WASTE MANAGEMENT AND REVERSE LOGISTICS IN THE HUMANITARIAN CONTEXT

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ABSTRACT

Purpose
Humanitarian organisations have frequently been criticised for not taking care of their waste that has resulted from delivering inappropriate items or excess packaging. Recognising this, several humanitarian organisations have joined an endeavour to reduce and manage the waste they generate. This paper supports this endeavour with reviewing academic and practitioner literature to further the understanding of the reverse logistics challenges and potential solutions in the humanitarian context. The purpose of this paper is to create a framework of waste management and reverse logistics in the humanitarian context.

Design/methodology/approach
This literature review combines academic with practitioner literature on waste management, reverse logistics, humanitarian logistics and disaster management. Academic literature has been identified through keyword searches and complemented with case reports from waste management programmes.

Findings
Numerous greening endeavours exist across humanitarian organisations. Yet the research and documentation of waste management and reverse logistics is limited in this context. The analysis of the literature identified three main themes: the umbrella theme of environmental sustainability, and the specific subthemes of waste management and reverse logistics, with specific unique topics attributed to each.

Research limitations/implications (if applicable)
This paper maps out the current state of research and practice in waste management and reverse logistics in the humanitarian context. It highlights challenges and defines contextual differences and gaps that will guide future research.

Practical implications (if applicable)
The paper contributes to the learning across humanitarian organisations and their programmes.

Social implications (if applicable)
The focus of this paper is on the ecological side of humanitarian logistics. The identified challenges bear important policy implications locally, as well as for global donors.

Originality
This paper lays the foundations of a joint endeavour across humanitarian organisations in the area of waste management and reverse logistics. By bringing in insights from grey literature, it extends on the so far purely conceptual stream of literature in this area.

Keywords: Humanitarian supply chain, humanitarian logistics, waste management, reverse logistics

1. Introduction

1.1. Background

The raison d'être of humanitarian organizations is to serve people in need, thereby contributing to people's survival and sustainment. This in itself is an important part of sustainability, and sustainable supply chains. Not surprisingly, the bulk of humanitarian activity is concerned with this, as is the bulk of both academic and grey literature on sustainable humanitarian supply chains. In contrast, commercial supply chains are primarily concerned with ecological questions when it comes to sustainable supply chain management (SSCM) research and practice, paying relatively little attention to social dimensions.

There is, however, considerable criticism that humanitarian organizations face when it comes to their environmental impact. Much of this criticism stems from the litter in the streets after disaster response. Waste is though but a manifest of numerous supply chain decisions.

There are numerous ways to tackle waste. Many of these have already been discussed extensively in commercial supply chains, including various streams of literature on waste management, reverse logistics, closed loop supply chains, to the circular economy. This paper takes a closer look at these concepts in the extant humanitarian logistics, and humanitarian supply chain management (HSCM) literature, to evaluate what has been done vs what overlooked in this context, with a particular focus on waste management and reverse logistics. The purpose of this paper is to create a framework of waste management and reverse logistics in the humanitarian context. This leads to the following research questions:

RQ1: What is the current state of research and practice on waste management and reverse logistics in the humanitarian context?

RQ2: What are the gaps in waste management and reverse logistics in the humanitarian context?

The starting point of the literature review are extant conceptual frameworks in the areas of waste management and reverse logistics. These frameworks guide both the identification of relevant literature, as well as those of relevant examples from the humanitarian context. The methodology of the review is explained next, before presenting thematically grouped findings. The paper concludes with the gaps that have been identified through the review.

2. Methodology

This paper explores the current state of environmental sustainability in humanitarian logistics, with a particular focus on waste management and reverse logistics. This is a nascent stream of research, and as with all HSCM, the inclusion of practitioner knowledge and literature is paramount (Starr and Van Wassenhove, 2014). Therefore, in this review we extend the search beyond published academic literature to include grey literature, reports from organizations, and other data sources to present a take on a 'state of the art' review (Grant and Booth, 2009). While we include some older literature to establish a framework of what has been done in this area in the past, the main focus is on what is currently being done. We also want to emphasize interdisciplinarity, as HSCM is influenced by several streams of research, such as commercial logistics and disaster studies. Considering the focus of this review, we have also included literature on waste management and reports from humanitarian organizations, as well as grey literature from non-academic sources.

This review was conducted through a keyword search on Google Scholar, as well as non-academic sources. The keywords used were "*sustainable", "humanitarian", "supply chain",*

"environmental", "waste management", "reverse logistics", "packaging" and combinations thereof. The sources were narrowed down further based on an overview of the titles, abstracts, and/or keywords. In Table 1, the specific inclusion and exclusion criteria can be seen for both academic and grey literature.

Table 1 Inclusion and exclusion criteria

	Academic literature	Grey literature
Inclusion	• Title, abstract, and keywords indicate humanitarian logistics, waste management, reverse logistics, and/or environmental sustainability as the focus • Published in peer reviewed journals	• Organizational documents and/or reports focusing on humanitarian logistics, waste management, reverse logistics, and/or environmental sustainability • Government data • Commercial sector information on logistics, waste management, reverse logistics, and/or environmental sustainability
Exclusion	• Title, abstract, and keywords do not indicate a focus on humanitarian logistics, waste management, reverse logistics, and/or environmental sustainability • Articles referring to debris management in a disaster context • Written in a language we do not understand	• Unrelated to humanitarian logistics, waste management, reverse logistics, and/or environmental sustainability • Debris management

How much any article has been used can be assessed through citation indices, including that of Google Scholar. This function was also used to ascertain which articles had cited a specific source and whether those bore relevance to this review. These were also narrowed down based on title/abstract keywords. Practitioner data is also particularly relevant within the humanitarian context, which is why this review also includes grey literature. In Appendix 1 is it possible to see the articles examined for this review in an excel spreadsheet.

The purpose was to identify the main themes in environmental sustainability in humanitarian logistics. Thematic analysis was used to categorize the literature under three main themes; Environmental sustainability (ES) in HSCM, waste management (WM) and reverse logistics (RL). ES in HSCM acts as an umbrella category, providing some background and a baseline for the contexts of waste management and reverse logistics in HSCM. The subthemes arising from the literature are further explored in Table 5.

3. Findings

3.1. Descriptive findings

Before going to the thematic findings, we provide a short overview of the sample. The academic literature comprised of 27 papers published between the years 2001-2022, and the grey literature 10 publications. Many of the sources cover multiple themes, but in this table for simplicity the primary theme is counted.

Table 2 Number of sources per type

Theme	academic	grey	Total
ES in HSCM	12	5	17
Reverse Logistics	5	-	5
Waste management	10	5	15
Grand Total	**27**	**10**	**37**

Table 3 presents the number of sources, both academic and practitioner, according to the year they were published. The past three years have seen a significant increase in sources available regarding environmental sustainability in HSCM.

Table 3 Number of sources by year and type

Year	academic	grey	Grand Total
2001	1		1
2006	1		1
2010		1	1
2012	2		2
2013		1	1
2014	4		4
2015	3		3
2016	1		1
2017	1		1
2018	1	2	3
2019	3		3
2020	4	2	6
2021	5	2	7
2022	1	2	3
Grand Total	**27**	**10**	**37**

The academic articles by journal are shown in Table 4. In addition to the journal articles, academic sources included one book chapter and a doctoral thesis.

Table 4 List of peer reviewed journals

Journal name	**# of articles**
International Journal of Production Economics	4
Journal of Cleaner Production	3
Production and Operations Management	2
Journal of Operations Management	2
International Journal of Logistics Research and Applications	2
Journal of Humanitarian Logistics and Supply Chain Management	2
International Journal of Operations and Production Management	1
Disasters	1
Waste Management	1
Journal of Business Logistics	1
Natural Hazards Review	1
Disaster Prevention and Management: An International Journal	1
Sustainable Production and Consumption	1
International Journal of Disaster Risk Reduction	1
Worldwide Waste: Journal of Interdisciplinary Studies	1
International Journal of Logistics Management	1
Journal of the Operational Research Society	1
Grand Total	**26**

3.2. Thematic findings

Table 5 summarizes the findings of the literature review into a table, classifying the literature into either academic or grey sources and provides examples and references. Waste management and reverse logistics are the primary context for this review, but in order to appropriately analyze them, we must also place them in the general umbrella stream of environmental sustainability (ES) in HSCM. The subthemes emerging from ES in HSCM, such as performance, procurement, climate change, and collaboration are relevant factors within waste management and reverse logistics as well. The table presents an example of each subtheme, as well as a reference to relevant literature. Reviewing the literature also presents a stepping stone for further research and identifies gaps. Potential research questions for future inquiries are also presented in the table.

Table 5 Summary of thematic findings and literature

		Subtheme	AC	Grey	Examples	Selected references	Gaps/Future research
Umbrella theme	**Environmental sustainability in HSCM**	Climate change	x	x	Climate related displacement	Climate Center, 2021	How do humanitarian operations contribute to climate change? What kind of partnerships are required for ES in HSCM? How and to what extent can local procurement contribute to sustainability in HSCM? The roles of donor limitations and requirements of use of funds How generic and established tools can improve ES in HSMC? Prevention of material convergence from donations Procurement initiatives in organizations Solid waste management in the Global South and disaster contexts
		Collaboration	x	x	Cross-sectoral partnerships	Cricelli *et al.*, 2021 European Commission, 2022	
		Localization	x		Local procurement	Pazirandeh and Herlin, 2010	
		Performance	x		Lean SCM	Haavisto and Kovács, 2014	
		Barriers	x	x	Funding limitations	Sarkis *et al.*, 2012 Brangeon and Crowley, 2020	
		Measures and tools		x	REA	EHA Connect, 2018 EHA Connect, 2022	
Main themes of review	Waste management	Material convergence	x		Unsolicited donations	Holguín-Veras *et al.*, 2014 Suzuki, 2020	
		Procurement		x	ICRC guidelines	ICRC, 2022 Pazirandeh and Herlin, 2010	
		Solid waste management	x	x	Lack of solid waste plans	WHO/WEDC, 2013 Das et al., 2019	
		Waste streams	x	x	Packaging; medical waste	George *et al.*, 2020 Tilley and Kalina, 2020	
	Reverse logistics	Recycling	x	x	Collect packaging, proper disposal,	George *et al.*, 2020 Stauffer and Kumar, 2021	
		Remanufacturing	x	x			

		Repurpose	x	x	continuous use of relief items, recycling programs with beneficiaries	Peretti *et al.*, 2015 Saidan *et al.,* 2017		

3.3. Environmental sustainability in the HSC

Humanitarian organisations have become increasingly more aware of the environmental impacts of their supply chains. However, research in this area is nascent and lacks in cohesion. Despite the notable research interest in environmental sustainability (ES) in the context of commercial supply chains, as well as calls from research and practice, there are significant gaps in such research in HSCs (Zarei *et al.*, 2019).

ES was notably absent in the results of a content analysis of annual reports from humanitarian organisations (Haavisto and Kovács, 2014), even though the same analysis discovered important links between various sustainability dimensions and performance measures. The actual efforts and the levels they targeted varied tremendously, however. For example, local sourcing as part of localization would contribute to the appropriateness as well as the effectiveness of aid, while climate change mitigation efforts were more considered in an organization's environmental policy. Fast forward, reverse logistics the topic of the day at the Global Logistics Cluster's meeting October 2019, and sustainability, especially greening, a main, shared concern at the Global Logistics Cluster's discussions at the Humanitarian Networks and Partnerships Weeks in 2021. At the same time, by 2020, for the first time, climate and weather events (and not conflicts) were the main factor of displacement (Climate Center, 2021).

A decade ago, Sarkis et al. (2012) were some of the first researchers to explore the greening of the HSC. They list various barriers to greening that exist within HSCs including a lack of knowledge of greening, the uncertainty of the context, technological and infrastructure challenges, and operational shortcomings. But as Zarei *et al.* (2019) found, most studies regarding ES in HSCs focus on establishing the status quo, rather than practical measures and mechanisms to address the various challenges and barriers. Abrahams (2014), like Sarkis et al. (2012), emphasized the sense of urgency that overrides the capacity to consider environmental factors. Strict limitations on use and duration of funding received from donors also hinders environmental sustainability (ES) efforts still today (Brangeon and Crowley, 2020).

The emergency mode of HSCs is well captured in the sudden-onset nature of many natural hazards but also man-made disasters, and the urgency of disaster relief. This is often quoted as a main reason for focusing on other than sustainability aspects of aid first. That said, humanitarian organisations are engaged with many types of disasters, many of which are slower in onset (see van Wassenhove, 2006, Table 6).

Table 6 Disaster type

	Natural	Man-made
Sudden onset	Earthquake Hurricane Tornado	Terrorist attack Coup d'état Chemical leak
Slow-onset	Famine Drought Poverty	Political crisis Refugee crisis

While this matrix presents a useful entry into defining the type of disaster, there are also complex emergencies that result as a combination of natural and man-made elements, protracted crises that can be sudden onset ones to begin with and yet are dealt with for years to

come, cascading disasters with unique incident evolutions, etc. Importantly for supply chain decisions, the urgency of the onset requires more agile approaches, while slower onsets allow for also leaner supply chains. Leanness emphasises waste minimisation in the first place, both from the perspective of eliminating waste activities but also superfluous resources. This is also where the notion "lean and green" stems from. That said, leanness does not link well with preparedness efforts that need to include pre-positioning of material items instead of an elimination of inventory.

Preparedness is an important phase of disaster relief. Other phases include mitigation, (preparedness), immediate response, and recovery/rehabilitation (Van Wassenhove, 2006). HSCM focuses little on the disaster mitigation phase, though from an environmental perspective, any effort that goes into (re-)considering choices of what is being delivered when could be seen as part of mitigation. Interestingly, however, sustainability research in HSCM has overwhelmingly concentrated on the response phase, with particularly little attention paid to the recovery phase (Abrahams, 2014), though depending on the very topic of the research, the focus across disaster relief phases varies. Importantly, the phases do also overlap and vary significantly by the context of the disaster (Kunz and Gold, 2015). The type of disaster largely influences the action carried out in the different phases of the relief SC. Phases also influence each other, so choices made earlier on in the process and/or supply chain significantly alter the consequences later on (Kunz and Gold, 2015), also in terms of environmental consequences. Hindrances to rehabilitation and recovery or threats to human health can occur, if for example the waste from relief aid is not dealt with properly (EHA Connect, 2022). In other words, timely environmental assessment is crucial in for example preventing secondary emergencies that may arise from improper environmental management. In their doctoral thesis, Zarei (2020) reviews some examples of adverse environmental consequences that have directly resulted from humanitarian efforts, such as cholera outbreaks due to substandard water treatment, deforestation due to brick production for HOs, and insecticidal nets releasing toxic chemicals into surrounding waters.

There are numerous tools available for the assessment of the environmental impact of humanitarian actions. A good overarching tool are the *Guidelines for Rapid Environmental Impact Assessment in Disasters* (REA) (EHA Connect, 2018). The REA is built around a qualitative assessment framework, which recognizes potential adverse environmental effects, ranks them in order of severity and identifies follow up actions. The REA first analyses the general context of the disaster, using for example the matrix in Figure 1 and identifying the geographical elements. It then considers whether the disaster itself or meeting basic needs of the beneficiaries could cause detrimental environmental effects. Lastly, it considers the environmental consequences of the relief operation itself, which is the focus of this review.

The pressure is though building up for addressing environmental challenges together, as also donors such as ECHO have recently embraced greening as one of their core concerns in humanitarian logistics. In fact, the European Commission (2022) in its Humanitarian Logistics Policy identifies management of waste as a key element in greening the HSC.

WREC is a timely project, especially so since it brings many organizations together. In their analysis of inter-organizational collaboration in reverse logistics, Cricelli et al. (2021) suggest that regulatory pressures from institutions, such as governments, bring about mimetic, coercive, and normative processes that organizations functioning in similar contexts start adhering to. Through mimetic processes organizations start to imitate one another's practices, while coercive processes result from formal or informal outside pressures such as legislation or societal expectations. Normative pressures stem from professional networks and education. These different types of pressures can initiate collaboration either horizontally, i.e. among supply chain peers on the same level, or vertically, meaning along the supply chain (Cricelli *et*

al., 2021). Also humanitarian organizations face numerous stakeholders who exert pressure on them to green their operations, but not all of these pressures extend to them the same way as to commercial organizations. For example, concepts such as extended producer responsibility are legally binding in certain countries and regions (only). Yet most humanitarian operations take place in the Global South. SSCM research in this context is scarce in the commercial stream due to complexity and uncertainty of the economies (Silvestre, 2015).

3.4. Waste management

Waste management comprises many different streams of research. While the bulk of it deals with end-of-life / end-of-use items at the very end of their lifespan, waste management actually starts by waste avoidance. From a supply chain perspective, waste avoidance is a matter of procurement. Procurement is intrinsically linked with product design, and in waste management literature, with concepts such as design for the environment, design for disassembly etc. In the humanitarian context, procurement is but one way of receiving items, however. Hence we will revisit procurement together with material convergence next, before turning to the aspects of waste streams, and solid waste.

3.4.1. Material convergence and procurement

One of the most distinguishing differences between humanitarian and commercial logistics is the number of stakeholders in the SC. Commercial SCs have a limited and controlled group of companies that function along the SC, but in a disaster situation, the donors of good and those in charge of distributing them can rise up to tens of thousands (individuals, different types of organizations, NGOs etc.) (Holguín-Veras *et al.*, 2014). Donors can thus be not only financial but also material suppliers, regardless of whether this is part of any procurement activity or not.

In terms of the phases of disaster relief, donations that arrive after the occurrence of a disaster are seen as part of post-disaster HL (PD-HL) (Suzuki, 2020). They can extend to any kinds of materials, including shelter, hygiene kits, food, water, or even medicine. PD-HL is special in that it is characterized by a lack of information, while it may involve thousands of decision makers, at the same time as logistical activities are impossible to plan for as material flows are uncertain and infrastructure potentially impaired (Holguín-Veras *et al.*, 2012). Because of the heterogenous group of stakeholders involved, the influx of solicited but also ***unsolicited items*** (materials and supplies) being sent as response to a disaster can be overwhelming, and this is referred to as material convergence. A lot of the supplies sent is life sustaining and critical, but there are useless items as well, which can cripple the already overwhelmed SC at the disaster site (Holguín-Veras *et al.*, 2014). Material convergence studies approach the problem through an elimination of flows that are not high priority, but these items still contribute to the levels of waste in the HSC (Suzuki, 2020). In comparison, in reverse logistics, eliminating reverse flows that cannot be used or where the flow creates more inefficiencies than the actual use of the items would warrant, is called gatekeeping. Humanitarian organizations engage in gatekeeping activities when e.g. actively soliciting material donations, thereby encouraging what actually meets needs vs. keeping away what does not. Alternatively, unsolicited donations can be collected and monetised where they occur, rather than delivered to locations where they are anyway inappropriate, where they may undermine local economies, and/or where the logistical costs of such deliveries outweigh any of their benefits.

The vast majority of decisions about materials and their deliveries lies with procurement. Either supplies are pre-positioned in warehouses in strategic locations globally, or context-specific items are procured immediately once the disaster has struck (Moshtari *et al.*, 2021). In terms of waste induced from HSCs, procurement is one of the most crucial elements to increase ES.

Importantly, procurement is also an internal function, and thereby under the control of humanitarian organizations – unlike delivery in the last mile that can occur through, and engage, a myriad of implementing partners. Sustainable procurement has been a reoccurring theme of the UNOPS supplements to their annual report, where already in 2010 there was a theme on the role of humanitarian procurement in creating and shaping markets (Pazirandeh and Herlin, 2010). On a more operational level, as of now, the ICRC (2021) for example has comprehensive guidelines on sustainable procurement in their product catalogue, where environmental and social factors are encouraged in addition to efficiency and financial perspectives. Environmental considerations include aspects such as biodegradable materials for packaging and the assistance items themselves, as well as space saving measures to decrease transportation externalities.

There is no evidence in the academic literature, however, of humanitarian organisations engaging with environmental audits of their suppliers, which is an integral part of environmental management and also the avoidance of waste streams in the commercial sector. On the other hand, design for the environment has started to be embraced in the humanitarian sector as well, and is being considered across humanitarian innovation labs.

3.4.2. Solid waste management

The solid waste management (SWM) crisis is an underlying factor in almost every HSC, but remains one of the most underfunded challenges in global development (Kaza *et al.*, 2018). Waste such as plastic, paper, and organic waste, if not properly disposed of, leak toxins into and pollute the environment (Das *et al.*, 2019). For many local authorities, waste management can be the biggest budget item (Kaza *et al.*, 2018). This is particularly relevant in the Global South, where most humanitarian operations take place, and disasters further exacerbate the challenges of waste management (Tilley and Kalina, 2020). In an overarching study of humanitarian organizations, George et al. (2020) conclude that most organizations or their field partners do not have solid waste management plans in their operations, even though awareness is there.

SWM is generally a decentralized operation, involving both public and private sector actors. Properly managing waste includes monitoring waste generation, which can be extremely costly and therefore less wealthy areas can seldom afford it (Das *et al.*, 2019). Under non-disaster circumstances, there are generally two options for SWM: landfilling and waste-to-energy (WTE) technologies (Soltani *et al.*, 2017). In low-income countries, 93% of waste is dumped in open landfills, which have little to no gas collection or recycling technologies (Kaza *et al.*, 2018).

3.4.3. Waste streams

Humanitarian aid deals with vast amounts of supplies, which are usually imported into the area of the disaster. Accumulated waste from relief aid can cause further environmental damage, such as block storm drains, or lead to improper disposal measures with detrimental consequences to human and natural health (George *et al.*, 2020). Aid is also set up into temporary locations, such as refugee camps and field hospitals, which have no permanent infrastructure for waste management. Generally, humanitarian assistance comes in the form of food items, shelter, medical aid, and drinking water (Dubey and Gunasekaran, 2016) – all forming very different waste streams. Focusing on specific waste streams is important for understanding (a) where the waste occurs and thereby, which stakeholders need to be involved

in managing that waste stream, and (b) which materials are included in the waste and thereby, which waste management processes need to be followed.

Within the humanitarian sphere, waste management can encompass several elements. There is a vast variety of literature regarding management of disaster debris and other large-scale waste resulting from natural disasters or conflicts (Boonmee *et al.*, 2018; e.g. Aydin, 2020) and very specific types of waste such as medical (Patil, Madaan, *et al.*, 2021). While debris removal is not always considered as part of disaster relief, it is essential in areas in which access to beneficiaries would otherwise be hampered by the debris.

Tilley and Kalina (2020) explore medical and hazardous waste management during the Covid-19 pandemic in a Malawi hospital, and conclude that there is a gap in the literature regarding management of waste resulting from humanitarian aid and emergencies. They name the WHO/WEDC (2013) technical note *Solid waste management in emergencies* as the only document addressing SWM in a humanitarian context, but the note is very generic and lacks context specificity for different types of emergencies.

In their review of the environmental impact of humanitarian assistance, Brangeon and Crowley (2020) dissect different sectors of assistance, and the level of impact. Food assistance, which is one of the largest sectors, impacts the environment from local to global level. Food's environmental footprint stretched throughout its supply chain from production to transport to consumption, and also produces a lot of packaging waste, particularly in a relief aid setting (WHO/WEDC, 2013). Food must be packed in a way that is hygienic, and prevents damage from vermin, moisture, and transportation. Waste from the shelter sector includes low quality tarps becoming waste, as they deteriorate quickly. Non-recyclable packaging waste in an issue in this sector as well, as kits are packed in plastic, as they are in the WASH sector as well (Brangeon and Crowley, 2020). Medical waste also presents problems, as there are additional hazards associated with medication and infected protective equipment which need to be disposed of and stored appropriately (Patil, Shardeo, *et al.*, 2021).

Figure 1 presents the different streams of waste, and whether they are generated by material aid delivered to beneficiaries, or by facilitating items (such as industrial packages) discussed in the literature.

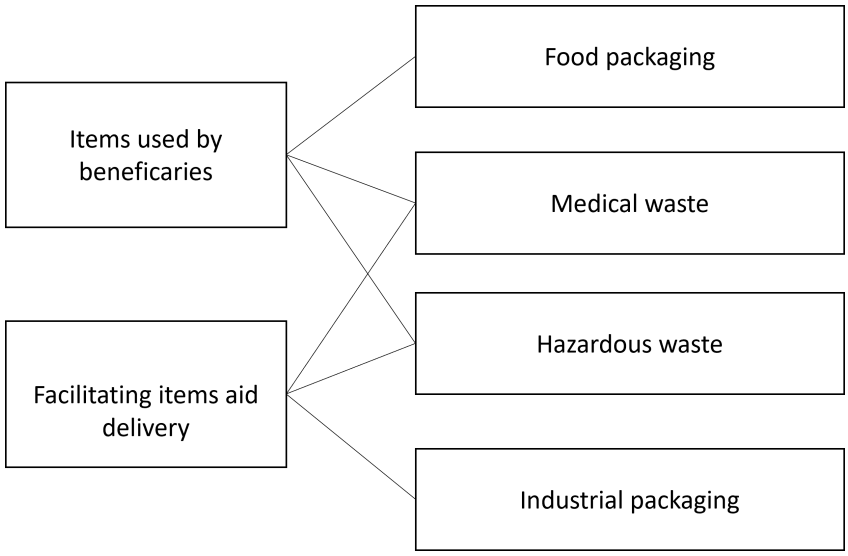

Figure 1 Waste streams

3.5. Reverse logistics

In a seminal RL research article, Rogers and Tibben-Lembke (2001) have separated the RL practices related to products vs packaging. Following their list of practices, Table 7 indicates corresponding examples from the humanitarian context.

Table 7 RL activities in HSC (adapted from Rogers and Tibben-Lembke, 2001)

Reverse logistics activities	Example
Return to supplier	Unused deployed resources
Resell	
Salvage	
Sell via outlet	
Recondition	
Refurbish	Small scale activities of refurbishing packaging of food assistance
Remanufacture	
Reclaim materials	Life jackets made into tarps
Recycle	Using biodegradable materials
Donate	
Landfill	Last resort
Re-use	E.g. jerry cans used long after disaster

In commercial SCs, reverse logistics practices have resulted in economic savings as well as environmental benefits (Prajapati *et al.*, 2019). There is reason to assume the same would be true for HSCs, as they largely take their cues from commercial SCs (Peretti *et al.*, 2015). As established, it is difficult to predict the amount of resources and items that are needed in an emergency, and but deploying vast amounts of inventory 'just in case' is extremely costly and can be detrimental to the organizations reputation if the unused items are not returned, improperly disposed of, or re-donated or resold through other charities (Stauffer and Kumar, 2021).

RL is rarely possible to any organization, commercial or non-profit, without collaboration (Cricelli *et al.*, 2021). It is a complicated process that requires technologies and knowledge that is only achievable through collaboration. George *et al.* (2020) describe a situation where a humanitarian organization attempted to collect non-recyclable packaging, but the communication of the scheme created confusion among the beneficiaries, and there was no real plan as to what to do with the waste once it was collected. RL practices in particular need to be extremely context specific, with local collaborators for both communication and management (George *et al.*, 2020).

There have been successful projects including volunteer refugees in recycling efforts in Darfur and Zaatari, which in addition to being environmentally sustainable, also contributes to the social side (Saidan *et al.*, 2017; Karl and Scholz Karl, 2022). Other initiatives include repurposing packaging such as grain bags and jerry cans for long-term use after the disaster, as well as using material from life-jackets to make tarpaulins (George *et al.*, 2020). However, George *et al.* (2020) highlight that packaging with organizational branding must be recycled

rather than re-used, as improper use of the branded product could result in reputational risks for the organizations.

4. Conclusions

Waste management and reverse logistics are subthemes within the environmental sustainability stream of HSCM literature. Figure 2 presents the concluding framework from this literature. It portrays the connectivity of the literature, whereby ES in HSCM is the umbrella under which waste management and reverse logistics reside. Factors like climate change, performance, and collaboration are also overarching themes in HSCM, and can therefore be applied to the context of this review as well. Thereby the framework illustrates the current state of the art of waste management and reverse logistics literature in the humanitarian context.

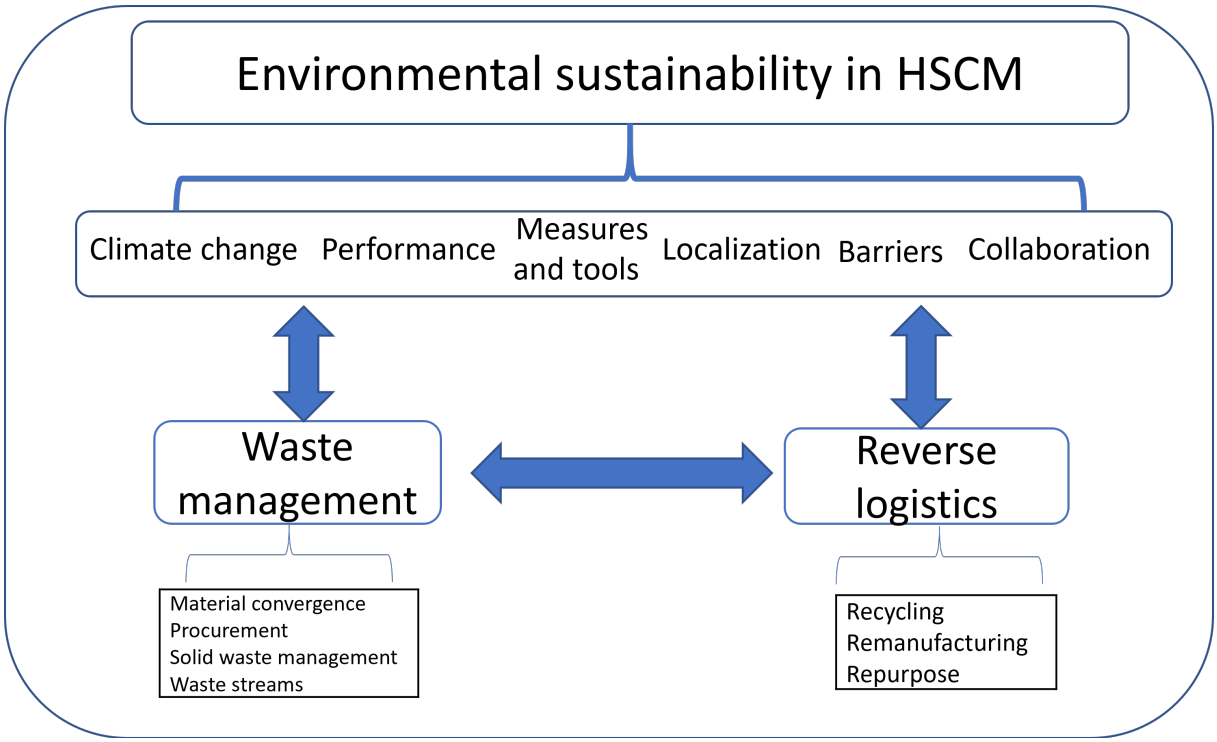

Figure 2 Framework of thematic findings

4.1. Research gaps

The awareness of HSC actors regarding environmental issues is clearly growing, but there are various practical and administrative limitations to what is possible to be done. For sudden onset emergencies, the sense of urgency of getting lifesaving assistance to those in the midst of the disaster overrides many other considerations (Van Wassenhove, 2006; Sarkis *et al.*, 2012). The environmental footprint of relief assistance is however a growing concern, as large amounts of waste is generated from HSCs.

Disaster waste management in the academic literature often refers to debris resulting from a disaster itself, such as collapsed buildings or natural material. Receiving less focus is the waste caused by the relief operation itself. Due to practical reasons, a lot of humanitarian aid needs to be packaged in a durable manner, leading to large amounts of packaging waste. Packaging is a

manageable starting point to greening efforts, but there are many other relevant waste management factors.

Missing from the academic literature are the detrimental environmental effects of the facilitating items needed by humanitarian organizations, such as transport and technological apparatus. Items such as car batteries, tires, and laptops are classified as hazardous waste if not dispose of or recycled properly, and many disaster contexts lack infrastructure for this. Material convergence also presents problems in relief aid operations, whereby unnecessary items are donated and delivered to the disaster area, with little or no resources to deal with them. Textile waste in particular is a hindrance to ES and dominant in well-meaning donations, particularly from individuals.

Literature on collaboration among humanitarian organizations is also scarce. Commercial SC literature indicates that horizontal and vertical collaboration is key in different areas of ES, such as RL. The humanitarian organizations rely on external funding for their operations, which makes them accountable to the donors. Strategic decisions on collaboration may therefore be difficult to achieve with the tight time frames of the operations and the resources available.

Waste management and reverse logistics may appear to be aspects that are dealt with at the end of the HSC, but actions taken in all four phases contribute to these processes. In this section we further analyse the literature in terms of ES, particularly waste management and reverse logistics, and the different phases of disaster relief.

Waste management and sustainability is mostly associated with the recovery phase of the HSC (Kunz and Gold, 2015). This phase of relief aid overlaps significantly with development aid, as there are efforts to return to some form of normalcy after a disaster. For sudden onset disasters, the recovery phase can occur fairly quickly after the fact, and therefore leaving little time to prepare. Mitigation of disasters goes beyond the scope of HL, as natural disasters and conflicts are the result of a myriad of underlying factors. However, it is possible to mitigate the environmental damages resulting from HSCs by assessing the products used in emergencies, and how those can be made more sustainable from a procurement standpoint. The ICRC (2021) for example has a sustainable procurement information sheet, where sustainable alternatives for common materials for e.g. tarps are suggested. This way when reaching the response phase, the materials used in necessary relief items are not as detrimental to the environment. Commercial supply chains emphasize leanness when it comes to ES, but humanitarian organizations need to have contingency stocks in preparation for imminent disasters. Sustainable procurement is therefore a particularly relevant factor in greening the HSC. This requires collaboration with suppliers to ensure that they adhere to ES guidelines or have gone through appropriate audits.

Generation of some waste is unavoidable, therefore managing it properly in the recovery/rehabilitation phase is crucial. However, both academic and grey literature is scarce in specifically managing relief aid waste. Establishing SWM plans with partners in the field, such as municipalities, NGOs, and local private sector actors is an important step in increasing ES within relief aid operations.

4.2. Avenues of further research

The thematic analysis of the literature can be used not only to summarise what already exists but also to highlight the themes where gaps continue to persist in this area. This analysis has highlighted a few important questions that are all great avenues for further research.

In relation to ES, further research would be needed to address the overall contribution of humanitarian operations to climate change to begin with. From a supply chain perspective, this also raises the question, which kinds of partnerships would be required for ES in HSCM. From

a waste avoidance perspective, this boils down not only to how procurement overall, but to how especially the trend towards local procurement would contribute to sustainability in HSCM. As the literature review also highlighted, the various strings attached to donor funding also restricts the possibilities humanitarian organisations have to engage with ES. This is an important point to address in future research as well as practice.

At the same time, while there are numerous tools in ES for commercial supply chains, how to adapt them to the humanitarian context yet remains to be addressed. This is not trivial, since disaster contexts are often in the Global South, and even regular waste management infrastructure may differ significantly from the contextual environment of waste management and reverse logistics research from a commercial perspective. Further research is thus needed to unearth the contingency factors of waste management and reverse logistics across different contexts.

Even though there is a substantial focus in literature on material convergence in donations, surprisingly many problems still occur in this area. One only needs to revisit how clothing donations to Ukrainian refugees have created not only waste problems but also clogged up warehouses and other focal points in Poland.

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