

worm

**Waste in humanitarian Operations:
Reduction and Minimisation**

D3.1 Local Humanitarian Waste Management Business Models

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LIST OF ACRONYMS

ACRONYM	FULL NAME
EPR	Extended Producer Responsibility
HO	Humanitarian organisation
NFI	Non-food item
NGO	Non-governmental organisation
VFF	Vietnam Fatherland Front
VNRC	Vietnam Red Cross
WHO	World Health Organization
WORM	Waste in humanitarian Operations: Reduction and Minimization
WPs	Work Packages
UNEP	United Nations Environment Program

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BACKGROUND ABOUT WORM

WORM aims to design guidelines and support actions for circular economy in the humanitarian sector. It integrates bio-based technological solutions, leverages procurement for waste reduction, improves waste management methods and prioritises the sustainable livelihoods of waste pickers. WORM focuses on two selected settings: field hospital deployments and humanitarian livelihood programmes with a waste picking component. Following a collaborative and multi-actor approach, WORM brings together medical and humanitarian organisations, procurement service providers, logistics providers, waste management services and academic partners.

EXECUTIVE SUMMARY

This document is a deliverable of the WORM Project, funded under the European Union's Horizon Europe research and innovation programme under the grant agreement No 101135392.

The aim of this document is to:

- Establish a baseline theoretical model for humanitarian waste management
- Categorize and assess the existing business models for humanitarian waste associated with the local social, economic, and environmental perspectives. The existing business models will be analysed to fit with the theoretical business models showing the value and benefits offering.
- Provide insight into avenues for scale up and innovation opportunity for greater sustainable impact
- Set the scene for welfare and livelihood examination for informal sector participation in humanitarian waste management

NON-TECHNICAL SUMMARY

Traditional theoretical ideas of humanitarian waste management business models have progressed beyond just production and disposal, and now integrate a sustainability focus. This focus concentrates on i) how producers of humanitarian supplies can design such supplies to reduce the post-use waste, and ii) encouraging Reuse, Reduce, and Recycle throughout the humanitarian waste management process.

We observe the adoption of these sustainability practices in the field in both our focal countries – Vietnam and Kenya. Whilst there is greater engagement of sustainability practices with domestic waste such as paper and plastic bottles, we do see some engagement with medical waste, especially with medical instruments and supplies that can be disinfected. The most common means of medical disinfection is with hot steam, i.e. autoclaving.

We also find that there are numerous areas for further research, specifically in business model innovation with new materials that are derived from living organisms such as plants, i.e. bio-based materials, and progressing the responsibility of producers of humanitarian supplies to reduce the waste produced or alternatively improve the amount of waste that can be recovered to minimise the ecological impact of humanitarian operations.

INTRODUCTION

The key focus of the WORM project is the examination of medical waste management during humanitarian operations where, within the order of priorities, the concept of minimising the environmental footprint may sit behind that of ensuring the safety and wellbeing of individuals impacted by the humanitarian crisis. However, in recent times, there has been concerted effort to reconcile the hierarchy of such priorities with the underlying waste management practices in humanitarian operations is a critical aspect of efficient aid delivery, i.e. sustainable and effective (Corbett et al., 2022; Zhang et al., 2019). While traditional supply chains emphasize on the flows between manufacturers and their partners, the complexity and multi-coordinated efforts among humanitarian organizations with donors, suppliers and beneficiaries become essential for effective disaster response (Besiou et al., 2021). The drivers of integration move toward sharing information and joint activities rather than sharing risk and rewards (Prajogo & Olhager, 2012; Wang et al., 2016). Moreover, the argument also extends beyond the entities who are directly and immediately impacted by the humanitarian crisis to longer term considerations for



Figure 1 Linear supply chain model

the community and ecology. In this light, the WORM project takes a holistic view of the medical waste value chain from upstream alternatives and producer responsibilities, intermediate management of medical waste across context specific humanitarian and local settings, and downstream medical waste treatment methods evinced within Figure 1

A breakdown of a simple waste management process is given in Figure 2, however, there is a need to be mindful that such waste management processes possess nuances across different settings.

Work package (WP) 3 progresses these discussions with an examination of medical waste management business models within the local settings of our focal nations of Vietnam and Kenya. The key goal of D3.1 is to provide a baseline illustration of the medical waste management sectors in both nations looking at the current state of medical waste management processes. This includes indicating the various medical

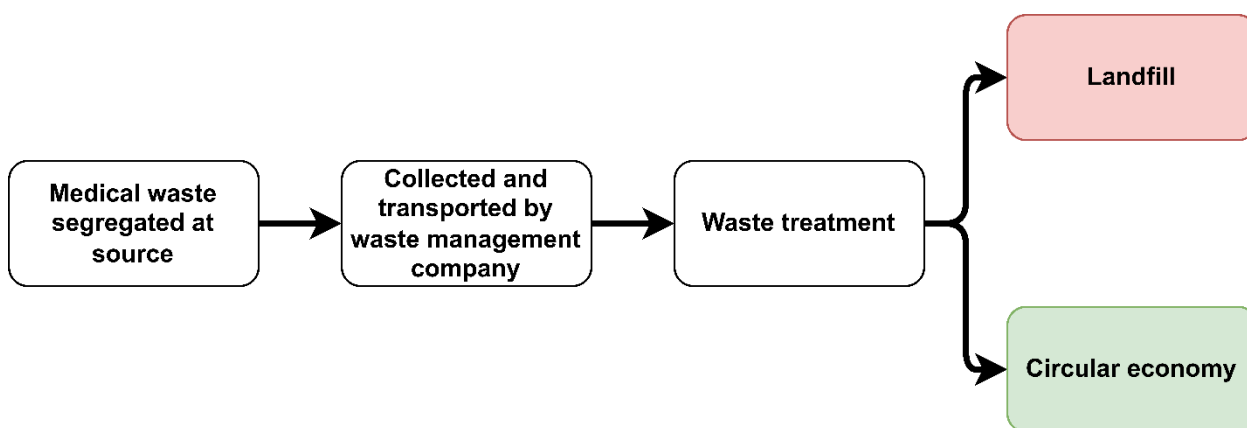


Figure 2 Simple waste management process

waste management treatment methodologies applied within the humanitarian context with a specific focus on non-destructive disinfection as part the project’s emphasis on the circular economy. Additionally, the business model evaluation from this WP will also inform other WORM WPs in relation to the use and implications of bio-based solutions within humanitarian waste management. Notably, this also extends our understanding to give some insight into the interface between the formal waste management sector and the informal waste “pickers”. Whilst WP3 will not directly address the more nuanced arguments

about livelihoods and wellbeing of said waste “pickers”, it will highlight where there are touchpoints between formal and informal agents.

In order to achieve the objectives of D3.1, we have engaged in data collection with key stakeholders within the medical waste management sector including waste management providers, humanitarian aid organisations (HOs), as well as, hospital and medical service providers. This data collection is primary in nature and covers both survey and semi-structured interviews.

Our discoveries are threefold. One, conceptually, we indicate that baseline theoretical business models present within humanitarian waste management are pluralistic in that there is intended capture of more contemporary sustainability practices such as that of extended producer responsibility and circular economy. Two, in relation to our focal countries and based upon the qualitative data that we have collected from our focus groups and interviews, we illustrate two distinct business models. For Vietnam, humanitarian waste management business models are very much integrated with conventional waste management in that there is no clear distinction between waste from conventional and humanitarian sources. This is the case for both medical and domestic waste sources, with waste management services provided by municipalities. For Kenya, with its more multifaceted humanitarian environment, humanitarian waste management is predominately undertaken by either HOs and their waste teams, or a contracted, certified waste service provider. For medical waste management in a Kenya context, such services can also arise from medical service providers. Three, across our interviews and focus groups, there is indication of the integration of circular economy practices. Much of these circular economy practices are with the recycling of domestic waste whose materials feedback into the production cycle of both future humanitarian supplies but also filtering into downstream value-chains that are outside of humanitarian activities. Circular economy practices in the form of non-destructive disinfection methodologies for medical waste are less widespread, but there is indication of such practices especially in relation to autoclaving. Whilst there is some suggestion of the use of chemical disinfection, this process not used with circularity in mind but rather within the context of disinfection for disposal. Absent from the circular economy discussions is upstream changes in practices to facilitate circular economy. Whilst there is mention of desire for the use of alternative materials, e.g. bio-based alternatives, there is no mention of any use of such articles within the humanitarian supply chain, at least as indicated from our interviews and focus groups.

From this study, there are some clear gaps in our knowledge about humanitarian business models. Firstly, we are uncertain about the true interface between the formal and informal waste management sector when it comes to humanitarian waste management activities. Whilst there is indication of (co-) participation of both entities, we are uncertain about the socio-economic dimensions of such interactions, thus setting the scene for our livelihoods and welfare analysis, especially of the informal waste management sector. Secondly, whilst of significant interest, the lack of field use of alternative bio-based materials for medical supplies means that we are unable to ascertain the impact of such innovations on augmenting the humanitarian waste management business models. This also presents substantial opportunity for future examinations into the motivations and effect of such material adoption.

1. Literature Review

1.1. Waste management in a humanitarian setting

Our understanding of waste management in humanitarian settings is generative and there is still, as yet much to be uncovered when we extend these examinations to look at waste management business models. Such examinations are predicated not only on the humanitarian context in relation to the type of crisis or situation that assistance is being provided for ((Brown et al., 2011; Ferronato & Torretta, 2019) but can be further decomposed into a myriad of underlying challenges identified in Table 1.

Table 1 Challenges to waste management in humanitarian settings

CHALLENGES	DESCRIPTION
Existing infrastructure	Limited availability of adequate waste disposal facilities and equipment that can be nested within insufficient financial resources to establish and maintain said facilities
Knowledge and training	Lack of or underdeveloped knowledge base amongst the human capital in the safe handling and disposal of medical waste with low awareness of the inherent health risks
Regulation and governance	Absence of clear regulations and guidelines for medical waste management in emergency settings that is compounded by difficulties in enforcing such rules given the chaotic nature of humanitarian crises
Volume of waste	Difficulty in managing the sheer increase in the volume of medical waste due to high demand of medical services during crises situations
Varying practices	Inconsistent waste collection and improper disposal practices including difficulties with waste segregation at source
Transportation	Challenges with safe transportation of medical waste from source to disposal sites, especially within conflict areas, thus increasing the risk of exposure and contamination
Innovative treatment methodologies	Lack of access to more environmentally friendly waste treatment and disposal methods with a prevailing reliance on incineration as a primary means of medical waste disposal
Dangers with mismanagement	Potential for outbreaks of disease due to one or a combination of the above challenges
Environmental consideration	Negative impact on environment due to improper disposal methods resulting in soil, water, and air pollution, and leading to long-term ecological damage

Such challenges present themselves to varying degrees across different crises settings and humanitarian deployments, for instance, waste management with rapid deployments during sudden onset of natural disasters or outbreak of war/conflict may differ greatly to waste management practices for more protracted support such as in the establishment of support for displaced populations and refugee camps (Ferronato & Torretta, 2019). Most notably, we observe some innovative waste management business models within the latter of the two deployments which will be discussed later in this report. As well, the propagation of waste management business models can be driven by national and institutional variances in the approaches to the provision of humanitarian aid (Zhang et al., 2019). For example, in countries such as Vietnam, the role of humanitarian aid agencies such as Vietnam Red Cross (VNRC) are concentrated within borders with extensive coordination and delegation of authorities to various local, centralised and provincial governmental bodies. In this regard, VNRC as humanitarian responders to a within border crisis do not provide field hospital set ups, but rather coordinates with the Ministry of Health to repurpose existing infrastructure into field hospital settings. Alternatively, HO activities in nations such as Kenya are more multifaceted and cross-border addressing various crises such as drought relief, flood response, and food security. Such multifaceted actions require coordination from international HOs and their regional chapters along with national and regional government to provide assistance including food aid, water, sanitation, and hygiene (WASH) services, and health and medical systems. Field hospital settings are more prevalent within the activities of HOs in such regards.

1.2. Waste management models

Waste management is a critical component of sustainable development, and increasingly so within humanitarian activities. As such, there is increasing discourse in the examination of waste management business models that facilitate the achievement of sustainability goals addressing not only the environmental impact of managing waste during humanitarian crises but also attending to the economic and social challenges (Habib et al., 2019; Zhang et al., 2019). In this regard, humanitarian waste management business models should look towards not only reducing environmental impacts but also enhancing resource efficiency, utilizing social and economic benefits from income generating activities and leveraging the potential for knowledge and skills development, in addition to awareness raising to local communities and affected populations. We can delineate the landscape of humanitarian waste management into two core typologies of which both have experience and undergone some transformation from digital and technological innovations. For tractability, we have elected to separate our explications of the following waste management models individually, however, in reality humanitarian waste management business models are pluralistic, and it is possible to nest multiple structures into a single base business model, for example, a public sector model could contain both linear and circular waste management practices. Even though we have explained them individually, our assertions for a baseline humanitarian waste business model captures this pluralistic dimension so as to provide a holistic view of the extant theoretical literature.

1.2.1. Traditional business models of waste management

On the one hand, we have traditional waste management models including the Linear Economy and the Public Sector Models. Within the former, also commonly known as the “take-make-dispose” model, the waste management value chain adopts a linear structure (see Figure 3) where products are manufactured, used and then disposed of as waste (Ghisellini et al., 2016).



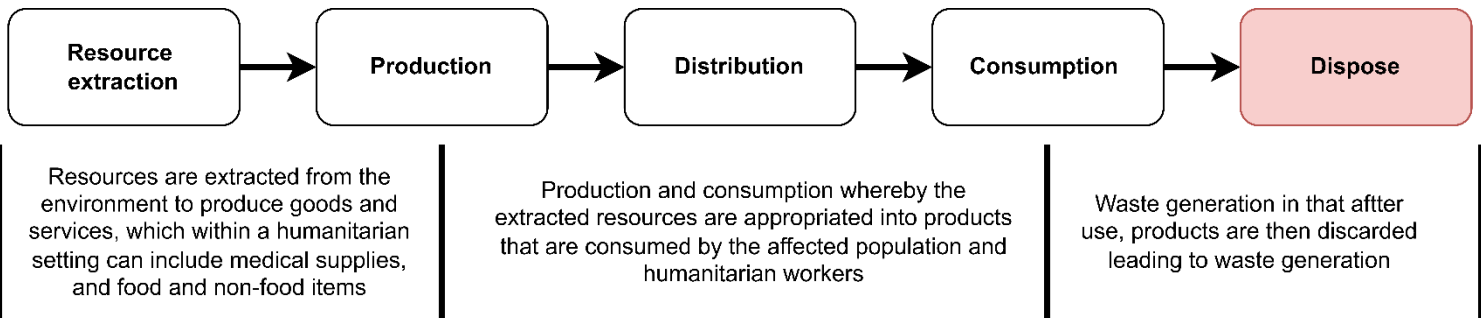


Figure 3 Linear model of waste management

Such a model is prevalent in many sectors including that of humanitarian sectors and its key deficiencies has been the basis of greater emphasis on sustainability practices in humanitarian waste management for example, such as within refugee camps and post natural disasters where the immediate focus is on relief and recovery.

Whilst a public sector model is classed as a traditional conception of waste management, the model itself can vary depending humanitarian setting. In fact, it is possible for public sector models to include contemporary elements such as circular economy practices. The key factor that distinguishes the public sector model as a traditional model of waste management is the concentration of responsibility within the public sector. Within a Public Sector Model much of the responsibility – collection, treatment, and disposal of waste - sits with government or municipal bodies (Wilson et al., 2006). Given this centralised nature of waste management service provision, this model is rarely seen with humanitarian waste management settings in light of the distinct challenges of crises. Most notably resource constraints meaning that large-scale public-sector investments prove challenging during such times, but also the underlying urgency and unpredictability of crises settings means that a degree of flexibility is required that is better evinced amongst non-governmental organisations, and the private sector. More modern approaches to waste management tend to advocate multi-actor coordination to offset the deficiencies of any one party. However, with the rigidity and slow-moving nature of public sector waste management its contributions to sustainable practices within humanitarian waste management practices should not be discounted and there have been numerous successful coordination utilising quasi-public and private sector models (Pascucci, 2021). We discuss such public-private partnerships to a greater detail in later in this section.

1.2.2. Emerging or contemporary business models of waste management

On the other hand, there have been more contemporary conceptions of waste management models that attempt to factor in interventions that are able to address the deficiencies of the traditional linear economy, more specifically in relation to the excessive use of resources and the lack of consideration of the implications of waste generation and its impact on the environment and society (Kirchherr et al., 2017). These emerging models of sustainable humanitarian waste management adopt a more holistic lens of the waste management value chain and consider the propositions of both up- and down-stream adjustments of waste management practices which have roll-on impacts on wider society such as opportunity creation which can prove vital during and post-humanitarian crisis. One such model is that of Extended Producer Responsibility (EPR), which extends the stewardship of waste management to that of the manufacturers (Kalimo et al., 2014), whereby these actors are held accountable, to a degree, in ensuring the lifecycle of their products including post-consumer waste – see Figure 4.

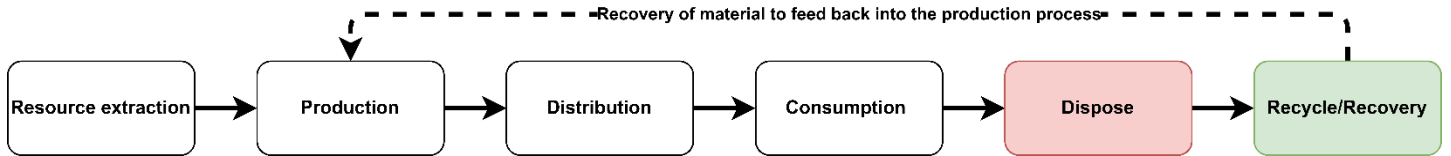


Figure 4 Extended Producer Responsibility model of waste management

While such models are prevalent within the fashion and retail sector, we are beginning to observe advocacy of EPR within humanitarian activities albeit outside that of a medical setting. For example, the United Nations Environment Programme (UNEP) has illustrated policies for the design and collection of lamps post-use by the manufacturer. Although the implementation of ERP models directly for medical waste presents challenges given the life-cycle nature of such items, this model does present opportunities for business model innovation such as within packaging of medical supplies. Additionally, whilst there are EPR schemes in place in more industrialised nations, within more development settings most EPR programs are only partially implemented and not completely functional (Kosior & Crescenzi, 2020)

Where there is greater traction and ecological impact is with the adoption of Circular Economy Models in humanitarian waste management where the emphasis is on the creation of a closed-loop system via reuse, recycling and recovery practices (Figge et al., 2023; Kirchherr et al., 2017; Kirchherr et al., 2023) across the waste value chain – Figure 5.

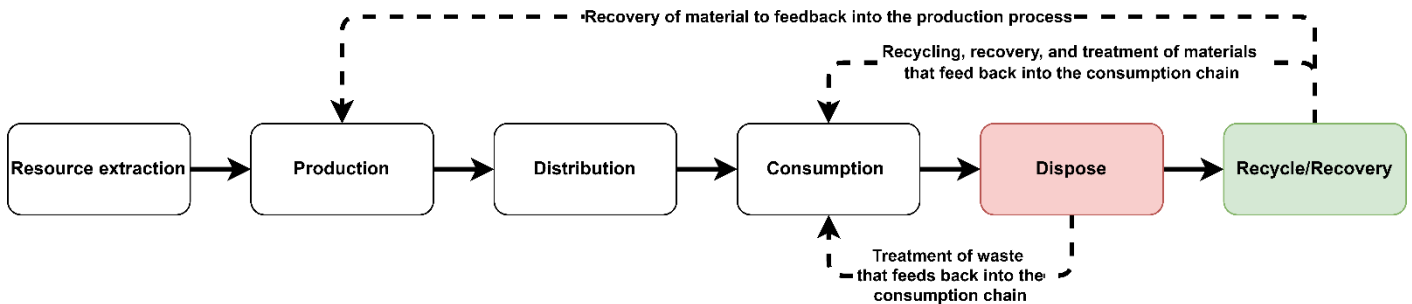


Figure 5 Circular economy model of waste management

Moreso, there is clear adoption of such circularity and closed-loop systems within the area of medical waste management for field hospital settings with WHO and ICRC guidelines for disinfection methodologies that allow for the recovery of certain medical implements (ICRC, 2011). In this light, some of the key principles of the circular economy model with medical waste management is in relation to product design and procurement wherein there is focus on designing medical items that are durable and/or recyclable, as well as, further consideration for the use of bio-based alternatives. Additionally, there is also emphasis on waste sorting and collection practices wherein there is, once again, substantial opportunity for business model innovation with the application of emergent disruptive technologies within smart waste management systems. Such technologies include data analytics and optimisation of waste collection (Arslan et al., 2017; Saberi et al., 2018), and smart sensing technologies to enhance waste segregation processes both at source and throughout the waste process (Sanathkumar et al., 2021). We provide a short summative of the waste management business models described above in Table 2.

Table 2 Summary of waste management business models

Waste management business model	Description	Challenges/Constraints	Benefits
Traditional Waste Management Business Models			
Linear Economy Model	Linear process where products are manufactured, used, and then disposed	<ul style="list-style-type: none"> - Resource depletion - Environmental degradation - Inefficient 	<ul style="list-style-type: none"> - No need for cultural or process change
Public Sector Model	Waste management services are provided by municipal or government bodies only	<ul style="list-style-type: none"> - lacking innovation - substantial financial constraints 	<ul style="list-style-type: none"> - concentrated organisation
Emerging and Innovative Business Models			
Circular Economy Model	Greater emphasis on reuse, recycling, and recovery to create a closed-loop system	<ul style="list-style-type: none"> - requires significant investment - public awareness and participation - Often a fully closed loop is aspirational, and elements of subsidisation will be needed 	<ul style="list-style-type: none"> - reduction of waste streams - conserves resources - creation of economic opportunities
Extended Producer Responsibility (ERP)	Holding manufacturers accountable for the entire/partial lifecycle of their products	<ul style="list-style-type: none"> - requires regulatory and supportive policies for adoption - public awareness and participation 	<ul style="list-style-type: none"> - encourages innovative eco-design - reduces waste generation - creation of economic opportunities
Public-Private Partnerships/ Private-Private Partnerships	Collaboration between the public and private sector in the provision of waste management services	<ul style="list-style-type: none"> - requires regulatory and supportive policies for adoption - increase complexity 	<ul style="list-style-type: none"> - combining strengths - economies of scale - increased operation efficiency

The transition from traditional to emerging and innovative business models of medical waste management is also premised on collaboration, in this regard, between public and private and/or private and private actors, giving rise to public-private or private-private partnerships (Massoud & El-Fadel, 2002; Pascucci, 2021). Whilst seen as an innovative model, public-private or private-private models are a key dynamic of humanitarian waste management activities with the key focus on resource sharing and have been a pivotal structure within much of humanitarian waste management provision (Pascucci, 2021).



The models highlighted above provide broad conceptions of waste management models that have been captured within humanitarian settings. There is increasing evidence of the desire to push into and encourage the adoption of more contemporary models of waste management given the enhanced sustainability benefits of increased producer responsibility and, especially, circular economy practices. Given this is possible to construct an ideal theoretical base case as a foundation for our comparison against actual practices within the field and within our focal nations of Vietnam and Kenya. This base case is given in Figure 6.

Figure 6 is read left to right with the rightmost side illustrating the up-stream production and procurement practices. Progression to the leftmost side of the process flow progresses into waste management practices. Key actors are indicated within the grey rectangles; for brevity, the key actors, indicated within Figure 6 are not exhaustive and we will further decompose into greater detail especially in relation to waste collection, and transportation, and waste management processing where there is participation from both formal and informal waste management sectors.

Yellow squares indicate waste stream, that for brevity, we have delineated along medical and domestic waste. It should be noted that the domestic waste can include both food and non-food items. Waste treatment processes are shown in diamonds with red diamonds indicating more traditional means of treatment including incineration and/or landfilling. Green diamonds indicate more contemporary means of waste treatment including non-destructive methods and recycling. From the literature (ICRC, 2011) non-destructive methodologies include:

- Chemical using compounds such as chlorine dioxide, sodium hypochlorite, peracetic acid, ozone, alkaline, and hydrolysis
- Thermal
 - o Low temperatures (100o to 180o): vapour or hot air
 - o High temperatures (200o to 1000o): incineration
- Irradiation: UV rays, electron beams
- Biological: enzymes

Downstream value chains are also captured on the distal right in white circles. These downstream value chains indicate that the processed waste via the various treatments have progress outside the medical waste stream into different value chains. On note as well, is the dashed arrows connecting the blue waste management processing boxes back to the producers. These dashed arrows are indicative of and application of extended producer responsibility wherein, materials are recovered from the waste streams to feedback into the production cycle. These production cycles can include processing the recovered materials for part inclusion in future production runs or material recovery can be channelled to downstream value chains.

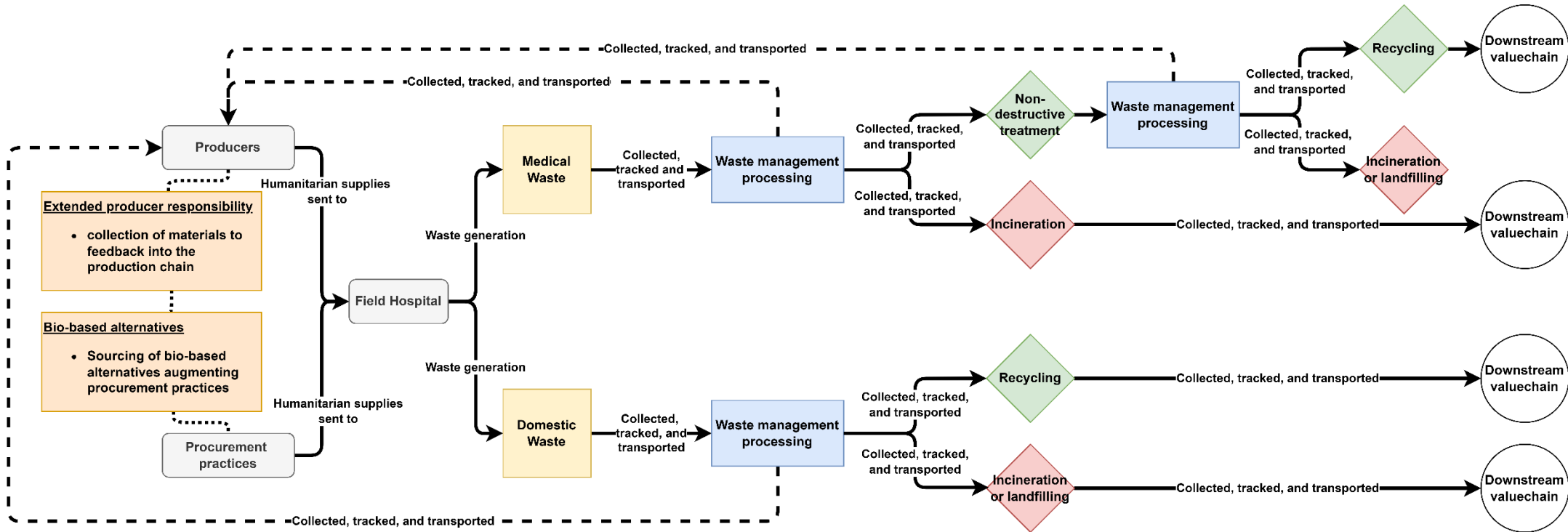


Figure 6 Baseline business model for humanitarian waste management

1.2.3. Waste management process – Contracting and the interface between formal and informal sectors

Of highlight is the means with which HOs contract waste management providers for various humanitarian settings. It should be noted that waste management provides can be contracted within the capacity of i) collection and transport of waste only, ii) treatment of waste only, or iii) collection, transport, and treatment of waste. From the literature (Gershon et al., 1995) this is essentially broken down into five stages including:

1. Needs assessment, where types and volumes of waste are identified
2. Request for proposal (RFP) which highlights the key selection criteria and compliance standards that are required of waste management contractors
3. Evaluation and selection of applicants including site visits and references checks to verify waste management contractor capabilities
4. Contract agreement setting out the terms and regulations of the contract including elements such as pricing, compliance requirements, and penalties for non-compliance.
5. Implementation and monitoring to ensure adherence to contract agreements and regulatory compliance

Given the nature of humanitarian activities regulatory compliance forms one of the key challenges for waste management contracting within the humanitarian waste management business model especially in relation to balancing the safeguard of welfare with quality-of-service provider. This is more so within the WORM context of medical waste as there is then also a need to ensure quality standards given the implications of mishandling potentially hazardous waste. Risk management practices in this light must be robust to ensure that all waste – both medical and domestic – are handled in a manner that minimises the risk associated with handling, transportation, and disposal (Hossain et al., 2011). Moreover, there is a continual push towards more sustainable and contemporary waste management models of circular economy and extended producer responsibility, contracted waste management service providers will need to exhibit or be supported with understanding these requirements.

Additionally, whilst the aim of this WP is not to examine the social and livelihoods argument of individual waste pickers that participate within the humanitarian waste management sector, we will use this section to set the scene for our future ambitions. Given the unique nature of humanitarian settings, there will invariably be interface between the formal and informal sector in relation to humanitarian waste management (Wilson et al., 2006). This involvement of the informal sector within humanitarian waste management could be borne from several different factors including poor formal waste management infrastructure, poor practices by the formal waste providers in terms of waste segregation that can encourage informal engagement, and centralised and/or decentralised participation of informal sector in waste management (Zolnikov et al., 2021). For the final of these points, formal participation can be seen as formal programs for recycling established by various bodies, whilst decentralised participation can be viewed as the acquisition of economic and social benefits from voluntary participation of waste management without any formal coordination, i.e. ad-hoc waste pickers looking to establish an economic livelihood from the inherent value of waste generated from humanitarian activities. This formal-informal interface would augment our baseline humanitarian waste management model to the following in Figure 7.

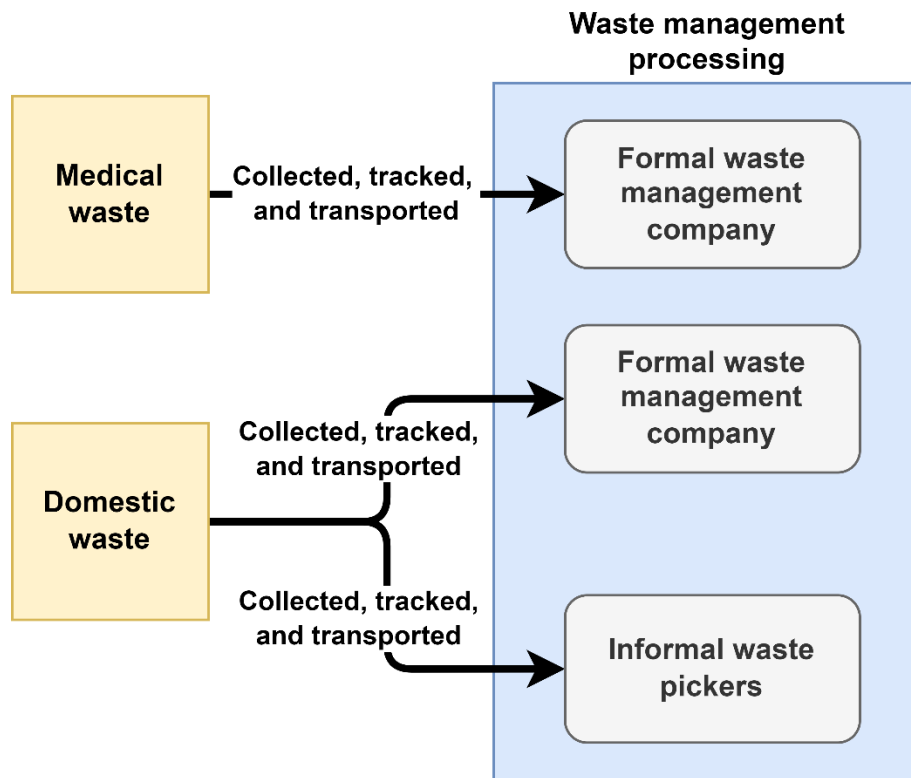


Figure 7 Formal and informal participation with humanitarian waste management

Whilst both centralised and decentralised programs are of interest, it is the latter that possesses more gaps in our underlying understanding given the difficulties in data collection and tracking, and usually these participants are unregistered (Zolnikov et al., 2021). Given the lack of data, the clear interface between formal and informal is nebulous at this stage, and where there are also pertinent questions are in relation to the underlying safety of participants. What we do know is that the activities of the informal sector is mainly in the areas of waste collection and sorting across a myriad of locales. From the literature (Nguyen et al., 2021; UNDP, 2020), there is indication of such activities alongside formal and contracted waste management providers, for example, as a hired hand, however, there is also evidence of waste picking before and after formal waste management companies have provided their services, for example, waste sorting and collecting valuable waste in advance or, alternatively, further waste collection and sorting at a landfill or incineration site (Pascucci, 2021). The engagement of the informal sector at this stage breeds substantial challenges in relation to livelihoods and personal safety especially in the handling of medical waste that may possess numerous danger-to-life health hazards (Zolnikov et al., 2021). The literature is also indicative of greater circular economy participation from the informal sector with much of the development of this dimension in relation to micro-scale enterprises focusing on repair of certain NFIs (Alloush et al., 2017; Dalal, 2015). What we do need further definition on is the degree of interface between formal and informal in relation to medical waste. Much of the literature indicates collection and sorting of NFIs, however, with the strict controls and regulation on medical waste is their ad-hoc participation with this waste stream. What is also unclear is how changing procurement practices and extended producer responsibilities affect waste streams – both medical and domestic waste. With changing parameters going into the production process and with the possible introduction of bio-based alternative materials, this can have an impact on the waste streams that could have an impact on the informal sector and their socio-economic livelihoods from waste management participation (Kovács & Heaslip, 2024).

2. Methodology, Activities, and Tasks

2.1. Research approach and design

The key tasks for D3.1 are as follows:

- Establishing a baseline theoretical model for humanitarian waste management
- Categorizing and assessing the existing business models for humanitarian waste associated with the local social, economic, and environmental perspectives. The existing business models will be analysed to fit with the theoretical business models showing the value and benefits offering.
- Provide insight into avenues for scale up and innovation opportunity for greater sustainable impact
- Set the scene for welfare and livelihood examination for informal sector participation in humanitarian waste management

To achieve the objectives of this WP deliverable for WORM, we adopt a qualitative research approach. This enables us to achieve deeper insights into the implementation and adoption of humanitarian waste management business models. Such an approach also enables us to further delineate the key structures and processes within adopted business models and would further a reconciliation of our baseline theoretical business model for humanitarian waste management and practice implementation.

Using a multi-method qualitative approach, we engage in both interviews and focus groups with key stakeholders within humanitarian waste management. These stakeholder groups include both HOs and local waste management providers to achieve the context specific requirements of our exploration. We adopt a framework-synthesis methodology, firstly utilising the extant academic and practice literature to establish out theoretical baseline business model for humanitarian waste management, and secondly, conducting thematic analysis of our interviews and focus groups. Whilst framework synthesis differs slightly from the traditional qualitative approaches in being more deductive in nature, the development of an *a priori* baseline from the extant literature provides more robust foundation from which to explore our practice adopted waste management business models. To implement our framework-synthesis methodology we adopt the procedures drawn from Barnett-Page and Thomas (2009) and Miles et al. (2019). Summarily, the processes are described as follows:

1. Data reduction: This is the creation of the underlying baseline model drawn from the existing academic and practice literature (Erlandson et al., 1993; Miles et al., 2019)
2. Data display: This is the transcription and visualisation of business models our interviews and focus groups
3. Conclusion: Comparison and triangulation of collected insights from interviews and focus groups, and theoretical business model to link them to the overall aim of the WP.

Both semi-structured interviews (Horton et al., 2004) and focus groups were conducted within individuals from the waste management sector, medical sector, and HOs. Given the nature of the research being conducted one of the key drivers of our use of focus groups, where possible, was the ability to gather diverse-perspectives across a single sector bred both context- and time-efficiencies for the achievement of our WP tasks, for example, the ability to gather immediate feedback and clarification of sector-based practices (Miles et al., 2019). The use of focus groups presented an opportunity for researchers to draw from a range of experiences and potentially reveal a group consensus thus producing data on three separate levels: the individual, group, and interactive. The individual level allows for data triangulation, whereas the group level allows for assessment of how the phenomenon under scrutiny is understood by the participants and subsequently allows for validation of the measurements. Conversation is the central element in a focus groups, but interaction between participants is a valuable source of data for researchers as well. These interactions can reveal tensions and potential complications to reaching a

group consensus. When analysing the interactions, the process of the conversation is emphasized over the result of the deliberation (Morgan, 1996).

Where we implemented focus groups for our data collection, they lasted no more than two hours. The focus groups were broken down into two separate sessions of 45 minutes each with a 15-minute rest break in between. The first session split the focus groups by sector to facilitate discussions on specific and unique dynamics. The second session brought the various sectors into a joint session to further conversations on cross-sector dynamics. However, we are also aware of the potential influences of groupthink and participant dominance that could arise during focus groups, and in this regard, sought to minimise such occurrences with follow up individual interviews where required (Morgan, 1996).

It should be noted that we reverted to individual interviews where situations did not permit the use of focus groups, for example, in the case of geographically spread research participants. The interviews were conducted via digital calls on MS Teams or Zoom, based upon interviewee availability, and lasted no more than sixty minutes. Where focus groups and interviews were conducted in a language other than English, they are facilitated by native-speakers and then translated by the research team. Translations were independently verified by different native speakers on the research team to ensure accuracy of translations and capture of participants' views.

Given the specialist and context specific nature of our study, we utilised a purposive, judgement sampling methodology leaning heavily on snowballing amongst our consortium members to establish our list of interview candidates. We targeted candidates from three specific sectors namely i) HOs, ii) waste management providers, and iii) medical service providers. In total, we were able to interview 73 entities across the three sectors. Breakdown down of interview numbers are as follows: 25 individuals from HOs, 17 individuals working within waste management companies, 25 individuals from medical service providers, with the remainder from research institute, and governmental entities. Working with the HOs within our consortium we were able to identify and interview entities that possessed the relevant knowledge within their sectors to contribute to the objectives of this WP, including on-the-ground responders, operations managers, firm owners, and institutional directors. Given that our focal nations are Vietnam and Kenya, we sought to establish representation across sectors from these nations, where possible, to provide context specific views.

To further to robustness of our exploration, pilot interviews were undertaken with the purpose of refining interview techniques, questioning sequencing and question coverage. This also serves to identify and reduce interviewer bias. The strengthen the validity of our framework-synthesis methodology we adopted independent coding of interview and focus group transcripts across the research teams. This consensus-based approach of the thematic analysis is to support with robustness (Maxwell, 1992; Seale, 1999).

3. Results and Findings

In this section we highlight the core findings from our exploration of the data collected from our focus groups and interviews with that of our theoretical baseline humanitarian waste management business model. We put forth a model conception for both a Vietnamese and Kenyan setting giving us an opportunity to compare this against the posited theoretical business model thus enabling us to also set the scene for examinations into innovation and business model gaps with a focus on the environmental, economic, and social implications. Whilst our focus is on Vietnam and Kenya, we will also provide some conception of auxiliary business models which have appeared as common themes during our qualitative data collection process. We provide illustrations of our business models within each of our settings in the following sub-sections.



3.1. Humanitarian Waste Management Business Models: Vietnam

Humanitarian activities within a Vietnamese setting are centrally coordinated by both Vietnam Red Cross (VNRC) and the Vietnam Fatherland Front (VFF). Humanitarian activities are mainly concentrated around the nation's monsoon season which can result in extreme flooding and landslides resulting in displacement of the local population. Those worst affected tend to be outside an urban setting and within more rural and less developed settings across the nation. Both VNRC and VFF are centrally designated by authorities and most, if not all, international and national humanitarian efforts are channelled via either of these institutions. Under special circumstances, there may be exceptions whereby international humanitarian relief and support may be deployed outside the purview of both VNRC and VFF but this is approved on a case by case basis and is somewhat rare. Moreover, there will also be coordination between VNRC and VFF with provincial authorities across the country, and the Ministry of Defence where the military will assist with aid distribution, search and rescue, and logistics. Of note, as well, is that the provision of medical supplies and aid is coordinated in collaboration with the Ministry of Health. Medical and healthcare services during humanitarian activities are provided via the existing hospital and clinic infrastructure. These hospital and clinic settings tend to be existing physical structures, however, where needed, non-medical buildings can be sequestered into a "field hospital" environment, for example, the use of a local provincial school. Neither VNRC nor the VFF will participate in field hospital setup and the provision of medical assistance but may support with coordination of services around these structures.

From our conversations with VNRC, there was no indication of contracting of waste management providers for specific humanitarian activities. Rather the suggestion was that the waste generated from such activities – whether medical or domestic waste – fed into the standard waste streams for both types and were managed by existing waste management providers. In other words, there was no clear delineation between domestic and medical waste during humanitarian activities and that of waste generation under normal circumstances. Regardless of humanitarian or day-to-day settings, waste is managed by existing contracted waste management providers. We pursued this dimension further during our interviews and focus groups with waste management providers in Vietnam and this finding was largely concurrent. Waste management companies were aware of humanitarian activities; however, the waste was treated no differently to their day-to-day operations. During the interviews and focus groups there was no indication of any additional specific contracting that was unique to VNRC's or ministerial humanitarian activities, just that they were required to collect the waste as per their existing agreements. This presented several challenges notably, from WORM's perspective, the inability to accurately decompose the origin of the handled waste, given that there was no clear demarcation of waste collection activities between day-to-day and humanitarian activities.

We also delineate the conversations with waste management providers along our identified waste streams, i.e. medical and domestic waste. From these conversations, the indication is that medical waste management is significantly more regulated with licensing and monitoring service being conducted by the Ministry of Natural Resources and Environment. This is very much in line with what is indicated within the humanitarian waste management literature and the guidance documents in handling medical waste. As such, medical waste management business ecosystem is significantly more concentrated in relation to the handling of medical waste, including that arising from humanitarian activities.

From a domestic waste perspective, waste management providers are still regulated, however, provisions slightly more numerous. Of note within the domestic waste stream, however, is the interface between the formal and informal waste management providers, where formal providers would be registered waste management companies. In addition to better understanding the relationship between formal and informal providers, there was also a desire to get a better understanding of the definition of the informal sector and in this regard was mainly premised as individual, unregistered waste pickers/sorters seeking an economic benefit from the waste management process. This economic benefit is mainly in the form of



waste sorting recyclables from which they are then able to sell back into the waste streams. Note that there was no mention of the informal sector within discussions on the medical waste stream, however, we address the reasons for this later in this section with the involvement of the medical service providers. In relation to the formal-informal interface we see the emergence of a co-relationship wherein the bulk of the domestic waste is collected by contracted municipal providers, however, there are “leakages” to the informal sector, especially in relation to recyclables, given the inherent economic benefits. What is not “leaked” to the informal sector will then be processed by the formal waste management providers. From our conversations, there is clear indication of circularity with once again a focus on recycling materials such as plastics, glasses, and paper. Given the economic benefits of recyclables, it is likely that the informal sector could play a significant, albeit unclear, role in relation to circular economy of domestic waste. There was some indication of rudimentary processing of these recyclables within waste management plants, for example, shredding, from which they will then be progressed back into the production chain. With the non-recyclables, the key means of treatment is still either incineration or landfilling. Rough estimates indicate a split of 70% to landfills and 30% to incineration, however, the incineration processes and implements adopted by waste management providers is not homogenous. Of note is that there is some element of “lower order” circularity with the use of incineration where the ash generated is then channelled towards cement production. This sale of ash from incineration towards cement production is an example of a downstream value chain activity as evinced from our theoretical baseline humanitarian waste management business model.

The lack of participation of the informal sector within the medical waste stream would seem unsurprising at first, given the inherent regulation surrounding medical waste and the potential implications of any mishandling during the waste management process. However, within the Vietnamese context, what is interesting is the intertwine between humanitarian activities, medical services provision, and locale of provision. Given that neither VNRC nor VFF as coordinating HOs can provide medical services but rather support the Ministry of Health and localised medical facilities, the medical waste streams, even for humanitarian activities, are channelled by these localised medical facilities. Put simply, the localised “field” hospitals oversee medical waste management at source/site, and this is then collected by the registered formal medical waste service provider for treatment and/or disposal. Our conversations with medical services providers further validated that there were clear guidelines of the management of medical waste at source, especially with sorting, and that registered waste management services providers would collect the sorted medical waste. Given that one of the interests of the WORM project is in relation to non-destructive disinfection methodologies, we were keen to discover if the waste management service providers were engaged in any such treatments of the medical waste streams. There was evidence of some non-destructive treatments, provided from a single, albeit, large, certified waste management service provider, where the adopted treatment here was autoclaving. We pursued this dimension further with the medical service provider as well as other who didn’t engage in any such practices and what was revealed presented an interesting dynamic of medical waste management in Vietnam. The medical waste service provider who did engage in non-destructive disinfection was part of a larger waste management corporation that also included facilities for domestic waste management. In this light, they were able to handle both waste streams meaning that they were able to keep all processing in-house. As such they were also able to extract further economic benefit from the by-products of non-destructive disinfection treatment. The conversations indicated, on average 5% of medical waste is disinfected whilst the remaining 95% progresses to landfilling and incineration. Like domestic waste streams, the ash produced from incineration of medical waste is also sold on to downstream value chains in the production of cement. We breakdown our conception of humanitarian waste management business model in Figure 8.



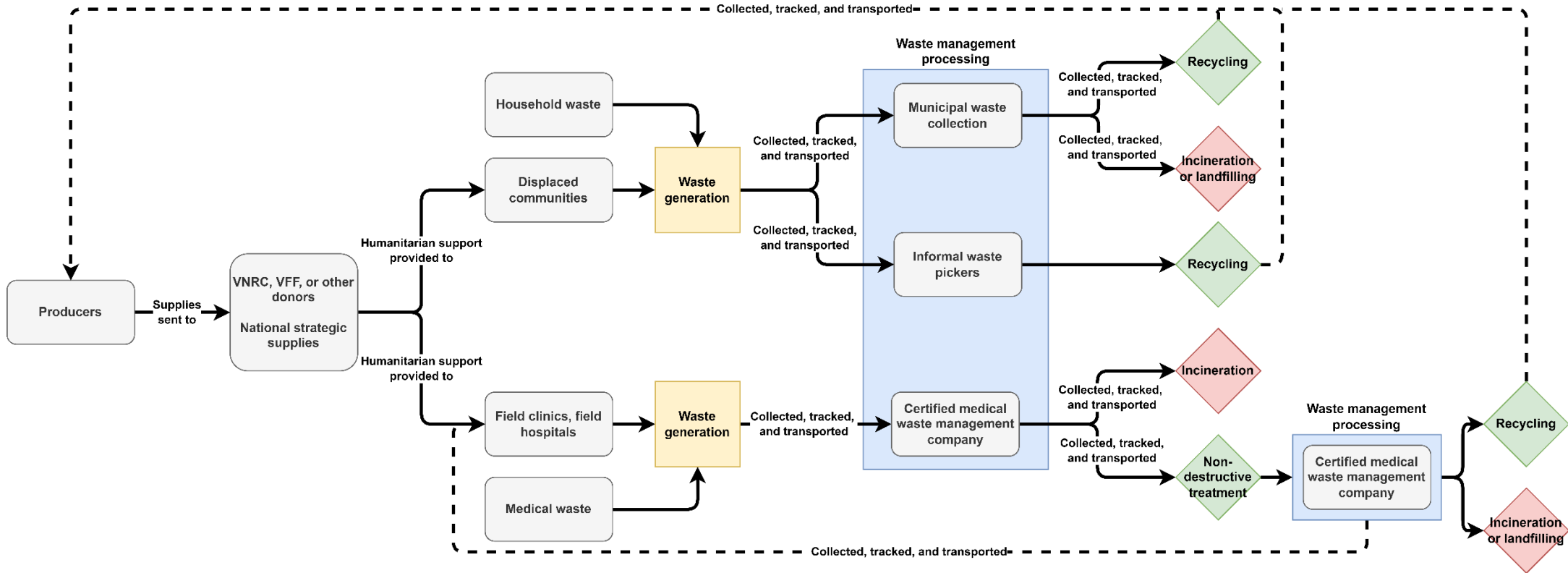


Figure 8 Humanitarian waste management business model for Vietnam

3.2. Humanitarian Waste Management Business Models: Kenya

Similar to Vietnam, for a Kenyan context, conversations were held with HOs, medical service providers, local waste management companies. However, an immediate difference within the conversations across both locales is the wider focus from our Kenyan interviews with much of the discourse from these discussions extending beyond just Kenya and into a regional (East) African setting. As such, whilst unconventional from a qualitative research perspective, it is possible to, somewhat, extend the conception of our Kenyan humanitarian waste management model into a wider, but cautious, regional generalisation.

The HO landscape in the Kenyan and African context is a mix of international organisations with regional and/or local chapters operating alongside local institutions. Waste management and its subsequent activities within humanitarian operations are governed and regulated by the Ministry of Environment (MOE), with waste management providers having to adhere to both ministry and contracting HO regulations. Humanitarian settings are more diverse ranging from healthcare provision, welfare protection, and the establishment and maintenance of refugee camps just to name a few. Across these settings, there are provisions for field hospitals, and we delineate our discussions and models along both medical and domestic waste types.

From our conversations with HOs, humanitarian waste management takes on two possible paths, i) managed wholly by HOs and their respective waste management teams, or ii) external contracting to a registered waste management service provider. This is the case for both medical and domestic waste across the humanitarian settings. With the former method HOs will establish the entire infrastructure around waste management from segregation procedures such as with waste bin designations, to collection and treatment processes including incineration and circular economy practices such as plastics recovery and non-destructive disinfection. With the latter methodology of external contracting, waste management providers must be certified by the health ministries with adherence to regulatory standards concerning safe handling of both domestic and medical waste. It is unclear from the conversations as to whether a single waste management company is utilised for both domestic and medical waste if externally contracted, however, from our sample of interviews, we do observe certain waste management companies possessing the capabilities to address both waste streams.

Delving deeper into the domestic waste stream conversations to begin with, we see indication of recycling of materials such as plastics and paper that can either feedback into the production value chain or process into downstream value chains such as the repurpose of materials into different use cases. Waste processing, for example, shredding of plastics into pellets, is undertaken by both waste management providers as well as by HOs should the equipment exist within the humanitarian setting. Of interest from the conversations is the mention of organics within the domestic waste stream, and, whilst somewhat outside the scope of the WORM project, the availability of mechanisms to facilitate circularity of such waste stream into bio-feed for a particular humanitarian environment suggests an opportunity for business model innovation within humanitarian waste management. The most common method of domestic waste treatment is incineration, and, unlike the Vietnamese case, there is no further downstream channels for the ash by-product but rather is deposited within managed ashpits to ensure adherence to quality standards.

For medical waste streams, in addition to certified medical waste management companies, and HOs, medical waste is also addressed by medical service providers, in this case, mainly hospitals. For such medical service providers, their existing medical waste management infrastructure is sequestered in the event that such facilities are not present or non-functional within a humanitarian setting. From the interviews, the most common occurrence of such an event involved a breakdown of an incinerator at a particular site, with the medical waste then requiring transfer to a separate facility, usually a hospital, who possess a working incinerator. Incineration remains the chief method of medical waste management



but from the conversations we do observe use of placenta pits as well. Similar to domestic waste, there is no downstream use of ash by-product, and it is disposed off within ashpits. There is clear indication of the use of non-destructive disinfection methodologies in the treatment of the medical waste stream, with mention of autoclaving, microwave, and chemical disinfection of medical implements. However, what is interesting is the paths that disinfected implements take within the medical waste value chain. Waste that is disinfected via both autoclaving and microwaves are fed back into the humanitarian medical supply chain on site, however, medical waste that is chemically disinfected will progress on for disposal via incineration. As such there is also some indication of the adoption of circular economy practices within humanitarian medical waste management.

Absent from the conversations are mentions of the participation of the informal waste management sector with the humanitarian waste management value chain within Kenya and regional African setting. Whilst the lack of specific citations of the informal sector is surprising, we should make it clear that this is not truly indicative of no participation from the formal sector and potentially presents an opportunity for further clarification within WORM's livelihoods examination to further delineate reasons for this. Absent as well, is the presence of mention of implementation of any bio-based alternatives within the medical waste streams. Whilst HOs have indicated a desire to explore such material use for medical supplies, our interviews are suggestive that there is minimal to no implementation of such materials within humanitarian operations, as least as indicated from our sample. We visualise our conception of the Kenyan, and wider regional African, humanitarian waste management business model in Figure 9.



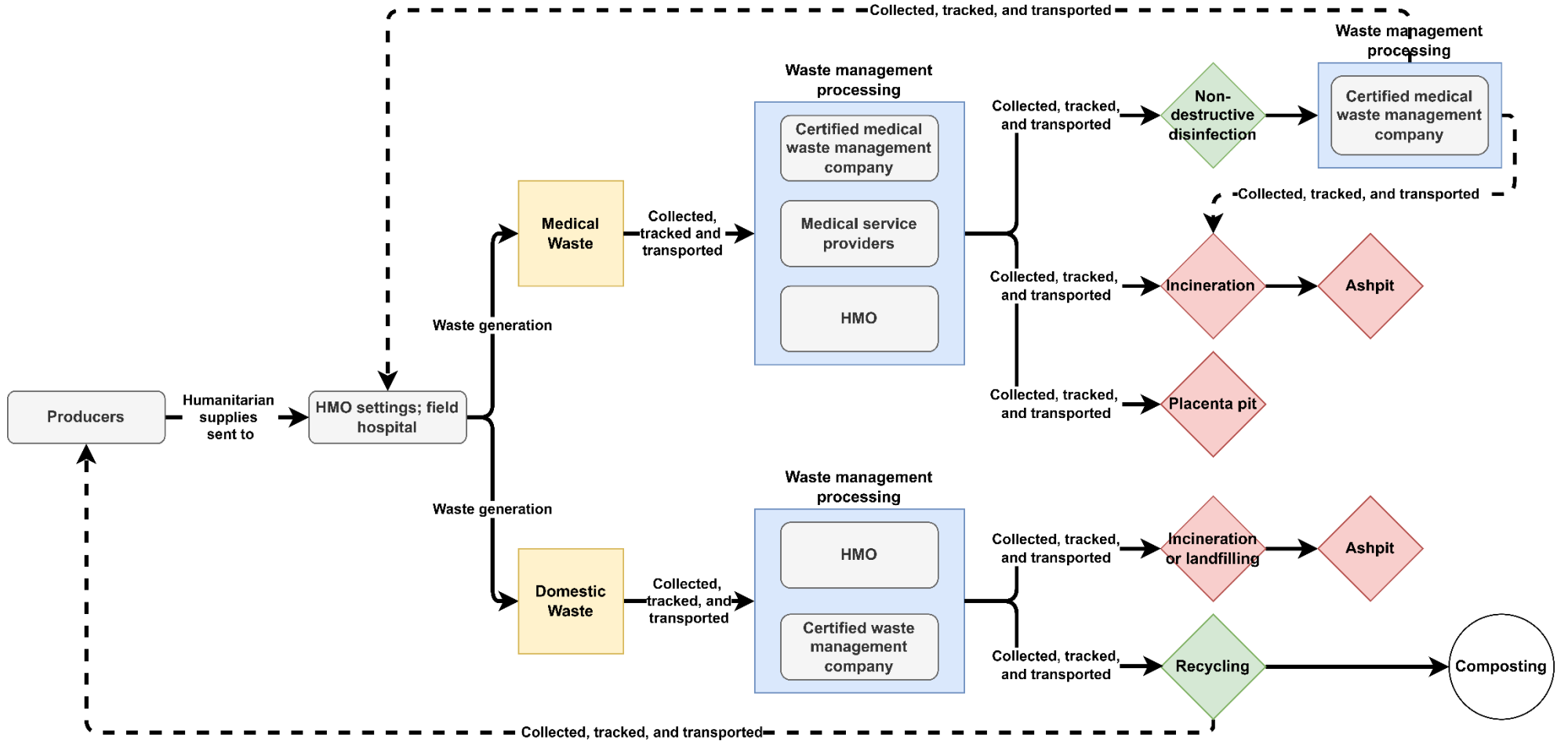


Figure 9 Humanitarian waste management business model for Kenya

3.3. Humanitarian Waste Management Business Models: Other settings

Across our interviews and focus groups we also observed a few recurrent themes in relation to humanitarian waste management business models. These auxiliary settings including refugee camps and field hospitals in conflict zones. While we are aware that refugee camps are prevalent within a Kenyan setting, and that it is possible to nest the proceeding structure amongst our Kenyan humanitarian waste management business model, our qualitative data does indicate a wider reflection, especially amongst HOs, for refugee camps in locations outside our two focal countries. Given this, we have elected to map the refugee camp waste management business model outside our Kenyan conception. This approach also enables us to capture richer nuances unique to refugee camp waste management that would, otherwise, not be considered with a Kenyan-specific exploration. We progress to provide some conceptions of waste management business models across both settings in the following sections.

3.3.1. Refugee camps

While the majority of refugees live in urban areas, 22% or over 6.6 million individuals worldwide are living in refugee camps, which often offer few opportunities to live independently and find employment (UNHCR, 2022a). Depending on the characteristics of a crisis displacing individuals, they may stay in a refugee camp for only a short time, but many spend years or even decades living there with multiple generations growing up at a camp (UNHCR, 2022b). Given these longer timescales, distinct economies develop in large refugee camps, shaped by host country policies and commonly geographic and/or social isolation, while interacting with the composition of the refugee community and the provision of national and/or international aid (Werker, 2022). Increasingly, cash- and voucher-based assistance is offered to complement or replace more traditional distribution of goods to refugees, a development regarded as enhancing independence, respecting cultural and individual differences, and affording greater dignity to recipients (Aker & Isik, 2017; Heaslip et al., 2018; Maghsoudi et al., 2021).



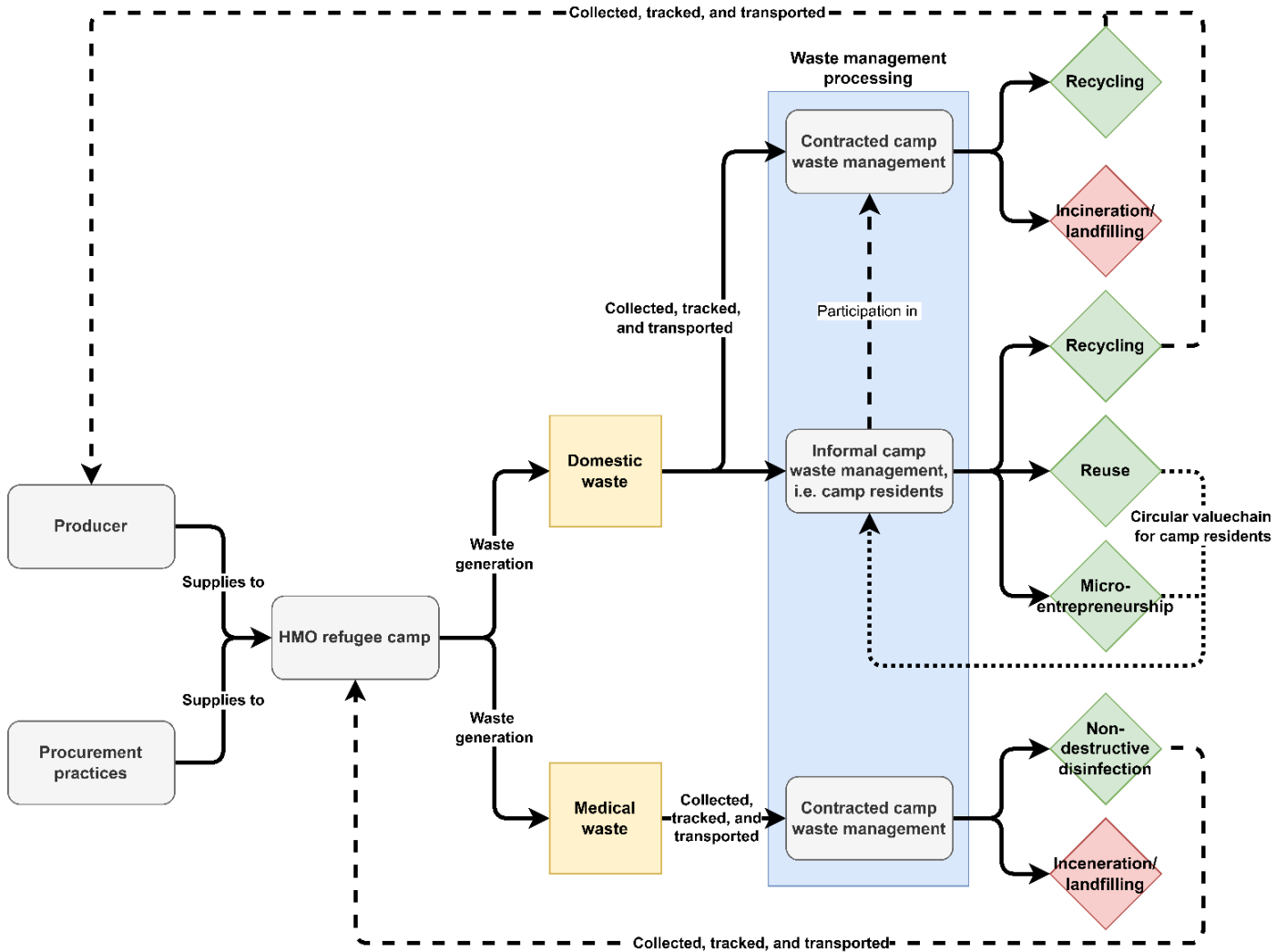


Figure 10 Humanitarian waste management business model in a refugee camp

These dynamics create unique settings for humanitarian waste management business models within a refugee camp setting. From our conversations with HO camp waste management can either be outsourced to external, local, waste management providers, or undertaken directly by HO waste management teams. However, there is indication, once again, of the involvement of the informal waste management sector here albeit in a different guise. Within camp settings, the informal sector could comprise of camp residents engaging in employment with the formal waste management providers, whilst at the same time also partaking in waste management activities independently of the formal waste management system. Whilst some instances direct contracting between external waste management contractors are illegal, there are indicators of HO programs including cash-for-work which can include waste picking in camp. With the former, a potential structure is where an externally contracted waste management provider would offer employment opportunities to camp residents, whilst in the latter, camp residents would undertake roles akin to informal waste-pickers, sorting and collecting waste that possesses some economic and social benefit. The informal dimension has seen some intriguing developments beyond that of just waste sorting and collection for recycling and reuse but rather has also seen the development of micro-entrepreneurship around waste and in particular non-food items. Here there is some indication of camp residents establishing micro repair shops for items such as lamps, as well as, repurposing of certain materials into wearables. This presents significant opportunity from an upstream extended producer responsibility perspective to be able to further these micro-entrepreneurship activities such as improving the reparability of non-food items within camp supplies. It should be noted that such activities within the waste streams only relate to domestic waste generation

and medical waste is still very much regulated and managed by specialist teams. Similar to other settings, there is some indication of the use of non-destructive disinfection methodologies – mainly autoclaving – but this is likely the exception rather than the norm. See Figure 9 for an illustration of our conception of waste management business models in a refugee camp setting.

3.3.2. Field hospitals in conflict zones

Field hospitals in active conflict zones have also been recurrent theme within the interviews especially within international HOs. Such sites receive and treat casualties with a wide range of injuries and waste management practices within such settings are plagued by poor terrain, lack of resources, ethical dilemmas, and underlying security risks (Caniato et al., 2016). From our conversations with HOs, waste management within such settings still take on a very linear economic model with minimal consideration for the waste generated. This is not because of a lack of desire in relation to improving waste management practices on site, but rather is driven by the chaotic nature within such settings. In this light, the discussions suggested that the augmentation of procurement practices, up-stream, could be the best means of addressing the amount of waste arising within such situations. Suggestions included encouraging central procurement departments of HOs to work with producers in minimising the packaging of medical supplies. Whilst there was an interest shown by HO representatives for bio-based alternatives, there was no indication from the discussions as to their current implementation. See Figure 10.

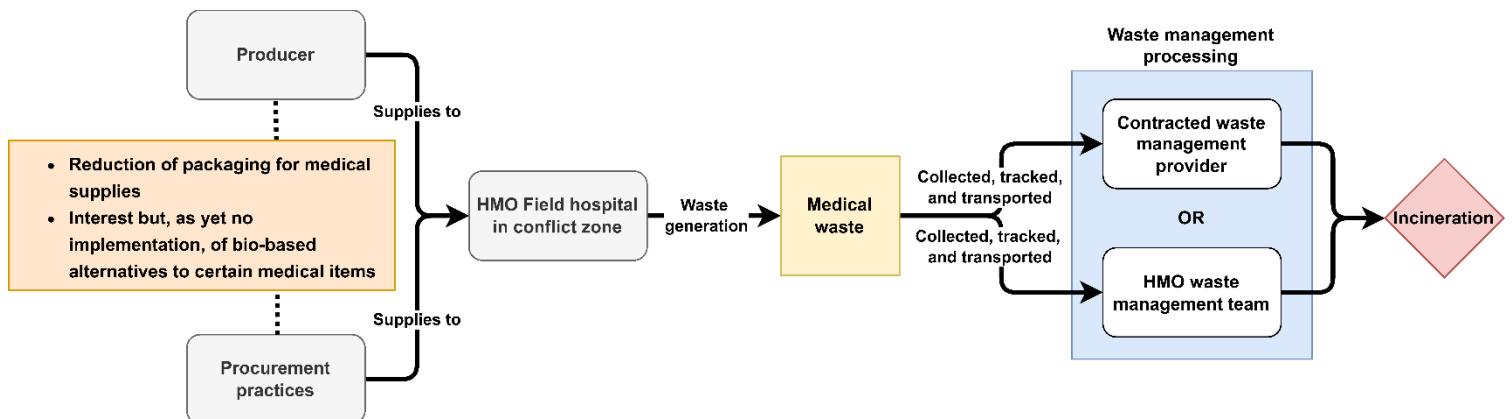


Figure 11 Humanitarian waste management business model in a conflict zone

4. Opportunities for the adoption of innovative practices

There are considerable opportunities and potential for innovation within waste management business models in humanitarian operations. It is uplifting to note a growing number of innovation projects pushing towards introducing circular elements into existing business models in the humanitarian sector, however successful pilots have been highly dependent on context, key stakeholders and local policies, and scale across contexts and geographies has been very rare.

Informed by interesting research conducted within the WORM Consortium (D2.1), it is clearly great potential for upstream innovation with regards to the introduction and streamlining of sustainability criteria in humanitarian procurement guidelines. Pushing this agenda forward will be crucial to incentivise business models based on EPR schemes, as well as strong incentives to invest in and utilise new and

existing technologies (treatment, remanufacturing and recycling of waste) for improved circularity. Such use of new technologies and innovation, especially, within the realm of EPR schemes are important given the cascade of these practices across the humanitarian waste management value chain. For example, currently in Vietnam, EPR has been embedded in environmental protection legislation encouraging collaboration and coordination between producers and end-users to satisfy the requirements of material recovery. Given the nature of humanitarian waste management in Vietnam this will invariably result in the augmentation current waste management business models and the creation of new waste recovery processes within the humanitarian waste management processing chain. Another innovation rests with the adoption of alternative bio-based materials. Similar to EPR, the introduction of bio-based materials within humanitarian medical and non-medical supplies will once again augment the waste streams and the resultant circular loops to an unknown capacity. Given the limited use of such bio-based alternatives, there is capacity for business model innovation across the upstream humanitarian waste management value chain from production and procurement practices. Upstream, such innovations can nest themselves as looking to create new models for closed loop humanitarian waste management systems.

Downstream innovation is another area within humanitarian operations showing potential for introduction of circularity, including closed and semi-closed loop circular initiatives, especially within the livelihood programming of international and local humanitarian organisations. The value in downstream innovation is in facilitating solutions for inefficiencies of the current extent humanitarian waste management systems. Here, considerations for bio-based alternatives also present opportunity for innovation considering material recovery and treatment. Such materials can trigger a host of new dimensions to existing humanitarian waste management business models including, but not limited to, i) material composting, and ii) valorising bio-waste into bio-mass and bio-energy production. The introduction of such materials will also highlight the importance of humanitarian waste management business model evolution and the alteration to the formal-informal waste management nexus. The change in waste streams with the adoption of bio-based alternatives can have a stark impact on the livelihoods of informal waste pickers from the resultant loss of economically viable material. It is possible that informal participation in the humanitarian waste management will have an evolutionary response to such new material use.

Additionally, increasing knowledge and awareness of value conservation and creation have triggered a stream of downstream innovation projects with a circular economy focus, experimenting with product repair, reuse, repurpose, as well as remanufacturing and recycling. These waste management business models represent an important component of efforts to limit the environmental footprint of waste generation by the sector at large. In addition, these models hold potential for income-generating activities for people affected by humanitarian crisis that often are at risk of being marginalised in other markets. This recovery and reuse should extend beyond NFIs and whilst we observe some consideration for the use of non-destructive disinfection methods, this represents a very small proportion of current humanitarian waste management practices. There is significant opportunity here in relation to technological innovation of existing machinery with costs and viability in mind for implementation within various humanitarian settings, whilst at the same time progressing the relationship between such disinfection and traditional medical waste management treatments. This segues well into discussions about multi-actor collaboration and coordination.

There is also untapped potential around strengthening of stakeholder coordination and collaboration within the sector. While great initiatives, including The Sphere Standards, the Joint Initiative on Sustainable Packaging, the UN sustainable Procurement Indicators and the WHO guidelines on Safe Management of wastes from health-care activities, aim to address collective issues and advocate for standardisation across the sector, the commitment to a sustainable humanitarian response cannot be achieved without new business models and include enhanced efforts of coordinated collaborations.



WORM WP3 (D3.2), while building on the existing research done in D3.1, will design policy recommendations and guidelines to support concrete actions for enhancing circular economy practices in humanitarian operations. This will include exploring a number of business models in greater detail to identify opportunities and improvements, suggest actions and provide guidelines.

5. Limitations and Avenues for Future Work

We are mindful of the limitations of the work that have undertaken in this regard, especially, in relation to two key dimensions. Firstly, whilst we are able to gather the views of HOs, waste management providers, and hospitals, we believe that the posited models would also benefit from discussions with the receivers of humanitarian support and the local community post crisis. This would enable us to provide further detail in relation to the right-hand side of our conceptions of humanitarian waste management business models. For example, within a refugee camp setting, this would enable us to provide a conception of a timeline of engagement and key motivators with circular economy practices. Alternatively, speaking to the local population in a rural village in the Vietnamese highlands after a flood would enable us to better understand any further engagement with waste management once HOs conclude a deployment. Although a limitation to our current study, this highlights a substantial opportunity for future work even within our WORM WP deliverables, for example, policy development for innovation within humanitarian waste management business models. This follow on study can extend the capture of views to local populations to better inform our conceptual business models. Moreover, a breakdown and quantification of impact of humanitarian activities on waste generation in such settings as well as, the participation within circular economy activities would also serve to advise policy targets (UNDP, 2020).

Secondly, whilst we have endeavoured to engage with the full gamut of available waste management innovations during our interviews and focus groups, we are mindful that our understanding of business model applications is not exhaustive, especially in relation to our capture of the layers and nuances of formal and informal interface within the humanitarian waste management sector. From our perspective, the posited business model conceptions for our focal countries of Vietnam and Kenya would further benefit from a deeper examination of this formal and informal interface with potential insight into the intermediate steps between both formal waste management companies and informal waste pickers (Williams, 2023). What is also unknown from this perspective is how up-stream changes in business models such as greater adoption of extended producer responsibility practices would impact the underlying downstream waste pickers and their involvement within the waste management value chain (Kovács & Heaslip, 2024). Once again, though these are gaps and limitations in our current work, they present substantial opportunities as avenues for further examination. A triangulation of the informal waste management sector via the extent academic literature, conversations with individual waste pickers, and any available aggregated data would greatly fill the current gaps in our knowledge. This would enable us to better understand the applied business models of the informal waste management sector and if there are quasi-formal-informal organisations at intermediate levels in the informal waste management value chain (Ghisolfi et al., 2017; Zolnikov et al., 2021). Such examinations will also greatly educate our understanding of the livelihoods arguments within the informal waste management sector, once more, allowing us to make targeted policy recommendations.



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ANNEX 1

No.	Organization	Type of organization	Country of operations	Position of respondent/ Number of respondents
1	International Medical Corps (IMC)	Humanitarian organization	N/A	Global WASH Advisor WASH TA (2)
2	Amref Health Africa	Humanitarian organization	Kenya	Administrator of Amref Kibera Clinic (1)
3	Tranbiz Enterprises Limited	Waste management service provider	Kenya	Business Development (1)
4	Kisumu County Referral Hospital	Hospital	Kenya	Public Health Officer (1)
5	Finnish Red Cross	Humanitarian organization	Finland	Logistics Coordinator (1)
6	Kenya Medical Research Institute (KEMRI)	Research institute	Kenya	Biosafety & Biosecurity Department Safety (2)
7	Getnet Addisie	Waste management service provider	Ethiopia	N/A (1)
8	International Rescue Committee	Humanitarian organization	N/A	Emergency Coordinator Health Coordinator Senior Coordinator (3)
9	St. Jairus Hospital	Hospital	Kenya	IPC personnel (1)
10	Médecins Sans Frontières (MSF) - Doctors without borders	Humanitarian organization	France, Kenya	Waste management Officer WASH C-level personnel Advisor Water & Sanitation (3)
11	Africa Inuka hospital	Hospital	Kenya	Assistant administrator/ Public Health (1)



No.	Organization	Type of organization	Country of operations	Position of respondent/ Number of respondents
12	Boredo Supplies Limited	Waste management service provider	Kenya	C-level personnel (1)
13	Infection, Prevention and Control Associates	Waste management service provider	Kenya	C-level personnel (1)
14	National Environment Management Authority	Government office	Kenya	C-level personnel (1)
15	Ministry of Health – Kisumu County	Government office	Kenya	Public Health and Sanitation C-level personnel (1)
16	Lumumba Sub-County Hospital	Hospital	Kenya	Public Health Officer (1)
17	Nyakach Sub-County Hospital	Hospital	Kenya	Public Health Officer (1)
18	Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH)	Hospital	Kenya	Public Health Officer (1)
19	United Nations Children's Fund (UNICEF)	Humanitarian organization	Kenya	Supply & Logistics Section at UNICEF Kenya Country Office (1)
20	Kenya Red Cross Society (KRCS) International Centre for Humanitarian Affairs (ICHA)	Humanitarian organization	Kenya	Innovation Manager (2)
21	International Committee of the Red Cross (ICRC)	Humanitarian organization	N/A	Essential Services Operations Partner (1)

No.	Organization	Type of organization	Country of operations	Position of respondent/ Number of respondents
22	Cho Ray Hospital	Hospital	Vietnam	Labor Safety, Health & Environment Department (7)
23	University Medical Center Ho Chi Minh City	Hospital	Vietnam	Building Administration Department (1)
24	South Saigon International General Hospital	Hospital	Vietnam	N/A (1)
25	FV Hospital	Hospital	Vietnam	Labor Safety, Health & Environment Department (2)
26	Tam Anh Hospital	Hospital	Vietnam	Infection Control Department (1)
27	National Hospital of Acupuncture	Hospital	Vietnam	Infection Control Department (2)
28	Traditional Medicine Hospital	Hospital	Vietnam	Infection Control Department (1)
29	Hanoi Medical University Hospital	Hospital	Vietnam	Infection Control Department (1)
30	Hanoi Heart Hospital	Hospital	Vietnam	Infection Control Department (1)
31	Genome Sciences Technology and Services Company Limited	(Private) Hospital	Vietnam	Infection Control Department (1)
32	Military Institute of Traditional Medicine	Hospital	Vietnam	Infection Control Department (1)
33	Moc An Chau Logistics Corporation	Waste management service provider	Vietnam	Factory Environmental Department (3)

No.	Organization	Type of organization	Country of operations	Position of respondent/ Number of respondents
34	Ho Chi Minh City Urban Environment Co., LTD (CITENCO)	Waste management service provider	Vietnam	Technology and Quality Control Department (1)
35	Asia Environmental Production Trading Services One Member Company Limited (A Chau)	Waste management service provider	Vietnam	Waste Department (2)
36	Hanoi Urban Environment Limited Company (URENCO)	Waste management service provider	Vietnam	N/A (1)
37	URENCO 13 – 13 Environmental Equipment and Material Joint Stock Company (URENCO 13)	Waste management service provider	Vietnam	N/A (2)
38	Industrial and Urban Environment Joint Stock Company no 11 (URENCO 11)	Waste management service provider	Vietnam	N/A (1)
39	Green Environment Company Limited (GECO)	Waste management service provider	Vietnam	N/A (2)



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