:** Examines how well practices align with environmental goals and existing or desired policy frameworks. / **Community needs and impact assessment:** Emphasizes understanding and responding to the specific requirements and potential effects on the affected communities.

engage these stakeholders directly, providing a clear pathway to the socio-economic and governance aspects evaluation. This will eventually serve as an input to the development of replication roadmap later in the project.

Policymakers

Policymakers play a pivotal role in establishing the regulatory and financial frameworks necessary for widespread adoption of bio-based SWM. To overcome the barrier of **Insufficient financial resources**, they can significantly contribute by increasing dedicated funding for SWM initiatives through advocating for more donor funding and establishing sustainable financing models, such as implementing gate fees or encouraging private sector investment and polluter-pays principles. Addressing **weak policy framework and enforcement** requires policymakers to enhance SWM policy enforcement by strengthening national policies³ with clear roles, responsibilities, and effective enforcement mechanisms. This should be supported by cross-sectoral coordination platforms⁴. This also involves aligning SWM practices set by international standards. It will ensure consistency and effectiveness, and they can support the creation of specialized environmental NGOs focused on waste management to provide expert oversight and advocacy. For **lack of strategic planning**, policymakers are crucial in adopting sustainable SWM models that integrate circular economy principles and green procurement practices into international humanitarian guidelines. This planning would support recognizing SWM across all humanitarian sectors by embedding it into policies, planning frameworks and personnel training. This will ensure that waste hierarchy practices (waste prevention, reduction, reuse, recycling, safe disposal) becomes standard. Furthermore, to tackle **insufficient data and inconsistent monitoring**, policymakers should support enhanced waste data collection and monitoring by prioritizing accurate measurement and reporting through standardized methods like waste audits. Improving overall **coordination and collaboration** is also within their scope, achieved through establishing platforms and fostering partnerships among humanitarian organizations, local authorities, communities, and the private sector for integrated SWM. Ultimately, strengthening national SWM policies and enforcement is critical to mitigate broader operational, knowledge, logistical, social, cultural, and regulatory challenges.

³ Examples from Africa: Republic of South Africa <https://www.dffe.gov.za/national-waste-management-strategy>, Gambia <https://kanifing.gm/2024/11/21/kmc-holds-general-council-for-the-month-of-november/>

⁴ Platforms, e.g., Juba stakeholder committee – a good practices identified within the Bio4HUMAN project: https://www.jica.go.jp/Resource/south_sudan/english/office/topics/fh2q4d000000rbey-att/221122_04.pdf for regular meetings among HOs, governments, and private actors to share updates and align strategies.

Bio-based Industries

Bio-based industries are crucial partners, offering the innovative products and technologies needed alongside having a vested interest in expanding their market. To address **insufficient financial resources**, they can be encouraged through mechanisms that link waste collection with income-generating activities in the humanitarian settings, fostering collaboration with private enterprises to create viable business models around waste. Their role in minimizing **weak policy framework and enforcement** can involve reducing distinguishable waste by minimizing branded packaging, thereby simplifying waste streams. In terms of **strategic planning**, bio-based industries can contribute by adopting sustainable SWM models that support circular economy principles. These principles aim to create closed-loop systems where products and materials are designed to be reusable, recyclable, or recoverable. Thereby keeping resources in the economy for as long as possible while reducing the need for virgin materials. Moreover, it contributes to green procurement practices by reducing the waste at its source. The industries could design their products according to the sustainability criteria which would allow them to enter the entire procurement life cycle. They could also develop products that incorporate sustainable criteria early in the supply chain, including thoughtful product selection and packaging. To tackle **challenges in sustainable procurement and planning**, they are uniquely positioned to focus on upstream solutions, addressing waste and sustainability issues at the earliest stages of the supply chain through product design and manufacturing processes. For **inadequate waste management at the end of the supply chain**, bio-based industries can provide local bio-based solutions such as composting organic waste into fertilizer, producing biogas, and transforming waste into useful products. They can also support reverse logistics, encouraging the return, donation, or resale of packaging waste to suppliers or local entities, thereby closing the loop on material flows.

Academia

Academia serves as a vital source of knowledge, research, and capacity building, directly addressing the **shortage of human resources** and **insufficient data and inconsistent monitoring**. To build SWM capacity, academic institutions can provide essential training and exchange programs for governments, businesses, HOs and communities, enhancing expertise in various waste management techniques. They can also supply external experts and facilitate on-the-job training opportunities to ensure the proper operation of new technical and technological solutions while simultaneously training local staff. In combating **lack of strategic planning**, academia can contribute significantly by conducting research that helps humanitarian actors to utilize published waste management guidance, enabling the development of more effective and data-driven SWM strategies. Their role is also fundamental in

addressing **insufficient data and inconsistent monitoring** by researching and promoting enhanced waste data collection and monitoring, prioritizing accurate measurement and reporting through standardized methods like waste audits. To overcome **limited awareness and education on SWM**, academia can design and support communication campaigns and educational programs for communities and stakeholders on proper waste segregation, environmental impact, and the benefits of bio-based solutions. They are also instrumental in integrating environmental and SWM education into training programs for all humanitarian staff and volunteers, ensuring a workforce with high awareness⁵.

Humanitarian organizations

HOs themselves are at the forefront of implementation, and their internal practices and collaborative efforts are critical for overcoming non-technical barriers. To mitigate **insufficient financial resources**, they can create income opportunities by linking waste collection with income-generating activities in the humanitarian settings and collaborate with private enterprises. Addressing the **shortage of human resources** involves building SWM capacity through providing training and exchange programs for their staff and engaging external experts for on-the-job training. In terms of **weak policy framework and enforcement**, humanitarian organizations can align their SWM practices with international standards, while also supporting the creation of specialized environmental NGOs and advocating for minimizing branded packaging. To tackle the **lack of strategic planning**, they must continue to adopt sustainable SWM models that integrate circular economy principles and green procurement practices into their operations. This includes prioritizing SWM across all humanitarian sectors by integrating it into policies, planning frameworks and personnel training. Moreover, they can adopt waste hierarchy practices and foster collaboration between their own teams (e.g., between needs identification and planning) to minimize downstream waste. Mitigating SWM risks through targeted strategies like segregation and safe disposal systems is also crucial. For **insufficient data and inconsistent monitoring**, HOs should prioritize enhancing waste data collection and monitoring by implementing accurate measurement and reporting through standardized methods⁶. Overcoming the barrier of **limited awareness and education on**

⁵ In the target locations there are academic actors that could play important role in this regard. In the DRC: Université Officielle de Bukavu, Université de Goma, Université Evangélique en Afrique, Université du Cinquanteaire, Université de Lubumbashi, Institut supérieur de développement rural de Bukavu ISDR-Bukavu, International Institute of Tropical Agriculture; In South Sudan: University of Juba, Yei Teachers Training College.

⁶ The "Waste or Material Characterization Exercise Guidance" developed by WREC was published in June 2024 describes two main methods of measuring waste: 1. Quantification Method - involves segregating waste by type and manually counting (weighing the quantities) of waste generated over five working days from offices, warehouses, and fleet workshops (for smaller amounts); for larger quantities (e.g., in project

SWM requires them to promote awareness and education through communication campaigns and educational programs for both communities and their own staff. Crucially, they must improve **coordination and collaboration** by establishing and maintaining platforms and fostering partnerships among HOs, local authorities, communities, and the private sector for integrated SWM. To address **challenges in sustainable procurement and planning**, HOs should focus on upstream solutions, promoting sustainable procurement through training, evaluating suppliers for environmental standards and conducting life-cycle assessments and life-cycle costings, while also prioritizing local procurement and incorporating sustainable criteria early in the supply chain. Finally, concerning **inadequate waste management at the end of the supply chain**, HOs can leverage local bio-based solutions (e.g., composting, biogas production). It is also important to promote reverse logistics and engage qualified local suppliers and recyclers, building their capacity and integrating informal sector efforts into formal SWM systems. They also need to address broader operational, knowledge, logistical, social, cultural, and regulatory challenges by advocating for the improvement of public infrastructure, standardizing storage facilities and packaging units.

5. Conclusions

The Bio4HUMAN project set out to identify and assess the applicability of bio-based solutions for waste management within the humanitarian sector, aiming to have a positive environmental impact. This paper, building on the project's Gap Analysis Report, has highlighted the critical non-technical barriers hindering the widespread adoption of these sustainable solutions and has outlined concrete enablers to overcome them. Successful implementation requires addressing the challenges related to financial resources, human expertise, policy frameworks, strategic planning, data availability, awareness, coordination, sustainable procurement, and end-of-supply chain management. The structured Gap Analysis highlighted that insufficient financial resources and lack of coordination among facilities as the most significant barriers, alongside the issue of weak policy framework and enforcement. This emphasizes the interconnectedness of funding, inter-organizational collaboration, and supportive governmental policies in driving sustainable change. By targeting policymakers, bio-based industries, academia, and humanitarian organizations with tailored enablers, we propose

areas), it recommends taking representative samples to analyse waste generated over seven consecutive days; 2. Estimation Method - Estimates potential waste at the procurement phase, based on procurement plans and information regarding the packaging and relief items' material characteristics

a multi-stakeholder approach that can collectively dismantle these obstacles. Bio4HUMAN project is a pure reflection of this effort.

The finding presented will directly inform the development of the Bio4HUMAN replication roadmap. This roadmap will serve as a practical guide, providing tools and strategies to address waste management challenges across diverse humanitarian contexts. The goal is to ensure the future replicability of the bio-based solutions identified within the Bio4HUMAN project. By focusing on these non-technical enablers, it will be possible to create an environment where innovative bio-based solutions are not only adopted but also wanted, leading to more sustainable and efficient humanitarian operations.

If you would like to reach out and contribute to the Bio4HUMAN project, or learn more about our findings and future work, please feel free to contact: Damian Kuznowicz (d.kuznowicz@procivis.org.pl) and Paweł Sobczyk (p.sobczyk@procivis.org.pl).