Compendium of Solid Waste Management in Humanitarian Contexts

1st Edition

GERMAN WASH NETWORK
eawag aquatic research
IFRC
WASH Cluster Water Sanitation Hygiene
sustainable sanitation alliance

Compendium Structure

Introduction

Background and Target Audience	What is Solid Waste Management?
Structure and Use of the Compendium	Why Solid Waste Management?
Compendium Terminology	Response Phases and Implications for SWM
The SWM System Template and Implementation Guidance	Roles and Responsibilities of SWM Actors
Using the Technology Sheets for Decision Making	Principles and Standards Related to SWM

PART 1: Preparing for Solid Waste Management

Waste Prevention	Waste Separation	SWM Assessment

PART 2: Domestic SWM Service Chain – Technology Overview

Storage	Collection and Transport	Treatment and Recycling	Use and Disposal
			Use
S.1 Individual/Household Storage	C.1 Manual Transport	T.1 Composting	U.1 Sale of Recyclable Materials
S.2 Community/Shared Storage	C.2 Animal Transport	T.2 Vermicomposting	U.2 Reuse of Waste Materials
S.3 Public Litter Storage	C.3 Motorised Transport – Small Vehicles	T.3 Anaerobic Digestion	U.3 Consumer Goods
	C.4 Motorised Transport – Large Vehicles	T.4 Black Soldier Fly Waste Processing	U.4 Construction with Waste Materials
	C.5 Transfer Station	T.5 Making Fuel from Biomass	U.5 Use in Agriculture
		T.6 Plastic Recycling	U.6 Use of Biogas
		T.7 Plastic Upcycling	U.7 Use of Fuel from Biomass
		T.8 Plastic Downcycling	Safe Disposal
			U.8 Controlled Waste Pit
			U.9 Controlled Disposal Site / Landfill
			Unsafe Disposal (not recommended)
			U.10 Open Dumping
			U.11 Open Burning
			U.12 Contained Burning

PART 3: Cross-Cutting Issues

X.1 Institutional and Regulatory Environment	X.5 Market-Based Programming	X.9 Protection, Accessibility and Conflict Sensitivity
X.2 Inclusive Planning and Participation	X.6 Hygiene Promotion and Behaviour Change	X.10 Advocacy
X.3 Monitoring, Evaluation, Accountability and Learning (MEAL)	X.7 Links to Other Clusters and Topical Domains	
X.4 Occupational Health and Safety	X.8 SWM and Climate Change	

PART 4: Management of Special Waste Types

W.1 Medical and Health Care Waste Management	W.4 Menstrual and Incontinence Waste Management	W.7 Management of Waste from Electrical and Electronic Equipment (WEEE)
W.2 Hazardous Waste Management	W.5 Relief Waste Management	
W.3 Disaster Waste Management	W.6 Management of Solid Waste from Sanitation Facilities and Drains	

Quotes

“Solid waste remains one of the most under-addressed challenges in emergency response, despite its direct impact on public health, environmental safety, and community dignity. This Compendium brings forward practical, peer-reviewed solutions that respond to operational challenges across diverse humanitarian contexts. Importantly, it empowers National Coordination Platforms (NCPs) by providing accessible, standardized tools that support national leadership, harmonized response planning, and cross-sector collaboration. As the WASH sector navigates increasingly complex emergencies, tools like this will be essential for strengthening preparedness, promoting local ownership, and ensuring a more resilient, inclusive, and accountable humanitarian response.”

Monica Ramos UNICEF, Global WASH Cluster Coordinator

“Effective management of solid waste during emergencies is crucial to protecting public health, the environment, and human dignity. Our IFRC network aims to make waste management a core part of Water, Sanitation, and Hygiene (WASH) responses. The Compendium highlights proven tools and methods for managing solid waste, showing how it can improve health, enhance accountability, and empower communities to find their own solutions. By engaging with local communities and listening to their needs, Red Cross and Red Crescent societies work with other humanitarian organizations to create cleaner, healthier, and more resilient environments before, during, and after crises.”

Jagan Chapagain International Federation of Red Cross and Red Crescent Societies, Secretary General

“What do you mean, waste? If managed properly, it is public health, valuable resources, food security, agricultural productivity, energy and a livable future for all. Who would be fool enough to neglect all that and call it waste?”

Marc-André Bünzli Swiss Agency for Development and Cooperation, Thematic Advisor/Head Expert Group WASH

“WASH is a crucial part of humanitarian assistance, including Solid Waste Management (SWM), as it helps to prevent the spread of infectious diseases. Access to water and sanitation is a human right that must be achievable for all people. WASH therefore continues to be one of the priorities of German humanitarian assistance. SWM in particular is vital for managing the health of our environment, and poses particularly complex challenges in humanitarian contexts, especially in emergency and crisis situations such as Gaza, where the ongoing conflict has led to a complete collapse of conventional services such as collection, treatment, and disposal of waste. In 2024 Germany supported a UNDP project in Gaza with 5 Mio. Euros, which included the purchase of forklift trucks, as well other measures for waste disposal management. The publication of the fourth compendium on “Solid Waste Management in Humanitarian Contexts”, recognizes the growing need for action in this and streamlines information and insights on SWM and SWM technologies.”

Dr. Ina Heusgen The German Federal Foreign Office, Director for Humanitarian Assistance

Acknowledgements

Authors Team (alphabetically):

Lorenz Ewers (arche noVa), Robert Gensch (GTO), Sarah Hayman (Swedish Red Cross), Manuel Krähenbühl (SHA), Marta Kucharski (WFP/Logistics Cluster), Alexandra Machado (IFRC), Adeline Mertenat (Eawag), Dorian Tosi Robinson (Eawag), Farah Salem (IFRC), Sara Ubbiali (Eawag), Christian Zurbrügg (Eawag)

We would like to thank the following individuals for their invaluable contributions to this publication (alphabetically):

Alberto Acquistapace, Syed Yasir Ahmad, Gemma Arthurson, Andrea Bindel, Steffen Blume, Kaspar Bomatter, Pierre Burgos, Francesca Calisesi, Jutta Camargo, Sue Cavill, Beatrice Decker, Valeria Dell'Aquila, Amelie Dubè, Kit Dyer, Amro Elzoubi, Michelle Farrington, Fidelis Folifac, Ana Fonseca, Olmo Forni, Charel Frick, Max Friedrich, Toby Gould, Siobhan Grath, Masoom Hamdard, Miriam Harter, Céline Heim, Alexandra Höhne, Aline Hubert, Aimee Jenks, Ina Jurga, Najwa Kallass, Munyah Khaled, Johannes Kleinrath, Zoë Lenkiewicz, Clara La Rosèe, Maria Luong, Ignazio Matteini, Abubaker Mayemba, Alexandra Möckel, Peter Nebel, Muhammad Omar Qasmi, Sary Quirant, Bob Reed, Philippe Reymond, Johannes Rück, Natalie Rzehak, Helen Salvestrin, Tariq Shahrouri, Siegfried Stadler, Kanika Thakar, Elizabeth Tilley, Brigitte Tonon, Jozef van Mierlo, Saloni Vijay, Verele de Vreede, Rolando Wallusche Saul, Anne Woolridge, Maya Zaatar, Julia Zeilinger

Coming from the following organisations, institutions or networks (alphabetically):

Action Contre La Faim (ACF), arche noVa, Austrian Red Cross, Bremen Overseas Research and Development Association (BORDA), Catholic Relief Service (CRS), Centre for Affordable Water and Sanitation Technology (CAWST), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Engineers without Borders Germany, Eawag/Sandec, Eidgenössische Technische Hochschule Zürich (ETH), Geneva Technical Hub (GTH), German Toilet Organization (GTO), Global Waste Lab, Groupe Urgence Réhabilitation Développement (Groupe URD), International Federation of Red Cross and Red Crescent Societies (IFRC), International Organization for Migration (IOM), International Medical Corps, Oxfam, RANAS, Resources and Waste Advisory Group (RWA Group), Solidarité International, Swedish Red Cross, Swiss Humanitarian Aid Unit (SHA), United Nations High Commissioner for Refugees (UNHCR), United Nations Human Settlements Programme (UN Habitat), United Nations Institute for Training and Research – Global Platform for Action (UNITAR-GPA), WASH United, Waste Netherlands, World Food Programme (WFP)/Logistics Cluster

We would like to acknowledge support from:

The German Federal Foreign Office
The Swiss Agency for Development and Cooperation (SDC)

german humanitarian assistance
DEUTSCHE HUMANITÄRE HILFE

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Table of Contents

PART 3: Cross-Cutting Issues

PART 4: Management of Special Waste Types

Appendix

Introduction

Background and Target Audience

The Compendium of Solid Waste Management in Humanitarian Contexts is a comprehensive, structured and user-friendly manual and planning guide that provides a systematic overview of existing Solid Waste Management (SWM) technologies and approaches appropriate for use in humanitarian contexts.

The main target audience is practitioners involved in water, sanitation and hygiene (WASH) humanitarian response. They include technical and management staff from governmental, local, national, international and multilateral organisations deployed during emergencies and subsequent stabilisation and recovery activities. The audience also includes academic institutions and capacity strengthening agencies, the private sector, donors and actors from other sectors and humanitarian clusters that intersect with SWM, such as Health, Shelter, Logistics or Camp Coordination and Camp Management (CCCM).

Although humanitarian WASH interventions primarily focus on immediate life-saving measures and protecting public health, the humanitarian community increasingly faces longer-term protracted crises that stretch beyond an emergency response. Awareness has also increased about the necessity of initiating adequate SWM at the early stages of emergencies and throughout stabilisation and recovery to protect public health, the environment, and, indirectly, the life, well-being and prosperity of affected communities. Furthermore, humanitarian WASH professionals are often called upon to work in multiple contexts – urban, rural and camp – addressing the WASH needs of refugees, internally displaced people (IDPs) and affected local and host communities. This publication addresses this reality and contributes to the Humanitarian-Development-Peace Nexus by covering the technologies, approaches and planning elements that can be adapted for use in a variety of scenarios.

The Compendium of Solid Waste Management in Humanitarian Contexts is part of a series of WASH in Emergencies compendia. The first three compendia focused on the main pillars of WASH – water supply, sanitation and hygiene promotion. This Compendium expands the series, focusing on another key area of WASH: Solid Waste Management. Like the earlier compendia, it has sought a sector-agreed categorisation and structure. It provides concise information about SWM technologies, planning aspects and cross-cutting issues, drawing on the latest initiatives, materials and evidence. It disaggregates SWM into its functional components, clarifies terminology and provides guidance on identifying the most appropriate solutions in different contexts.

The Compendium of Solid Waste Management in Humanitarian Contexts is primarily a capacity strengthening tool and a reference book, but it also supports the planning, implementation and decision making for designing context-specific SWM interventions. It offers easy access to relevant summarised information about SWM and provides details and links to additional guides and publications where available.

Structure and Use of the Compendium

The Compendium consists of five chapters:

Introduction

The introductory chapter has ten sections; it describes the structure and use of the Compendium, defines key SWM terminology, principles and standards and gives an overview of the general framework used to identify and configure context-adapted SWM solutions for humanitarian contexts. It also provides information about different humanitarian response phases and their implications for SWM interventions. Compendium users are particularly encouraged to review the sections 'Why Solid Waste Management?' **(page 21)**, 'What is Solid Waste Management' **(page 20)**, 'Roles and Responsibilities of SWM Actors' **(page 26)** and 'Using the Technology Sheets for Decision Making' **(page 16)**. These sections help familiarise users with the importance, main terms and scope of SWM.

Part 1: Preparing for SWM

Part 1 introduces three key areas to consider before implementing SWM: waste prevention, waste separation and assessment. The section on waste prevention describes the waste management hierarchy, based on the principle of reduce, reuse and recycle (3R); it also includes aspects of green procurement, the importance of behaviour change, and advocacy for SWM. The waste separation section includes initial waste segregation and subsequent waste sorting. These processes support the treatment of different waste types according to their characteristics, the opportunity to recover valuable and usable materials from waste and the ease of handling reduced waste amounts. The assessment section covers all aspects related to the initial (and continuous) gathering of information about the amount and composition of the waste generated, the existing SWM infrastructure, actors, legal frameworks, and health and environmental risks that help to inform SWM strategies and interventions and to forecast future needs.

Part 2: Domestic SWM Service Chain – Technology Overview

This core chapter of the Compendium is a comprehensive compilation of relevant SWM technologies that can potentially be used in a wide range of humanitarian contexts, ranging from acute response to longer-term stabilisation and recovery settings. The technologies are categorised, ordered and colour-coded according to the stage (or functional group) of the SWM service chain to which they belong (S Storage, C Collection and Transport, T Treatment and Recycling, U Use and Disposal). The chapter contains 28 "Technology Information Sheets". These standardised two-page summaries of each technology provide the Compendium user with an overview of the basic working principles and design considerations. Key information about each technology's applicability, cost implications, space and materials needed, and operation and maintenance requirements is also included.

Part 3: Cross-Cutting Issues

This chapter presents cross-cutting issues and background information to address when making technology and design decisions. The ten sections include the institutional and regulatory environment, occupational health and safety, market-based programming, hygiene promotion, advocacy, as well as protection, accessibility and conflict sensitivity considerations and links to various other humanitarian sectors and thematic domains.

Part 4: The Management of Specific Waste Types

This Compendium focuses on the management of domestic and municipal solid waste, including non-hazardous commercial and institutional waste. However, other waste types are found in humanitarian contexts. This chapter therefore provides more detailed information on the management of specific wastes such as disaster waste, hazardous waste, menstrual and incontinence waste or medical and health care waste.

Compendium Terminology

SWM Service Chain

An SWM service chain is a multi-step process in which various solid waste products are managed from the point of generation to the point of use or final disposal. It is a context-specific series of technologies and services for the management of these products, i.e. for their storage, collection and transport, treatment and recycling, and use or disposal. A logical, modular chain of SWM technologies can be designed by selecting technologies from each applicable step of the chain (or functional group), considering the incoming and outgoing products, the suitability of the technologies in a particular context, and the management and operation and maintenance required to ensure that the system functions safely and sustainably.

SWM Technology

SWM technologies are defined as the specific infrastructure, methods, or services designed to collect, contain, transform and treat products, or to transport products to another stage of the service chain. Each of the 28 technologies included in this Compendium is described in a two-page technology information sheet in Part 2 of this publication. The Compendium is primarily concerned with technologies directly related to managing domestic-like or municipal solid waste. The technology information sheets do not, therefore, address other relevant waste types, such as disaster waste, hazardous waste, or medical and health care waste that can occur in humanitarian contexts. However, some general information on these specific wastes is provided in **PART 4: Management of Special Waste Types**.

Stages of the SWM Service Chain

Stages of the SWM service chain (also referred to as functional groups) are groupings of technologies that have similar functions. Each stage has a distinct colour; technologies within a given stage share the same colour code so that they are easily identifiable. Additionally, the technologies within each stage are assigned a reference code with a single letter and number. In Part 2, the Compendium describes four different stages from which technologies can be chosen to build a SWM service chain:

Storage S (Technologies S.1–S.3) refers to technologies that allow for the temporary holding of waste materials at or near the point of generation. It is usually the first step of the SWM service chain before collection and transport, treatment and recycling, and the final use or safe disposal. Without sufficient and functional storage at the point of generation, waste is scattered within settlements, leading to public health risks: the waste may never enter the SWM service chain. Storage of waste can occur directly at the household level but can also be transferred to communal and shared solutions. Waste storage in public areas is another option that can prevent littering and unmanaged waste deposits in public areas where household or communal storage does not provide sufficient coverage.

Collection and Transport C (Technologies C.1–C.5) refers to the processes of gathering waste from its point of generation, temporarily holding and moving it to a facility where it can be treated and recycled and finally used or disposed of. Collection and transport need to be reliable and regular; their capacity must be adjusted to the production levels of waste. Although primary/secondary products may need to be collected and transported between different functional groups, the most prominent gap is usually between storage and treatment and recycling. To simplify the service chain model, the transport of products between other steps of the chain (e.g. between treatment and the final use and disposal) is not displayed in the SWM service chain structure but may have to be taken into consideration.

Treatment and Recycling T **(Technologies T.1–T.8)** refers to technologies that promote circularity and value recovery from waste and reduce the waste amounts for disposal and the respective environmental and public health impacts. This section focuses on technologies for organic waste treatment and the recycling of plastics. Technologies for recycling other waste fractions (e.g. paper, metal, or glass) are purposely omitted. Due to their sophistication, energy requirements or required processing scale, it is unlikely that these recycling processes would be implemented in humanitarian settings by humanitarian actors but would instead be handed over to local market actors.

Use and Disposal U **(Technologies U.1–U.12)** refers to technologies and methods employed for the final use of the output products of the SWM service chain or – if use is not an option – the various options for safe or unsafe disposal. The recommended use and disposal options are listed in the SWM service chain structure in descending order of priority: whenever possible, the use of recovered valuable and usable materials is prioritised over safe disposal, and safe disposal of waste is prioritised over unsafe disposal. Although it is strongly recommended to avoid unsafe disposal options, they have nonetheless been included to highlight their disadvantages and as these practices might be applied at the onset of emergencies due to the lack of suitable alternatives.

Solid Waste Products

Solid waste products refer to the wide range of different domestic solid waste streams generated in a humanitarian context (often also referred to as primary products) and the various products generated as part of the SWM process (so-called secondary products). For the design of a robust SWM service chain, it is necessary to identify all the products that are flowing into (inputs) and out of (outputs) each of the technologies of the chain. The various products are described in **Figure 1**. Liquid waste, such as human excreta and wastewater, is intentionally not included and should never enter the SWM service chain.

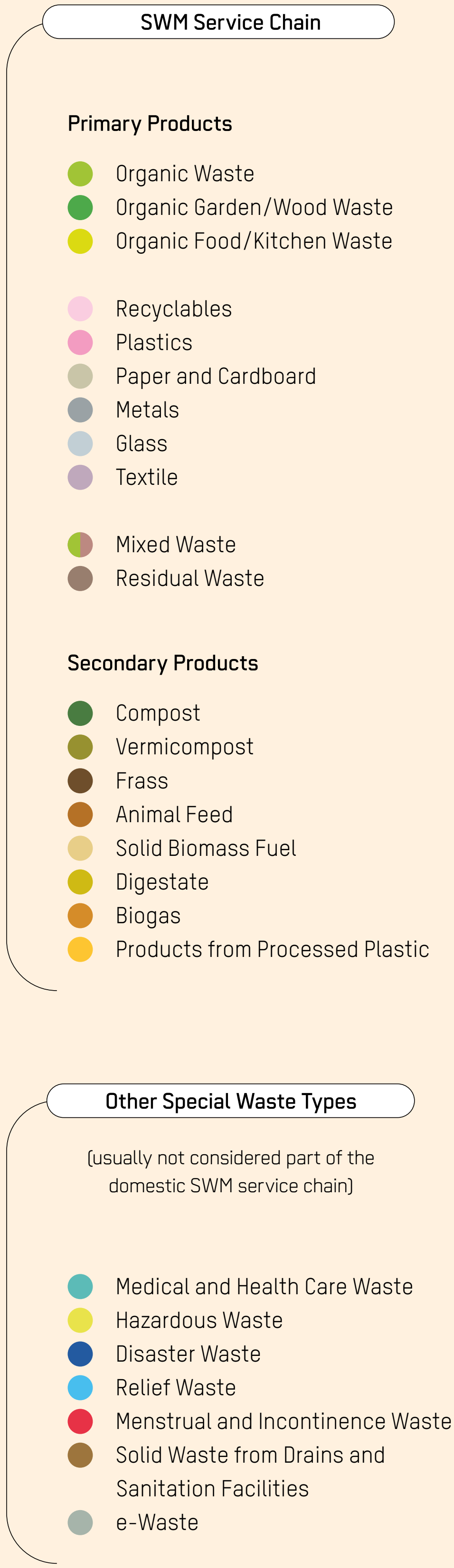


Figure 1:
SWM Waste Types

Primary Products

Organic Waste: refers to any organic matter that can be broken down by microorganisms into their constituent elements and compounds. It commonly consists of plant and animal matter, kitchen waste (such as food scraps, trimmings and spoiled food) and food market waste. It can be decomposed during aerobic and anaerobic processes and transformed into valuable resources like biogas **(T.3)**, compost **(T.1)**, fuel **(T.5)** or animal feed and frass **(T.4)**. Using processed organic waste in agriculture **(U.5)** enables the recirculation of nutrients and carbon for plant growth. Organic materials which take longer to decompose, such as wood or bamboo, can be used to produce solid fuels **(U.7)**. Separating and processing organic waste helps to reduce the volume of waste sent to disposal sites and reduces the emission of flammable and greenhouse gases from deposited waste. It contributes to more environmentally friendly waste management practices and to reducing public health risks. Organic waste can be further differentiated into fast-degrading Organic Food/Kitchen Waste and slower-degrading Organic Garden/Wood Waste (see detailed description below). Organic waste is often also referred to as "biodegradable waste".

Organic Garden/Wood Waste: refers to the slower-degrading fraction of organic waste that is generally more fibrous than food waste. It commonly consists of bamboo, nut shells, sawdust, agricultural residues, twigs, branches and (untreated) timber and construction wood. It has a high carbon content, which makes it an important component in composting **(T.1)** and vermicomposting **(T.2)** for balancing the carbon-to-nitrogen (C:N) ratio and is a valuable source for producing solid biomass fuel **(T.5)**.

Organic Food/Kitchen Waste: refers to any fast-degrading organic matter that can be broken down by microorganisms into their constituent elements and compounds. It commonly consists of food scraps, trimmings, leftover and spoiled food, and food market waste. It is rich in nutrients, particularly nitrogen, phosphorus and potassium, making it suitable for composting **(T.1)** to produce nutrient-rich compost. It can be decomposed during aerobic and anaerobic processes and transformed into valuable resources like biogas **(T.3)**, compost **(T.1)**, or animal feed and frass **(T.4)**. Using processed organic food/kitchen waste in agriculture **(U.5)** enables the recirculation of nutrients for plant growth. Separating **(PART 1: Waste Separation)** and processing organic waste helps to reduce the volume of waste sent to disposal sites, reduces the emission of flammable and greenhouse gases from deposited waste and contributes to more environmentally friendly waste management practices **(X.8)**.

Recyclables: are mainly non-biodegradable materials that can be collected, processed and reused to create new products. Recycling these materials involves sorting, cleaning and processing them so that they can be used as raw materials to produce new goods. Recycling indicates that the produced new goods have comparable material properties and functions as the original material. The reuse of materials to produce items with reduced material properties is termed 'downcycling' **(T.8)**, while 'upcycling' **(T.7)** describes the artistic and creative reuse of waste materials with the potential to increase their quality or value. Recycling waste is a key component of SWM, helping to conserve natural resources, reduce energy consumption and decrease the environmental impact associated with the extraction and production of new materials. Recyclable waste typically includes paper and cardboard, glass, metals, plastics or textiles (see detailed description below). However, whether a material can be categorised as "recyclable" depends on the location, as recycling is driven by regulatory requirements and economic interests. While it may be technically feasible to recycle the above-mentioned materials, the recycling infrastructure and service chain may not be in place in a particular location.

Plastics: refers to synthetic or semi-synthetic material made from a wide range of organic polymers. Different plastic types are distinguished by their polymers, including Polyethylene (PE), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), and various others. If a plastic item only consists of one plastic type, it is potentially recyclable. The feasibility, complexity and economic incentive to recycle depends on the plastic type and cleanliness of plastic waste. If plastics are mixed with other materials, such as metal coating or cardboard, they are considered composite materials. While the recycling of composite materials might be technically feasible, it might not be of economic interest, and composite materials are therefore commonly considered non-recyclable. Plastic waste includes plastic packaging, bottles, containers and other products made from plastic materials. Plastic waste poses environmental challenges due to its persistence and potential for pollution. Recycling involves collecting, sorting and processing plastic waste to manufacture new plastic products.

Paper and Cardboard: encompasses products from cellulose fibres such as cardboard or paper packaging, newspapers, magazines or office paper. Processed cellulose fibre originates from wood, grasses or other plant sources. However, as paper or cardboard also contains non-biodegradable auxiliary materials (such as colour pigments, glue or lamination), they are not commonly listed as biodegradable materials. Paper or cardboard is considered recyclable waste that can be collected, processed and reused to create new products. The recycling of paper and cardboard is a common practice, and these materials are often collected separately from other waste streams to facilitate the recycling process.

Metals: refer to a range of materials which are made completely or mostly of metal material such as copper, aluminium or iron. Metal waste includes items such as aluminium cans, steel packaging and scrap metal from construction or manufacturing processes. Metals are valuable materials that can be recycled repeatedly without significant loss of quality. The recycling of metal waste involves collecting, sorting and processing these materials for reuse in manufacturing new metal products.

Glass: refers to a solid, brittle and often transparent material. Silica is commonly its main component and the main glass-forming constituent, but depending on function and colour, glass can also contain other constituents such as soda, lime, metals and other fining agents. Glass waste includes used glass bottles, jars, containers, or other consumer products made of glass. Glass recycling can be conducted with both intact and broken glass items. It involves the separate collection of used glass and its melting to produce new glass products. Different glass colours and glass types, which are used for different functions and contain different additives (e.g. glass used as beverage containers, window glass, or laboratory glass), may need to be collected separately.

Textile: refers to materials made from natural or synthetic fabrics. Textile waste includes worn-out clothing, household textiles and manufacturing scraps. Recycling initiatives often focus on collecting and processing textile waste for reuse, either through transforming textiles into new products or converting them into fibres for use in various applications.

Mixed Waste: refers to a combination of various types of waste materials that are commingled and disposed of together and that are difficult to separate. This waste stream typically includes a mixture of biodegradable, non-biodegradable, recyclable and non-recyclable materials. Mixed waste may include a diverse range of items such as food scraps, paper, plastics, glass, metals and other miscellaneous waste. Managing mixed waste can be challenging because the separate handling of different waste components is not possible unless labour-intensive sorting is done. Hence, effective waste management strategies aim to encourage source segregation, with the separation of recyclable and biodegradable materials from non-recyclables, reducing the complexity and environmental impact of mixed waste disposal **(PART 1: Waste Separation)**. The advantage of the initial source segregation is that reusable and recyclable resources are not soiled by the entire waste matrix. This simplifies their further processing and commonly leads to higher prices for the sale of recyclables. A specific form of mixed waste is litter, which is small pieces of rubbish or discarded items that are improperly disposed of in public places. Litter commonly includes items such as food wrappers, cigarette butts, beverage containers and other small items left in outdoor areas, parks, streets, or public spaces. It is also prone to end up in drainage and stormwater systems and can lead to blockages or reduced drainage efficiency.

Residual Waste: refers to the waste that remains after materials that can be reused, recycled or composted have been separated and removed. It includes items that are typically disposed of in landfills or incinerated in municipal waste incineration plants. Residual waste encompasses a variety of materials, such as composite plastics, mixed waste and other items that are challenging to recycle or do not have established recycling markets. Reducing the generation of residual waste through waste minimisation and recycling efforts is a key goal in sustainable waste management practices. Waste-to-energy technologies are sometimes employed to generate energy from the incineration of this waste. However, this approach is mainly found in high-income settings as municipal waste incineration is expensive, complex and high maintenance and the generated energy is costly compared to other energy sources.

Secondary Products

Compost: refers to decomposed biodegradable matter that results from a controlled aerobic degradation process **(T.1)**. In this biological process, microorganisms (mainly bacteria and fungi) decompose the biodegradable waste components and produce an earth-like, odourless, brown/black material. Compost has excellent soil amendment properties and a variable nutrient content. Because of leaching and volatilisation, some of the nutrients may be lost, but the material remains rich in plant-available micro and macronutrients and organic matter. Generally, the composting process should be long enough (2 to 4 months) under thermophilic conditions (55 to 60 °C) to sanitise the compost sufficiently for safe agricultural use. Vermicompost: refers to a type of compost produced through the breakdown of organic waste by earthworms. In this process **(T.2)**, earthworms consume organic materials such as food scraps, agricultural residues and other biodegradable waste. As they digest this material, the worms produce castings or worm excrements rich in nutrients and beneficial microorganisms.

Animal Feed: either refers to nutritious biodegradable waste, ideally free from impurities and pathogens, for animal nutrition. Alternatively, it can refer to the indirect usage of biodegradable waste, for instance, the usage of Black Soldier Fly (BSF) larvae grown on biodegradable waste **(T.4)**. Animal feed derived from solid waste contains nutrients such as protein, carbohydrates, fats, vitamins and minerals and can be produced from biodegradable solid waste such as food waste, crop residues, food processing waste or animal manure.

Frass: refers to the waste products or excrement produced by insects, particularly larvae that feed on plants or organic material **(T.4)**. It is rich in nutrients and organic matter which are beneficial to plants. It is typically used as a fertiliser or soil amendment and can help improve soil health by adding organic content and beneficial microbes.

Solid Biomass Fuel: mainly derives from biodegradable garden/wood waste that has a higher cellulose content such as wood, bamboo, nut shells, sawdust and agricultural residues. While larger pieces of wood or bamboo can be directly used as fuel, smaller and more dense or powdery materials will burn less efficiently or not at all. These biomass wastes can be processed into pellets or carbonised or non-carbonised briquettes **(T.5)**. To produce pellets, crushed biomass is pressed into small granules with the natural lignin acting as a binder. For carbonised briquettes, biomass waste is transformed into charcoal, crushed into charcoal powder and compacted into briquettes with the use of additional binding agents. For non-carbonised briquettes, crushed biomass is directly mixed with binding agents and compressed. It is important to note that many of the stoves used to burn biomass fuels do not lead to clean cooking according to guidelines of the World Health Organization. The only exception might be the fan-based pyrolysis of biomass pellets in specialised stoves.

Biogas: is the common name for the mixture of gases released from the anaerobic digestion **(T.3)** of organic material. Biogas comprises methane (50 to 75 %), carbon dioxide (25 to 50 %) and varying quantities of nitrogen, hydrogen sulphide, water vapour and other components, depending on the material being digested. Biogas can be collected and burned for fuel.

Digestate: is a by-product that remains after the anaerobic digestion **(T.3)** process, in which organic material is broken down by microorganisms in the absence of oxygen into biogas (a mixture of methane and carbon dioxide) and digestate. The digestate is a nutrient-rich slurry that typically includes organic matter, macronutrients such as nitrogen, phosphorus, potassium and micronutrients beneficial to soil health. The composition of digestate can vary depending on the type of feedstock used in the anaerobic digestion process. It can be used as a fertiliser, or soil conditioner or can be further composted.

Products from Processed Plastic: both single-type and composite plastic waste used in plastic bottles, containers, packaging materials and single-use items can be used to produce a wide range of new products. Three different approaches to plastic processing exist, and they differ in the properties, functionality and value of their end-products compared to the initial material. Recycling refers to the process where the end-product is of similar value and functionality as it originally was (e.g. using waste plastic items to make new plastic items); it is limited to single-type plastic waste. Upcycling **(T.7)** refers to a higher value end-product and downcycling **(T.8)** leads to an end product with lower value and functionality. Both upcycling and downcycling can use single-type and composite plastic waste, depending on the type of process. Recycling, and in some cases downcycling, requires the thermal modification of the raw material. It includes sorting, cleaning, shredding, melting and forming into granules and the moulding of granules into new products (by extrusion moulding, injection or compression moulding). Thermal modification must always be limited to single-type plastic waste. For downcycling, plastic waste might be mixed with other substances, such as sand, before thermal modification.

Other Specific Waste Types

Medical and Health Care Waste: refers to waste materials generated by health care activities (such as waste produced in hospitals, clinics, dental practices, veterinary clinics, medical research facilities and laboratories). It also includes domestic-like waste that can be separated and managed as part of domestic or municipal SWM. Medical and health care waste includes a wide range of materials, some of which are hazardous to human health and the environment if not properly managed. It may include infectious waste, sharps, needles, syringes and other sharp objects, pathological waste and pharmaceutical, chemical and/or radioactive waste that must be managed separately **(W.1)**. In addition, medical and health care facilities produce domestic-like waste that can be separated and managed as part of the domestic or municipal SWM service chain.

Hazardous Waste: refers to waste that contains materials posing a potential threat to human health or the environment. These materials often exhibit the characteristics of toxicity, flammability, corrosiveness or reactivity. Examples of hazardous household waste include certain cleaning products, paints, solvents, pesticides, batteries and electrical and electronic devices. The proper disposal of hazardous domestic and municipal waste is essential to prevent environmental contamination and to protect the health and safety of waste handlers and the public **(W.2)**.

Disaster Waste: includes all solid and liquid waste generated from a natural disaster or conflict, both during the event itself as well as in the emergency response and recovery phases. It is characterised by typically large waste quantities, a mixture of various waste types and a strongly intertwined waste matrix, which further complicates its management **(W.3)**. It can include debris from damaged buildings and infrastructure, vehicles, hazardous substances, e-waste, unmanaged medical waste and domestic solid waste.

Menstrual and Incontinence Waste: refers to discarded items used for managing menstruation or incontinence, including products such as sanitary pads, tampons, panty liners and infant and adult diapers. This waste stream poses unique challenges due to the nature of the materials involved. Managing this waste requires both hygiene considerations and environmental impact to be addressed, as improper disposal can contribute to pollution and sanitation issues. Waste management practices for menstrual and incontinence products include dedicated collection systems, exploring environmentally friendly treatment options such as composting or recycling where feasible, and safe disposal methods. Public awareness and education are essential components of responsible waste management in this context **(W.4)**.

Relief Waste: refers to all waste generated by humanitarian relief operations, often also referred to as humanitarian waste **(W.5)**. This includes the waste generated by the humanitarian services provided, such as food waste, packaging materials, shelter waste and other Non-Food Items, and waste from the organisations' functional services in offices, guest houses, warehouses and vehicle workshops.

Solid Waste from Sanitation Facilities and Drains: refers either to waste that has been directly discarded into sanitation systems (such as pits or septic tanks) or to solid waste and litter discarded in public spaces or streets that eventually accumulates in stormwater lines and drainage systems where it can lead to blockages, overflow, clogging of pipes and channels or stagnant water pools. The accumulation of solid waste in sanitation facilities is often due to a lack of other waste collection and management options. It can be comprised of a wide range of materials, including biodegradable matter (such as food waste), non-biodegradable materials (such as plastics, paper, glass, and metals), sanitary products (menstrual products or diapers), or debris. The removal of solid waste from sanitation facilities takes considerable effort (e.g. the manual removal from pits to facilitate proper pit emptying or waste screens in faecal sludge treatment plants). It contains a high faecal pathogen load, which requires corresponding treatment. Solid waste in drains may also consist of a wide range of materials, including biodegradable matter (such as food waste, leaves, and plant debris), non-biodegradable materials (such as plastics, paper, and metals), sediment, silt, sand and other debris. It may contain contaminants such as oils, grease, chemicals, pathogens and other pollutants, which can pose risks to human health and the environment if not properly managed **(W.6)**.

e-Waste or Waste from Electrical and Electronic Equipment (WEEE): refers to discarded or obsolete electrical or electronic devices and appliances. E-waste includes a wide range of items such as computers, mobile phones, household appliances, lamps, photovoltaic panels and other electrical and electronic equipment. Due to the presence of toxic materials like heavy metals, e-waste must be considered as hazardous and posing a risk to public health and the environment; its safe recycling and disposal are critical. E-waste can also contain valuable commodities, including rare-earth metals, copper or gold. These can be recycled and reused if the waste is effectively managed. Improving the collection, treatment and recycling of electrical and electronic equipment at the end of their life can increase resource efficiency and support the shift to a circular economy **(W.7)**.

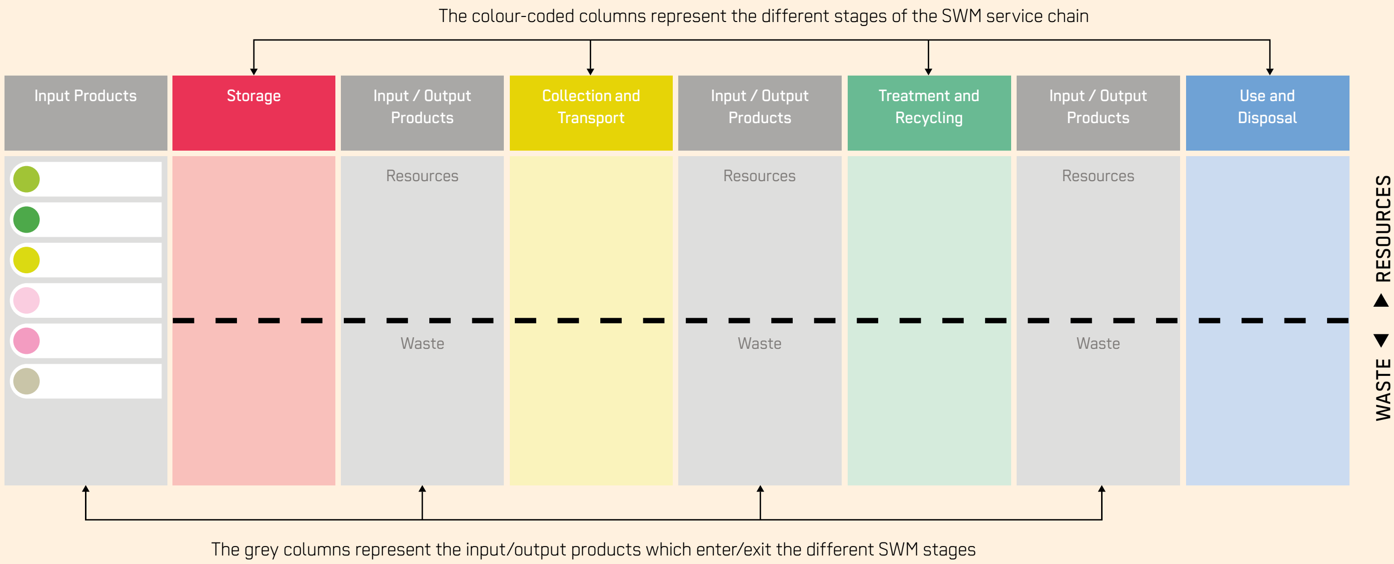
The SWM Service Chain Template and Implementation Guidance

A SWM service chain can be visualised as a matrix of the SWM stages (columns) and the products (rows) that are linked together where potential combinations exist (**Figure 2a**). The matrix provides an overview of the SWM system's technology components and the products that it manages. The graphical presentation further allows for a horizontal differentiation between resource products (upper part) and waste products (lower part).

In an SWM system, different waste/resource products are successively stored, collected, transported and potentially transformed along different compatible technologies from the four stages of the service chain. The output of a technology at one stage of the system becomes the input for the next. A product may not need to pass through a technology from each of the four stages; however, the ordering of the service chain stages should usually be maintained regardless of whether they are included within the SWM system. 'Collection and Transport' is the only functional stage where the same product can go through several technologies, leading to a vertical cascade. This is, for instance, necessary if the same product is consecutively transported between different transfer stations by different transportation means, or if transported products are pre-processed before 'Treatment and Recycling' or 'Use and Disposal'. The focus on defining transport means has intentionally been placed on the initial collection of waste. For the sake of simplicity, potential additional transports such as those after 'Treatment and Recycling', are omitted in the template.

Figure 2a (above):
SWM system template

Figure 2b (below):
Example case how the SWM system template can be used



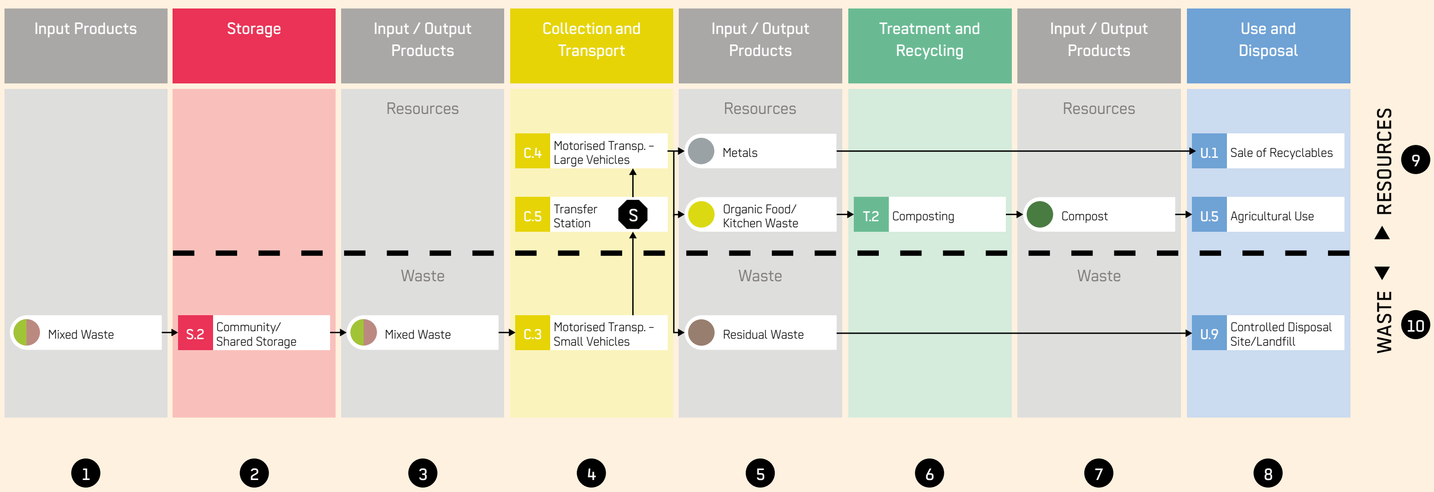


Figure 2b is a simplified example of a potential SWM system configuration. It shows how a product (in this case, mixed waste) enters an SWM system and is managed using different technologies along the service chain, moving from left to right through the sections ❶–❽ of the system template.

❶ Mixed waste enters the system as an input to ❷ the 'Storage' section (in this example Community/Shared Storage **S.2**). The stored mixed waste ❸ then enters the ❹ 'Collection and Transport' section (here Motorised Transport – Small Vehicles **C.3** leading to a Transfer Station **C.5**) where the mixed waste is sorted into ❺ metal, organic material and residual waste and then transported further (with Motorised Transport – Large Vehicle **C.4**) either in separate vehicles or one vehicle with different compartments. The organic material is then subjected to a Composting **(T.1)** process in the 'Treatment and Recycling' section ❻ and converted into compost ❼. In the final 'Use and Disposal' section, the segregated metal is sold to local recycling traders **(U.1)**, the compost is used in agriculture **(U.5)** and the remaining residual waste is disposed of in a Controlled Disposal Site **(U.9)**.

The horizontal dotted line also helps to visually differentiate between input/output products that either become ❾ resources again that can be meaningfully used (in this example, the metal and compost generated from organic material) or remain as ❿ waste products (the residual waste fraction in this example).

An essential element in the SWM service chain is waste separation (including waste segregation and waste sorting) **(PART 1: Waste Separation)** which can take place at different stages of the chain. In the **Figure 2b** example, it is taking place at the Transfer Station **(T.5)** shown by the symbol Ⓢ where the mixed waste is segregated into recyclable metals, organic food/kitchen waste and the remaining residual waste.

The following steps are recommended to determine the best SWM options for specific contexts:

- Make a baseline assessment of the initial situation **(PART 1: Assessment)** including the assessment of waste composition and quantity, the identification of practices and preferences of the user groups to be served, the context-related conditions and challenges, the existing infrastructure and services in the area, relevant stakeholders and potential partners and the institutional and regulatory environment **(X.1)**.
- Identify the input products that are generated. Based on the technology overview provided by the Technology Information Sheets **(pages 40–125)**, identify technologies that are potentially appropriate for each stage of the SWM service chain and identify their respective input/output products. Parts of a system may already exist and can be integrated.
- It may also be advisable to outline several potential SWM scenarios using several SWM service chain templates with different combinations of technologies, including their input/output products at each stage of the SWM service chain. The systems can then be compared and individual technologies iteratively changed based on, for example, user priorities, time pressure, operation and maintenance requirements, the demand for specific end-products (e.g. compost), economic constraints and technical feasibility.
- A blank system template can be downloaded from **www.emergency-wash.org**, printed and used to sketch site-specific SWM systems, for example, when discussing different options with experts or stakeholders in a workshop.

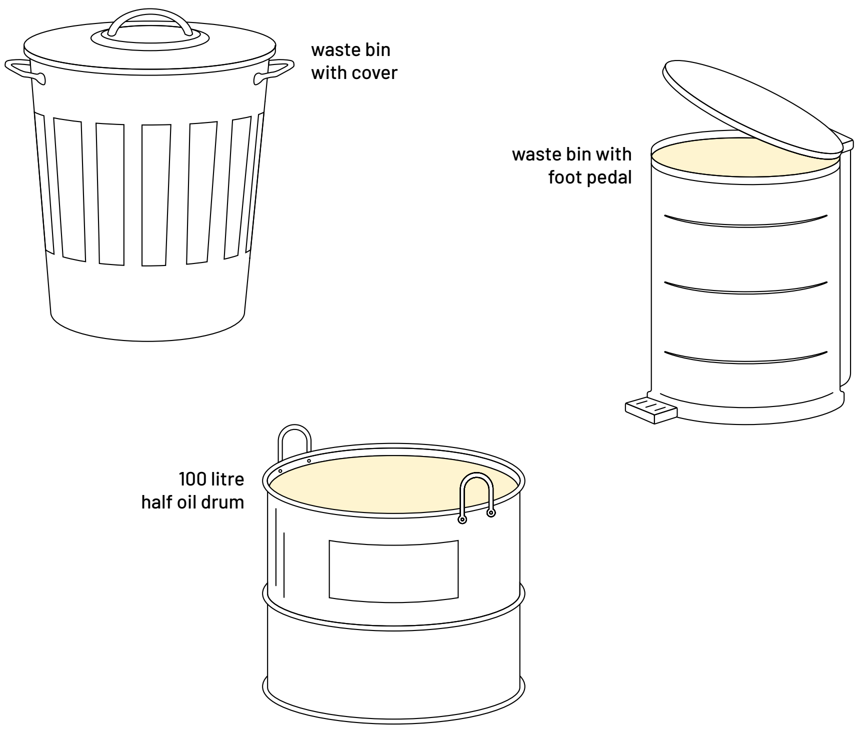
Using the Technology Sheets for Decision Making

Selecting the most appropriate set of SWM technologies for a specific context is challenging and requires considerable experience. The key decision criteria **(see Figure 3 and detailed description on the following pages)** offer the Compendium user general guidance on technology selection and the overall design of an SWM system. Each technology information sheet **(PART 2)** uses the decision criteria and structure described below.

Figure 3:
Generic Structure of the
Technology Information Sheet

Name of the Technology

Response Phase ❶	Application Level ❷	Management Level ❸	Key Objectives ❹	Prerequisites ❺
Acute Response * Stabilisation * Recovery ** Protracted ** Development	* Individual / Household ** Community / Municipality ** Institution ** Urban * Rural	** Household Shared Public	Key features and functions of the technology	Preconditions that need to be in place for the technology to be effective and applicable
Space Required ❻	**Technical Complexity ❼**	**Link to other Actors ❽**	**Input Products ❾**	**Output Products ❿**
*** High ** Medium * Low	*** High ** Medium * Low	Indication where cooperation and collaboration with other actors may be required	Products going into a certain technology (e.g. Organic Waste or Plastics)	Products coming out of a certain technology (e.g. Mixed Waste or Compost)



Technology Description	⓯ Health and Safety
⓫ Design Considerations	⓰ Costs
⓬ Materials	⓱ Social Considerations
⓭ Applicability	⓲ Strengths and Weaknesses
⓮ Operation and Maintenance	⓳ References and Further Readings

❶ Response Phase

This section indicates the response phase for which the technologies are appropriate. Their suitability is characterised for the five phases (described in more detail in **Response Phases and Implication for SWM**):

- **Acute Response**
- **Stabilisation**
- **Recovery**
- **Protracted Crisis**
- **Development**

An indication of whether a technology is suitable in the different phases is given using asterisks (**two asterisks**: suitable, **one asterisk**: less suitable, **no asterisk**: unsuitable). The level of appropriateness is decided on a comparative level between the different technologies, mainly based on applicability, speed of implementation and material requirements. Determining the applicable emergency phase for a context of interest is up to the Compendium user.

❷ Application Level

The application level describes the different spatial levels for which the technology is most appropriate. It is subdivided into the following levels:

- **Individual/Household** (applicable for one up to several individual households)
- **Community/Municipality** (applicable for serving several households, an entire settlement, camp or district)
- **Institution** (applicable for serving an entire institution, school, business or market)
- **Urban** (applicable in densely populated areas)
- **Rural** (applicable in less populated areas)

An indication of whether a technology is suitable at a specific spatial level is made using asterisks (**two asterisks**: suitable, **one asterisk**: less suitable, **no asterisk**: unsuitable). Determining the appropriate application level for a context of interest is up to the compendium user.

❸ Management Level

The management level describes where the main responsibility for operation and maintenance (O & M) for a specific technology lies:

- **Household:** all O & M related tasks can be managed by the individual household
- **Shared:** a group of users are responsible for O & M by ensuring that a person or a committee is in charge on behalf of all users. Shared facilities refer to a self-defined group of users who decide who is allowed to use the facility and what their responsibilities are
- **Public:** government, institutional or privately run facilities: all O & M is assumed by the entity operating the facility

An indication regarding the appropriateness of each management level is given using **zero to two asterisks**, with two asterisks meaning that the technology can be well handled at the respective level and zero not at all.

❹ Key Objectives

This section gives a concise indication of the main features and functions of the specific technologies. It also provides general guidance for the immediate evaluation and classification of technologies and their suitability for an envisioned application or context.

❺ Prerequisites

This section indicates the preconditions that need to be in place for the technology to be effective and applicable. It includes aspects such as the purity of the input materials (sufficiently sorted, cleaned with no composite or mixed materials), whether waste needs to be segregated first for the technology to function, the need for community participation or the user demand of the final products.

❻ Space Required

This section gives a qualitative estimate of the space required for each technology, meaning the area or spatial footprint required by the technology. This can help planning in areas where space is a limiting factor. Asterisks are used to indicate how much space is needed for the given technology (**three asterisks**: much space required, **two asterisks**: medium space required, and **one asterisk**: little space required). The categorisation is based on a comparative approach between the different technologies and not in absolute terms.

❼ Technical Complexity

This section gives an overview of the technical and operational complexity of each technology, meaning the level of technical expertise needed to implement, operate and maintain the given technology. This can help planning where skills and capacities are limited or temporarily unavailable. Asterisks indicate the technical complexity of the given technology (**three asterisks**: high complexity, **two asterisks**: medium complexity, and **one asterisk**: low complexity). Low technical complexity means that no or minimal technical skills are required to implement, operate and maintain a technology: it can be done by non-professionals and artisans. Medium technical complexity means that certain skills are required either for implementation or O&M. Skilled artisans or engineers are required for the design and O&M of such a technology. High technical complexity means that an experienced expert, such as a trained engineer, is required to implement, operate and maintain a technology sustainably. The categorisation is based on a comparative approach between the different technologies and not in absolute terms.

❽ Link to Other Actors

This section indicates where cooperation and collaboration with other actors may be required. It may include links to the host communities, private sector actors, utilities, or the necessary coordination with other humanitarian sectors (such as camp coordination and camp management, shelter, or agriculture).

❾ Input Products

Different technologies are required for the management of different inputs and the generation of specific outputs. Therefore, when selecting technologies, consider the input products that must be managed and the desired output products. This section lists the input products that typically flow into the given technology.

❿ Output Products

This section lists the output products that typically flow out of the given technology.

⓫ Design Considerations

Key design considerations are described in this section, including general sizing, space requirements and other features. This section does not cover the detailed design parameters that allow the complete implementation of a technology but gives an idea of the dimension features to consider and the main potential pitfalls to be aware of when designing and implementing the technology. This section helps the Compendium users understand a given technology's technical design and complexity.

⓬ Materials

This section lists the different materials and equipment required for the construction, operation and maintenance of a given technology. It indicates whether materials are likely to be locally available or producible (e.g. wood and bricks) or whether materials will need to be imported or require special manufacturing, which will considerably delay implementation during an emergency. The materials section also indicates whether a technology can be prefabricated as a unit to speed up implementation.

⓭ Applicability

Applicability describes the contexts for which a technology is most appropriate. This section indicates a technology's applicability in terms of type of setting, distinguishing between rural or urban, short or longer-term. The section also describes the phases of an emergency in which a technology can be implemented and provides information on the potential for replicability, scalability and the speed of implementation.

⓮ Operation and Maintenance

Every technology requires O & M, more so if it is used over a prolonged period. The O & M implications of each technology must be considered during initial planning. Many technologies fail due to a lack of appropriate O & M. In this section, the main operation tasks that must be considered and the maintenance required to guarantee longer-term operation are listed. The section differentiates between different O & M skills and provides an indication of the frequency of O & M tasks and the time required to operate and maintain a technology. A list of potential misuses and pitfalls to be aware of is also provided.

⓯ Health and Safety

Most SWM technologies have health and safety implications. The health implications or risks described in this section should be considered during planning to reduce health risks in the local community and among staff. The health and safety section also describes overall risk management procedures, which can lead to decisions to exclude a technology if safety cannot be guaranteed. Where relevant, the personal protective equipment needed to guarantee personal safety is listed.

⓰ Costs

Each technology has costs associated with construction, operation, maintenance and management (including the cost implications for other technologies along the SWM chain). Costs are geographically dependent and cannot be described in absolute numbers. Hence, this section presents the main cost elements associated with a technology and a price range where possible, allowing for a first approximation.

⓱ Social Considerations

Social considerations are important when deciding on specific SWM technologies, especially at the user level. Potential cultural taboos, user preferences and habits as well as local capacities may be challenging, impossible or inappropriate to change. An SWM technology needs to be accepted by/acceptable to the users and the personnel operating and maintaining it.

⓲ Strengths and Weaknesses

This section concisely summarises the main strengths and weaknesses, supporting the decision-making process. A technology's weaknesses might indicate that an exclusion criterion is fulfilled and a technology is not suitable for a specific context. Both strengths and weaknesses can be effectively used to inform the decisions of users and all those involved in the planning and implementation of the SWM system.

⓳ References and Further Readings

This section refers users to specific pages of a detailed bibliography included in the annexe to the Compendium. The bibliography is a compilation of the most relevant SWM publications sorted by chapter with a short description for each listed publication. Users can use the publication list to find additional relevant information (e.g. design guidelines, research papers, case studies) on specific technologies.

What is Solid Waste Management?

Appropriate SWM refers to a controlled and strategic approach to the sustainable management of solid wastes. It entails progressing towards environmentally sound management for all waste – covering all sources of waste generation and all aspects of the service and resource value chain, including waste avoidance, reduction, generation, segregation, collection, transfer, transport, sorting, treatment, recycling, recovery and disposal. Solid waste management is a cross-cutting issue which impacts many global challenges such as health, environmental degradation, climate change, poverty reduction, food and resource security and sustainable production and consumption.

But what is waste? Solid waste is any solid, discarded material generated from human activities. Waste becomes waste when the person discarding it has no further use for it, irrespective of whether it has use or value to others. There are different ways of categorising solid waste. A common starting point is to differentiate waste by its source, i.e. the location or entity generating the waste. For example, household waste encompasses different materials discarded by household members. A wider category is 'Domestic Waste' or 'Municipal Solid Waste' (MSW) – both describe the different sources and types of solid waste generated in a settlement. Domestic Waste includes discarded materials from households, commerce, schools, offices and public spaces. Domestic Waste may even include waste from small industry, construction and demolition debris or agricultural waste generated in the settlement area. This Compendium focuses on humanitarian Domestic Waste: the generation and management of wastes from households, commerce, schools, offices and public spaces linked to a humanitarian crisis and humanitarian aid, or to the aid response itself.

Waste can be further categorised by its type. For example, organic waste from households or restaurants typically consisting of easily biodegradable organic material is described as organic food/kitchen waste. Slower degrading cuttings from trees and bushes are also organic and may also originate from the household but would be described (and managed) as organic garden/wood waste. Other examples of such product type descriptions are e-Waste **(W.7)**, or Hazardous Waste **(W.2)**.

The next level of detail in describing waste is its specific material composition, for instance differentiating between the types of waste plastics in packaging waste or the substances contained in e-waste.

The amount and characteristics of solid waste can vary considerably between emergency phases, communities and nations depending on consumption patterns, income and lifestyle.

Integrated Sustainable Waste Management (ISWM)

Developing a waste management system is complex. In addition to infrastructure, technology, equipment and operations, SWM interacts with and depends on numerous, diverse actors with different behaviours and perceptions. To be sustainable in the long term, consideration needs to be given to:

The physical elements (infrastructure and equipment) of the system along the entire SWM service chain: from waste generation through storage, collection, transport, transfer, recycling, recovery, treatment and disposal. This includes appropriate infrastructure, technology and equipment which is 'fit for purpose' and that is operated and maintained according to best practice, to ensure reliable and safe service for all. These physical elements are described in more detail in **PART 2** of the Compendium.

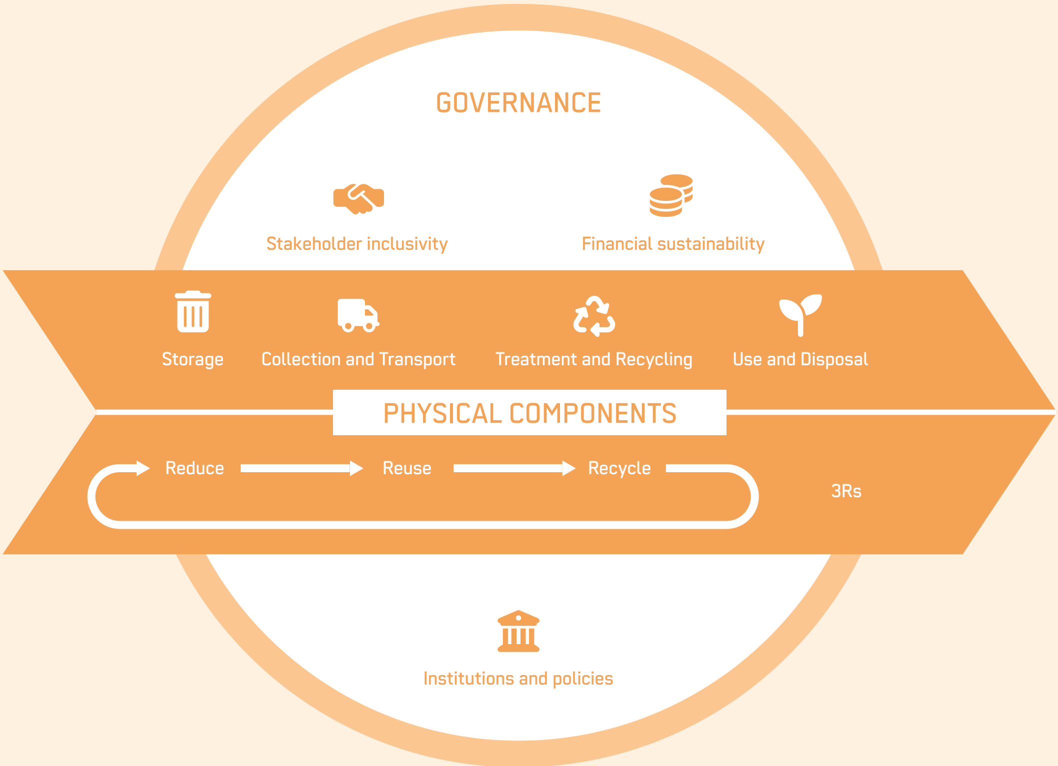
The stakeholders (actors), who include local, regional and national governments, waste generators/service users (households, commerce and institutions), manufacturers of the consumer goods which become waste at the end of their life, service providers (public or private sector, formal or informal, large or small), civil society and national non-governmental organisations, those outside the affected community impacted by the SWM process and international aid agencies.

Institutional and legislative aspects, i.e. adhering to national or international strategy, policy and political goals such as specific technology solutions endorsed for waste treatment and the avoidance of certain products and materials.

Financial and socio-economic aspects require the system to be cost-effective, affordable and well-financed. In addition to capital expenditure, attention must be paid to how ongoing operational expenditures will be covered.

The Monitoring **(X.3)** of key performance criteria is often overlooked but is essential to operate an efficient SWM system and understand how the service interacts and performs with respect to the above issues. Monitoring starts with a careful assessment **(PART 1: SWM Assessment)** of the baseline conditions in which the service is established.

Figure 4:
Integrated Solid Waste Management (ISWM)



Why Solid Waste Management?

In all phases of humanitarian response, whether acute response, protracted crisis or even in transition to development, safe SWM is a crucial element of the protection of affected communities and sustainable, healthy and inclusive living conditions for all. This priority is reflected in the UN resolution of the human right to a clean, healthy, and sustainable environment. It is addressed in various Sustainable Development Goals, including the 11th (sustainable cities and communities), the 12th (responsible consumption and production) the 14th (life below water) and the 15th (life on land). SWM is included with dedicated minimum standards in the Sphere Handbook, highlighted in the Climate and Environment Charter for Humanitarian Organizations and aligned with the Global Compact on Refugees.

Inadequate and unsafe SWM can have adverse effects on public health and the environment and affect the well-being, dignity and prosperity of communities. In humanitarian contexts and protracted crises, governments, in collaboration with humanitarian and development organisations, must aim to reduce and prevent the exposure of individuals, communities and the environment to risks and threats, which includes unmanaged solid waste. Further, the efforts of humanitarian actors must adhere to the 'Do No Harm' principle and not contribute intentionally or unintentionally to the existing instability, destruction and suffering **(Introduction: Principles and Standards)**. This demands action on waste prevention **(PART 1: Waste Prevention)** and the safe and adequate handling of solid waste.

Humanitarian contexts increase the already challenging provision of day-to-day waste management services in stable and peaceful contexts. Disasters or armed conflicts might disrupt regular waste services, reduce capacity for safe waste handling, or generate significant amounts of additional waste. A sudden increase in service recipients and generated waste volumes may overburden existing infrastructure and services. Rapidly growing temporary settlements may require the establishment of new or additional services.

In humanitarian response, SWM is still frequently under-prioritised through insufficient funding and because the lack of SWM is not considered an immediate threat to life. This is a misconception, as inadequate SWM can significantly increase the protection risks of affected communities that may already be vulnerable. Ensuring proper waste management is essential to ensure protection, maintain hygiene, prevent disease outbreaks and support the overall recovery and rehabilitation effort. As a public good service, it is essential that no one is excluded from SWM services. The negative effects of non-availability and non-use affect all individuals.

The level of risk due to a lack of SWM services depends on the quantity and composition of waste, the duration of the disrupted service and the likelihood that people are directly exposed to the waste or indirectly exposed to the waste's harmful effects. The likelihood of exposure is linked to population density, the location of the population, aspects of the waste system, environmental factors such as predominant winds and water resources, and geographical factors such as the topography. In locations with high population density and poorly managed waste, the risk that the population will be exposed to the adverse effects of waste increases. In cases of open and uncontrolled disposal **(U.10)**, public health and environmental risks extend beyond the initial location of waste disposal. Animals, wind and water can spread the waste in settlements and into the neighbouring environment.

The overall importance of SWM is reflected in five actions:

1

Protection of Public Health: Unmanaged waste can increase the prevalence of chronic diseases, pathogenic infections and the infestation of vermin. For example, open burning **(U.11)** and contained burning **(U.12)** emit highly toxic and carcinogenic substances (dioxins, polycyclic aromatic hydrocarbons) and short-lived climate pollutants (black carbon) that can cause severe respiratory and cardiovascular diseases and increase cancer risk. A lack of waste management can lead to stagnant water where several species of mosquitoes breed, transmitting diseases such as malaria, chikungunya, dengue and zika fever. Unmanaged waste can also attract and provide a breeding ground for other disease vectors, such as rodents. Uncollected waste in streets, open spaces and watercourses lead to the clogging of drains **(W.6)**, water stagnation and pollution, as well as flooding which results in the spread of water-borne diseases such as cholera or even the plague. Flooding can also damage infrastructure and lead to the direct loss of life. Uncollected waste in streets and open spaces may also pose a direct threat to people who come into contact with it and may suffer from cut injuries or skin diseases.

2

Prevention of Environmental Pollution and Degradation: Inappropriate SWM can introduce harmful substances into the soil, water bodies and the air. This contamination can lead to short-term, long-term or irreversible damage to the natural habitat and wildlife and may affect the human food chain. Pollution can be caused by the waste materials themselves, by water flowing through waste to contaminated streams (leachate) or from inappropriate handling of waste such as open and uncontrolled burning **(U.11)**. Uncontrolled open burning of waste releases persistent organic pollutants, which bioaccumulate in ecosystems with significant negative impact. Leachate from waste can contaminate surface and groundwater water bodies and contaminate soils. Plastic waste and its persistence over time have emerged as one of the global waste and resource management challenges of our time. The disintegration of plastics can release toxic additives or lead to the formation of microplastics. Unmanaged plastic waste can also cause deadly entanglements for animals and plastic pieces or microplastics are ingested by animals and accumulate throughout the natural food chain. While microplastics have been found in human food chains and even human blood, the health risks remain unclear.

3

Avoidance of Resource Depletion: A large part of the natural resources extracted to produce consumer goods are finite or limited. Resource extraction itself commonly comes with environmental risks and pollution. Linear consumption, where resources are used and discarded after their lifespan, increases the required resources and corresponding pollution. This dependency on, and need for, virgin resources can be counteracted by applying the principles of a circular economy and waste management strategies that prioritise reduction, reuse and recycling (3Rs) **(PART 1: Waste Prevention)**. Agricultural production extracts nutrients and organic matter from soils, reducing soil carbon over time and leading to soil degradation, including lower water retention and higher soil erosion. Organic waste recycling and its use in livestock and agricultural production can ensure that carbon and nutrients are recovered and re-enter the soil and food cycle. 3R strategies and their implementation not only contribute to a circular system but also reduce waste amounts requiring transport, treatment and disposal, alleviating the overall solid waste management challenge.

4

Maximising Peaceful Coexistence Between and Within Communities: The first three actions – protection of public health, prevention of environmental pollution and degradation and avoidance of resource depletion – need to be addressed so that all members of the affected communities benefit equally from SWM and equitably share its burden **(X.9)**. An uneven provision of services, or the protection of one part of a community at the expense of another, will not foster peaceful coexistence between or within communities. This is particularly important in humanitarian settings, where communities are already vulnerable, traumatised, exhausted and might struggle for their survival. It becomes even more essential in displacement settings, where suddenly different communities are living side by side. This may include refugees and host communities living side by side. Equitable and fair SWM can and must play its part in creating an enabling environment for peaceful coexistence. Providing SWM services creates employment and livelihood opportunities, for example, through 'cash for work' programmes, paid volunteers or regular employment. Recycling and resource recovery can also generate employment outside the SWM provider such as in the private recycling sector or for community-based organisations. Creating value from waste and making inexpensive raw materials locally available can support local economies. Good SWM also contributes to community well-being by living in a clean and well-managed environment and supports community cohesion.

5

Climate Change Mitigation: Waste also significantly affects the global climate, aggravating climate change. The open burning of waste **(U.11)** and the uncontrolled decomposition of high volumes of organic waste in dumpsites **(U.10)** generate greenhouse gas emissions. Methane from uncontrolled decomposition in dumpsites or black carbon from open burning are both short-lived climate pollutants, a group of pollutants that have a particularly high impact on climate change **(X.8)**.

→ **References and further reading materials for 'Why SWM?' can be found on page 173**

Response Phases and Implications for SWM

The design of humanitarian SWM must be adapted to the local context, the type of crisis and the current phase of an emergency. Common categories used to distinguish phases are **(1)** acute response, **(2)** stabilisation and **(3)** recovery. Depending on the type of humanitarian crisis, these phases might develop linearly with substantial overlaps, for example, after a natural disaster, or phases may display an erratic back-and-forth, especially between the first two phases, commonly found in armed conflicts.

Additional longer-term phases to consider are **(4)** protracted crisis and **(5)** development. Protracted crisis refers to situations where significant populations are acutely at risk over a prolonged period, such as during armed conflicts. The term might also be used for protracted displacement situations, which UNHCR defines as 'at least 25'000 refugees from the same country (...) living in exile for more than five consecutive years'. The development phase describes the shift from humanitarian aid towards development, which is longer-term, responds to systemic problems and is focused on economic, social and political developments.

The identification of these broad phases is helpful when planning assistance, whilst recognising that the division is theoretical and offers a simplified model of a highly complex situation.

Acute Response: this usually covers the period from the first hours and days of a crisis up to the first few weeks or months, when rapid, short-term and life-saving measures are implemented until more permanent or durable solutions can be found. Rapid humanitarian relief interventions immediately follow natural disasters, conflicts, epidemics/pandemics or further degradation of a protracted crisis. The purpose of these humanitarian interventions in the acute response phase is to secure and ensure the survival of the affected population and alleviate suffering. These humanitarian interventions are guided by the principles of humanity, neutrality, impartiality and independence. It usually takes time for external support agencies to mobilise; those affected typically deal with the emergency initially themselves.

Immediately after a crisis, hygiene and waste disposal are usually poor, so disease vectors like rodents and vermin can spread and breed rapidly. SWM is a crucial element during the acute response to prevent the spread of diseases and protect public health. SWM interventions usually start with a risk analysis identifying and prioritising the main public health concerns related to solid waste and the outlining of potential countermeasures. The risk analysis is usually based on a rapid assessment of the current status of SWM, which may include the type and volume of waste generated, existing SWM practices, the identification of potential (temporary) storage, containment and disposal sites, and the available means for waste collection and transportation **(PART 1: SWM Assessment)**. This risk analysis will determine the immediate needs for SWM infrastructure, equipment and personnel. Based on the initial assessment, and depending on the local context, acute response SWM interventions may include establishing clearly marked collection points (with waste segregation options where possible) **(PART 1: Waste Separation)** and setting up a system for the regular removal and transport of waste to disposal sites (or, in the unlikely case of source-segregated waste, to treatment and recycling sites) **(chapter: T)**. Ideally, waste can be deposited in existing properly functioning facilities. In the absence of suitable disposal facilities, temporary and, if possible, final disposal sites need to be rapidly identified and prepared to protect public health and the environment. Coordination with local authorities, humanitarian actors (intersectoral and cross-sector) and other relevant stakeholders is important to ensure a coordinated response to waste management.

Depending on the type of crisis and context, initial SWM interventions might require preparatory actions which likely do not involve traditional SWM actors. This can include the movement of debris for the provision of access **(W.3)**, the clearing of sites of non-explosive ordnance or the recovery of human remains. It is also possible that an initially limited SWM focus will lack the capacity to address the management of specific waste types with elevated risk potential, such as Medical Waste **(W.1)** or Hazardous Waste **(W.2)**.

Stabilisation: the stabilisation (or transition) phase usually starts after the first few weeks/months of an emergency and can last six months or longer. The focus now is increasing the service coverage, the incremental upgrade and improvement of temporary structures and ensuring the active participation and engagement of the affected population. After natural disasters or in crisis settings with an elevated risk of natural disasters, relevant pre-emptive resilience and Disaster Risk Reduction (DRR) measures should be implemented during the stabilisation phase. The active involvement and inclusion of affected communities in the design and execution of humanitarian interventions should start as early as possible **(X.2)**. Depending on the type of disaster and crisis, this inclusion could be initiated during the stabilisation phase, ensuring equitable consideration of the needs of women, children and marginalised and vulnerable groups in the planning, decision-making and local management of SWM solutions. In addition, awareness-raising about proper waste management practices or encouraging participation in clean-up efforts may be required as well as the provision of targeted information on waste separation, disposal and potential health risks **(X.6)**.

Participation helps to ensure that the entire affected population has safe and adequate access to SWM services and practices corresponding behaviours. Additional in-depth assessments **(PART 1: SWM Assessment)** of the factors underpinning behaviours may be needed to respond adequately within a given local context and increase the longer-term acceptance of the planned interventions. The effectiveness of the initial interventions and the environmental impact of SWM activities (to prevent pollution and ensure compliance with regulatory standards) need to be monitored and should also lead to adaptations and improvements in the response where required **(X.3)**. SWM interventions may include the establishment of additional community-supported structures and, where possible, the increasing involvement of development actors. The scope for using Market-Based Programming (MBP) should also be examined **(X.5)**.

Recovery: the recovery phase, sometimes referred to as the rehabilitation phase, aims to recreate or improve the pre-emergency situation of the affected population by increasingly incorporating development approaches and principles. This phase usually starts after, or sometimes during, acute relief or stabilisation interventions (usually >6 months) and can be viewed as a continuation of completed relief efforts. Overall, it can prepare the ground for longer-term development interventions and for handing over to medium and long-term partners. In general, recovery should consider the implementation of durable solutions and the concept of build-back-better. Depending on local needs, the general timeframe for recovery and rehabilitation interventions is usually between six months and three years. Difficult and complex situations, such as conflict-affected areas, may need much longer and can move in and out of crisis.

Recovery and rehabilitation programmes are characterised by the active participation of local partners and authorities in planning and decision making, strengthening local capacity and promoting the sustainability of interventions **(X.2)**. The scope for using MBP approaches should be further assessed here **(X.5)**. SWM recovery interventions vary; they continue to depend on local conditions as well as the affected population's immediate and structural needs. Beyond the technical implementation of relevant SWM infrastructure, these interventions include significant efforts to strengthen SWM service structures and systems. Routines should be rapidly developed and implemented for waste storage, collection and disposal. Whenever possible, existing national or local SWM actors should be strengthened to increase the quality of their services and potentially expand them beyond their current mandate. In displacement settings, strengthened local utilities may cover both host and displaced communities. This can ensure an equitable provision of services and prevent tensions between different communities **(X.9)**.

Recovery interventions also include longer-term capacity strengthening and training, including working with relevant local authorities and development partners. Stronger collaboration with utilities, civil society and the private sector, and the handing over of responsibilities is important; it requires the increasing participation of stakeholders in planning and decision-making early on **(X.2)**. Where possible, recovery interventions should provide a foundation for the further development of SWM facilities and services and include relevant resilience and DRR measures. Such plans should also integrate a long-term development vision that enhances recycling and recovery options, technical skills and capacity, financial self-sufficiency and other elements of a sustainable SWM system. Effective recovery plans have clear transition or exit strategies, including hand-over to local governments, communities or service providers to ensure that the intervention's service levels can be maintained.

Protracted Crisis: refers to populations affected by recurrent disasters and/or conflicts, prolonged food crises, the deterioration of people's health and a breakdown of livelihoods. In these environments, a significant proportion of the population can become acutely vulnerable to a prolonged increase in mortality and morbidity rates. Protracted crises often occur in already fragile environments, where the state is unwilling or unable to fulfil its basic functions and to manage, respond to, or mitigate risks. In protracted crises, including protracted refugee situations, SWM interventions may resemble actions normally conducted during the acute response or the stabilisation phase. The short or medium-term perspective of these actions might be affected by fluctuating security and stability, the need to adapt to changing boundary conditions such as increased population figures, the elevated need for humanitarian assistance, the limited self-reliance of affected communities or the constraint to only implement measures of a temporary nature.

Development: the development phase is characterised by a stronger focus on universal access and the longer-term sustainability of services. Interventions in the development phase may include the fostering of relevant legislative frameworks **(X.1)**, institutional strengthening and enhancing technical capacities for local authorities and utilities, recognising that these national and local actors must take the lead in SWM and execute it in a safe, effective and financially sustainable manner. In the development phase, affordable and equitable access to SWM services must be ensured for the entire community, including measures for the inclusion of vulnerable, marginalised and low-income households **(X.2)**. SWM interventions in development may also aim to shift away from simple waste disposal towards an increased recovery of usable and valuable materials and more circular economy approaches. This can include the improvement of reducing, reusing and recycling waste, livelihood opportunities, operation and maintenance of services, longer-term behaviour change and habit formation **(X.6)**, ownership and empowerment **(X.2)**. In disaster and crisis-prone regions, preventative measures such as DRR, preparedness and climate change adaptation activities should be considered and addressed during the development stage.

Roles and Responsibilities of SWM Actors

SWM is a governmental responsibility. It is part of its public duty to provide basic services to protect public health and the environment. At a national and local government level, this responsibility is typically assigned to one specific ministry or local government unit tasked with resources management, public health engineering or environmental protection. The mandate, tasks and responsibility for SWM are set in the respective national legislation **(X.1)**.

Public, Private and Informal SWM Service Provision

When unaffected by conflict or disaster, the provision of SWM is either fulfilled by the local authority or is delegated to a public utility company. The organisational form and ownership of such a utility can be public or private. A publicly owned utility is the operational arm of the responsible authority; it is owned by the public sector and likely directly managed by it. A privately owned utility is a private-sector enterprise, which has offered its services through a public tender and has received the concession to run this service, or parts of it, for a certain period. In both cases, public or private, the utility tasked with the execution of the SWM service – the SWM service provider – has the responsibility for the provision of an inclusive, safe and financially sustainable handling of waste. The SWM service provider is subject to public control and regulation. Depending on its mandate and overarching legislation, the SWM service provider may further outsource SWM activities to specialised private sector actors. The responsibility and due diligence for these outsourced services still, however, remain with the SWM service provider.

In settings with insufficient SWM services or none, community-based, non-governmental or multilateral organisations may advocate for the enhancement of national SWM services or even take over service provision on a limited scale. In low and middle-income countries, the informal sector often engages in SWM service provision with a specific focus on handling recyclables. However, informal waste management activities are usually limited to easily recoverable items and higher-value materials, such as metals or certain plastics. Informal SWM services can involve child labour and may put the health of the informal workforce at risk.

SWM in Humanitarian Settings

In the event of disasters, conflict or displacement – or humanitarian settings in general – the business-as-usual provision of SWM services is likely to be dysfunctional. Existing services might be completely disrupted due to the lack of access, workforce, equipment, funding or prioritisation of SWM in a crisis. Even if still functional, sudden or rapidly changing conditions may overwhelm SWM services. A significant and rapid expansion of the population due to displacement will increase the demand for SWM services and generate rapidly increasing amounts of waste to manage. Services that enable SWM can also be threatened by a sudden deterioration of infrastructure (e.g. inaccessible roads) and equipment (e.g. vehicles) or an unavailable workforce due to death, flight, conscription or incapacitation. For humanitarian settings, it is fair to assume that the quality, coverage and effectiveness of SWM services are always lower compared to peacetime or the pre-disaster period.

Roles and Responsibilities in Humanitarian SWM

In humanitarian settings, the responsibility for SWM always remains with the respective local or national government authority. National legislation always applies and must be respected **(X.1)**. When humanitarian actors and donors play a role in supporting the existing SWM system or even providing a service, it is essential to collaborate closely and coordinate with local authorities and get approval for planned interventions and infrastructure implementations. Interventions re-establishing or providing SWM services in humanitarian settings must build on the previously existing and functioning system whenever possible and avoid creating parallel systems, which risk undermining the existing setup and its SWM service providers. Building on existing systems also facilitates future handover to the normal SWM service providers and the phasing out of humanitarian actors.

In some settings, local authorities and their service utilities may still be sufficiently functional and not require external support. However, if the funding and capacity of local authorities and utilities are significantly reduced, humanitarian actors may assist with funding, equipment and human resources, enabling the authorities to maintain service provision or outsource tasks to private sector entities until the regular SWM service provider has recovered and is operational. In cases where utilities are absent or fully incapacitated, or in remote locations out of reach of the utilities, humanitarian actors may take over the role of the SWM service provider. Such a situation is often found in remotely located temporary settlements of forcibly displaced persons. Independent of the SWM service provider – be it a public or private utility or a humanitarian actor – parts of the services can also be outsourced in humanitarian settings to further qualified entities, for instance, private-sector actors, or non-governmental, community-based or multilateral organisations.

Scope of the SWM Compendium Regarding Service Providers

The SWM Compendium outlines the technologies and actions of the SWM service provider in humanitarian settings. It does not, however, specify who or which type of service provider (governmental, private, non-governmental, community-based or multilateral organisation) should do what, as this will vary depending on the specific context.
The SWM Compendium is a guide for governmental, private or humanitarian organisations directly involved in the execution of SWM and acting as the SWM service provider. It also aims to support all entities involved in the secondary roles of SWM service provision and potential donors.

→ **References and further reading materials on Roles and Responsibilities of SWM Actors can be found on page 173**

Principles and Standards Related to SWM

The planning and implementation of SWM is guided by principles but bound by standards. This is the case in peaceful and disaster-free settings as well as in humanitarian response. Principles are approaches for the design of SWM interventions. They are non-binding and act as guidance and inspiration to plan, implement and execute context-adapted, reasonable, effective and efficient SWM interventions. Some of the SWM principles listed below are universal and can be applied in most settings, such as the principle of the waste management hierarchy or the proximity principle. Others, such as the polluter pays principle, may not be applicable in humanitarian settings. It is nevertheless advisable to consider them in the design of humanitarian interventions to help identify the most suitable SWM solution, plan the exit strategy or facilitate the establishment of chargeable basic services in development settings.
On the other hand, standards specify how SWM interventions must be executed and define the targets to be achieved. In contrast to principles, standards define binding requirements in quality and quantity, work approaches and target values; they are based on relevant national regulatory frameworks **(X.1)**. National SWM standards are the highest-ranking requirement but may be complemented by international conventions. The Sphere Minimum Standards in Humanitarian Response **(see Figure 5)** should be used in the absence of national legislation.

Key SWM Principles

The Principle of the Waste Management Hierarchy defines an overarching approach for SWM. It is based on waste prevention **(PART 1: Waste Prevention)**, the recovery of valuable and useful materials from waste for reuse and recycling and the safe disposal of the remaining waste. The waste management hierarchy ensures that resources are used in a circular economy approach and waste disposal volumes are minimised.

The Principle of Risk-Based Waste Management is a reminder that SWM is an important measure to protect public health and the environment. This principle establishes that while some waste fractions are of higher value or simpler to treat, reuse or recycle, the management priority of different waste materials is directly proportional to their risk potential. Waste types, or fractions with a high-risk potential for public health and the environment, must be managed before lower-risk fractions. This is particularly important in humanitarian settings where the available funds and capacities may be insufficient to manage all waste materials.

The Precautionary Principle intends to prevent underestimating or falsely neglecting the potentially adverse impacts of solid waste. For instance, if the risk level or composition of the solid waste is uncertain or unknown, it must always be considered significant and a threat, and corresponding protective measures taken.

The Proximity Principle essentially states that solid waste should always be managed as closely as possible to the location of its generation. This prevents the shifting or disguising of SWM needs and issues to another location. Reduced transport distances also help to reduce costs and emissions and lower the risk of intentionally or unintentionally dropping waste during transport.

The Principle of Collaboration and Partnership intends that, whenever possible, SWM in humanitarian settings should work with existing actors, services and infrastructure.

The Polluter Pays Principle is a common approach to funding SWM but is less applicable in humanitarian contexts where ensuring financially sustainable SWM operations and holding waste generators to account for their actions is less likely. Instead, SWM in humanitarian settings is primarily about the protection of public health and the environment. SWM funds are often provided by external donors as affected communities are unable to pay. Important polluter pays measures, such as limiting waste collection to official and chargeable waste bags or preventing the disposal of household waste in public litter bins, are therefore commonly not required in humanitarian responses but may have to be considered in longer-term programming.

The Principle of a Circular Economy states that resources and products should be kept in circulation as long as possible to prevent or reduce waste generation. A circular economy starts with the design of products that enable their reuse, repair, refurbishment and recycling. Applying the principle of a circular economy can significantly reduce waste generation **(PART 1: Waste Prevention)** and the corresponding need for SWM.

The Principle of Do No Harm is a guiding principle for all humanitarian interventions. The planning and implementation of SWM in humanitarian settings must be guided by and adhere to the principle of Do No Harm. It demands organisations to be aware of the context they are working in, understand the interaction between their actions and the context and apply this understanding to minimise negative impacts while maximising positive impacts. For SWM in humanitarian settings, the Do No Harm principle applies in multiple ways. For instance, humanitarian aid should, whenever possible, resolve, rather than contribute to waste issues, or the generation of livelihoods or employment related to SWM must not jeopardise public health, environmental protection or the health of waste workers.

National Standards

Regardless of the balance between national capacity and international support mobilised in response to a crisis, all parties must respect and observe the national regulatory environment **(X.1)**. This includes relevant national policies, laws and standards. Local regulations at the municipal level are unlikely to be familiar to external actors but must be understood and adhered to. This is of particular importance when transitioning to longer-term solutions during the stabilisation and recovery phases. While respecting national legislation, international support should also comply with potentially stricter or more detailed guidance, such as donor requirements or the Sphere minimum standards in humanitarian response.

Sphere Minimum Standards in Humanitarian Response

National SWM standards may not exist or be easily adapted to crisis situations. In these cases, the Sphere Minimum Standards in Humanitarian Response should be referred to for guidance. Whenever possible, government stakeholders should be engaged in discussions about the application of emergency standards and indicators.
The Sphere Handbook provides a set of globally agreed, universal principles and standards in core areas of humanitarian assistance. With its rights-based and people-centred framework, Sphere aims to improve the quality of assistance provided to people affected by disasters and to enhance the accountability of the humanitarian system in disaster response. In the technical chapters, standards state the minimum to be achieved in any crisis for people to survive and re-establish their lives and livelihoods in ways that respect their voice and ensure their dignity. The solid waste management standards should be used in conjunction with the standards for the whole WASH chapter **(Figure 5)**. They include promotive and preventive measures enabling individuals and communities to exercise their human right to life in dignity. These rights are translated into three specific SWM standards entitling everyone to access the means to reduce public health risks associated with solid waste and enable hygiene, health, dignity and well-being.

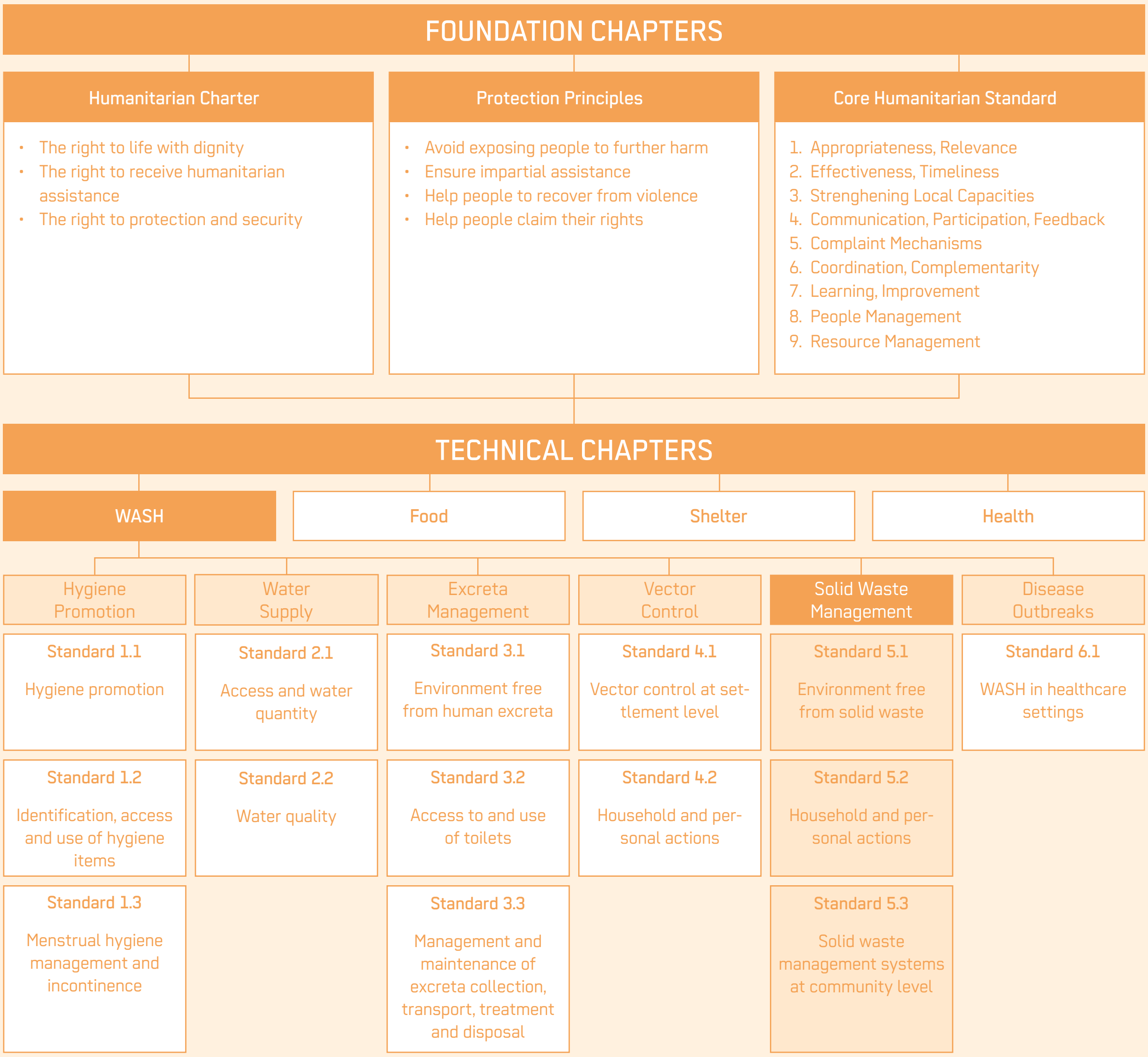
Quality Standards for Private Sector Engagement

When outsourcing services to private sector entities, or for engagement with the private sector in general, SWM service providers **(Roles and Responsibilities of SWM Actors)** must ensure that these entities have the required qualifications. SWM service providers may define the qualifications, or they may be pre-defined by national standards. References from completed, similar works, and relevant certificates can also be requested. Although less common in humanitarian response, these certificates are receiving more and more attention, partly because of the due diligence requirements of humanitarian actors. Below is an overview of potential standards and certificates:

- ISO 14001 of the International Organization for Standardization (on environmental management systems)
- ISO 45001 on management systems of occupational health and safety
- Waste-specific certificates confirming safe handling, disposal, and consideration of occupational safety (e.g. for e-waste: RIOS or R2, **W.7**)

→ **References and further reading materials on SWM Principles and Standards can be found on page 173**

Figure 5:
WASH minimum standards according to Sphere, including solid waste management (see standards 5.1 to 5.3)



Structure of all Technical Standards

Standard: Universal, general and qualitative, state to be reached
Key Actions: Practical steps to attain the standard
Key Indicators: Signals to measure progress and whether a standard is being attained
Guidance Notes: Additional information on how to consider context and operational requirements

PART 1 :

Preparing for SWM

Waste Prevention

Waste prevention is an essential and effective measure within SWM: if waste is not generated in the first place, no effort is required for its management and waste cannot pose a risk to public health or the environment. In addition, resources for waste management can be saved and more attention and action can be invested in the management of the remaining waste.
Waste prevention is highly relevant in both disaster-free settings and in humanitarian responses. It is the first step and highest priority in the principle of waste management hierarchy **(see Introduction: Principles and Standards)**.

The Waste Management Hierarchy

The principle of the waste management hierarchy is a cascade of generic SWM measures, from most preferred to least preferred **(see Figure 6)**.

Reduction: whenever possible, waste must be reduced or prevented directly at the source, to decrease the amount of waste that needs further management.

Reuse/Repair: waste that cannot be prevented should be repaired and/or reused, meaning that waste materials are not transformed but reused in their current form.

Recycling/Organic Waste Treatment: if direct reuse is not possible, waste materials should undergo material transformation to create new and valuable goods. This either means recycling (for metals, glass or plastics) or it refers to various treatments for organic materials **(see T.1 to T.5)**. Inorganic materials which cannot be recycled, for instance certain plastics can still undergo upcycling **(T.7)** or downcycling **(T.8)** to prevent the need for their disposal.

Energy Recovery: energy can be recovered from organic waste through, for example, biogas production **(T.3)** or making fuel from biomass **(T.5)** and is used for functions such as cooking, lighting and heating.

Disposal: if waste materials cannot be prevented, reused, repaired, recycled or transformed through organic treatment, disposal is the final option. In humanitarian settings, this is either disposal in controlled waste pits **(U.8)** or larger-scale controlled disposal sites or landfills **(U.9)**.

The waste management hierarchy can be simplified as the **3Rs of waste management**:

"Reduce, Reuse, Recycle". Like the waste management hierarchy, the highest priority of the 3Rs waste management is the reduction of waste followed by reuse and recycling.
Measures to prevent waste take place even before waste is generated. All other steps of the waste management hierarchy come into play once waste has been generated and ideally include waste separation **(PART 1: Waste Separation)**. Without waste separation (either segregation at source or waste sorting at a later stage), reuse or recycling cannot take place. Waste prevention is particularly crucial for non-recyclable and non-biodegradable waste materials. Except for the limited upcycling **(T.7)** and downcycling **(T.8)** possibilities of such waste streams, safe disposal is often the only end-of-life option. Preventing the generation of such wastes directly reduces the amount of residual waste to be disposed of.
Although they eventually end up in the same waste stream, three distinct waste origins can be distinguished in humanitarian settings: waste directly caused by humanitarian organisations and their operations, waste caused by individuals, households or institutions because of their consumption patterns (purchase power, lifestyle and access to markets), and disaster waste **(W.3)**. For waste directly generated by humanitarian relief operations **(W.5)**, there is higher potential for waste prevention, as organisations have a direct influence on the purchase and management of, for example, relief items and packaging materials. It is more difficult to prevent waste caused independently of humanitarian assistance and may not be possible for humanitarian actors.

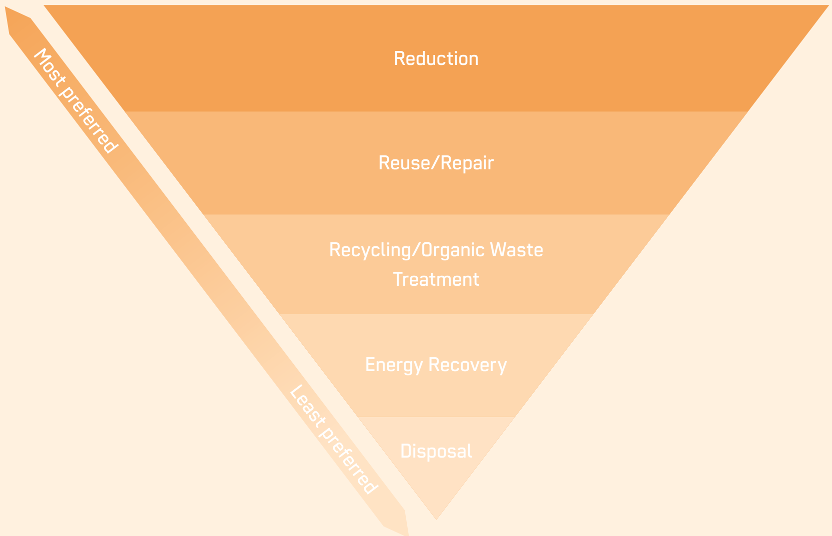


Figure 6:
Waste Management Hierarchy
(adapted from EPA)

Preventing Waste in Humanitarian Assistance

Examples of waste directly caused by humanitarian assistance include:

- Packaging materials from distributed goods and foods such as cardboard boxes, pallet plastic films, plastic bags and plastic strips
- Distributed non-food items which have reached their end of life, such as tents, tarpaulins, cooking sets, lamps or mattresses
- Distributed food items
- Materials used for humanitarian operations such as office equipment, construction materials, chemicals, energy systems or fleet items

Humanitarian organisations have a direct influence on the selection, purchase and management of these different products and materials and can therefore minimise their operational waste creation **(W.5)**. This aspect and responsibility have gained increased attention in recent years and can be addressed, amongst others, with the following measures:

Green Procurement: refers to prioritising the purchase of goods and services that have minimal environmental impact. Aspects of green procurement include the prioritisation of products with reduced packaging, products from recycled or sustainable materials, products designed for durability and repairability and products that can be recycled locally. An assessment of the total costs of ownership (which includes disposal costs) or a life-cycle-assessment can help to identify suitable products and facilitate greener procurements. Procurement teams must be engaged in understanding these requirements and incorporate environmental considerations and minimum technical specifications in tender and contract documents. They can also conduct green procurement market analysis and look for opportunities to work with local suppliers to analyse the availability of green goods and services in the market where they operate. This also reduces the need to ship materials which is costly, fuel reliant and time consuming.

Repairability and Take-Back Schemes: ideally, goods used in humanitarian settings are durable and repairable. This is particularly important for items which are distributed to affected communities. Durability and repairability not only extend a product's lifespan but also prolong the assistance of the goods to affected communities. Take-back schemes refer to measures where end-of-life goods are collected and returned to the supplier; they can be applied to goods directly used by humanitarian organisations or to goods distributed to affected communities. Repairability and take-back schemes are particularly relevant for products which cannot easily be disposed of locally or which contain hazardous materials, such as e-waste from solar lanterns and other electrical and electronic devices **(W.7)**. If necessary, take-back schemes for distributed items can also be fostered by providing financial or material incentives if used goods are returned. Take-back schemes can also be connected to in-kind distributions where, for instance, empty food packaging can be returned when picking up new food baskets. Repair and take-back schemes might also be part of voluntary or mandatory Extended Producer Responsibility (EPR) measures of suppliers.

Prevention of Single-Use Items: the distribution of single-use items like plastic cutlery, plates or plastic water bottles should ideally be minimised. Single use items should only be used in the immediate aftermath of events, for instance, during a handout of ready-made food. In such cases, affected communities are likely to have lost their own household appliances and food producers, and the logistics for the distribution of multi-use items (including jerrycans, food containers or cutlery) and food baskets have not yet been set up. Inclusive packaging should be used where possible, such as using buckets as packaging for hygiene kits, pallets as boxes, and tarpaulins repurposed into bags.

Planning and Forecasting: stocks should be closely monitored and programme planning and forecasting improved; this will reduce the duplication of purchases and the total number of items entering the waste cycle. Additionally, excessive or unwanted donations should be identified and take-back systems for donations considered if items are unused.

Prevention of Waste from Humanitarian Offices and Facilities: waste prevention can also be applied in humanitarian offices and facilities. It can include reducing paper usage, promoting recycling and composting organic waste from kitchens.

Community Relief Items Acceptance: a thorough needs assessment **(PART 1: SWM Assessment)** should be conducted and the affected community be consulted **(X.2)** to ensure that relief items will be used and will not end up as waste. Organisations that bring in the materials should take full responsibility for the proper management and disposal of their waste.

All humanitarian sectors produce waste within their operations **(X.7)**. Some organisations and sectors – especially those involved in food security, nutrition, logistics and shelter – have a greater potential for and responsibility to prevent waste. Waste prevention from humanitarian assistance will likely require inter-sectoral coordination between different humanitarian actors and sectors.
Many of the above measures may be challenging to implement ad-hoc during acute emergencies. However, in the

preparedness phase, organisations can integrate them in advance by identifying suppliers of environmentally sustainable relief items, equipping staff with the necessary knowledge and resources and establishing waste reduction strategies for effective implementation.

Preventing Waste from Commercial Goods and Activities

Preventing waste from individuals, households or institutions is far more difficult than waste from humanitarian assistance. The creation of such waste depends on the behaviour of affected communities and individuals, their purchasing power, personal preferences and access to markets. Humanitarian actors have little influence on these factors. Waste prevention from regular consumer goods must be established through national legislation **(X.1)**. This can include regulating packaging types, the duty to include mandatory prepaid disposal fees in market prices or enforcing EPR measures for private-sector companies. Waste prevention can also be facilitated by the consumers through conscious consumption and selecting goods with minimal environmental impact – similar to the green procurement of institutions. Neither the introduction and application of legislative frameworks nor the behaviour change of individuals purchasing commercial goods can be significantly changed by humanitarian actors alone, especially within the potentially short timeframes of humanitarian assistance.

→ **References and further reading materials on Waste Prevention can be found on page 173**

Waste Separation

Waste separation is the process of separating waste into different waste materials, often referred to as waste fractions. Waste separation is an integral part of SWM. In keeping with the circular economy principles **(Introduction: Principles and Standards)** and the waste management hierarchy **(PART 1: Waste Prevention)**, the objective of waste separation is to separate items and materials of value from the main bulk of waste which can be repurposed, reused, recycled or treated. Separation and subsequent recovery, treatment and recycling reduce the amount of waste for disposal and thus increase the lifespan of landfills.
Waste can be separated at different stages along the SWM chain. When separated right after generation it is referred to as 'Waste Segregation'. In this case, the segregated waste fractions have never been mixed with other waste. When waste fractions are extracted from mixed waste, it is referred to as 'Waste Sorting'.

Waste Segregation at Source

Waste segregation should be prioritised over waste sorting as segregated waste is higher quality and purity and therefore facilitates recovery rates by reducing the complexity and cost of waste treatment and recycling **(see section T)** and providing safer and cleaner working conditions for SWM workers **(X.4)**.
Waste segregation is essential when dealing with specific wastes such as medical waste **(W.1)**, hazardous waste **(W.2)** or e-waste **(W.7)**, given their high potential health hazard. If such specific wastes are not rigorously separated from regular domestic solid waste, their hazardous nature contaminates all the waste they come into contact with. Consequently, all the waste must be considered and handled as hazardous. Medical waste illustrates the problem: of the waste generated in health care centres, the largest waste fraction consists of unproblematic and harmless waste comparable to household waste; only a small amount is toxic or infectious. However, if these different fractions are stored together as mixed waste, the whole amount of waste must be considered toxic or infectious and would require special handling and treatment. This is also the case if some waste containing infectious or hazardous substances is mixed with waste from other sources (e.g. households, restaurants and markets).
Waste segregation ensures that items of value are kept separate at an early stage and are not contaminated by other waste. This allows much easier and cost-efficient processing in the next waste handling steps.
Waste can be segregated by using different containers/bins for the different fractions that are to be segregated. The bins are located in households or at a communal and public level. When waste has been segregated it is essential to follow up with a separate waste collection **(see section T)** and to prevent segregated waste from being mixed with other waste again.
To further facilitate and maintain the segregation of waste, it is essential to clearly mark the different segregation categories with, for instance, colour codes, symbols and short words. The same marking must then be applied throughout the SWM service chain, from waste storage to collection and transport vehicles, and at the various facilities such as transfer stations **(C.5)**, processing facilities and disposal sites.

Waste Sorting

As opposed to waste segregation at source, waste sorting is the process of extracting specific waste fractions from mixed waste during the different stages of the SWM chain. Waste sorting and the subsequent use and treatment of the sorted fraction reduces the amounts of waste requiring disposal and allows the recovery of recyclables and organic materials. Waste sorting can happen at multiple stages: during collection and transportation, at waste transfer stations, at treatment facilities or even at disposal sites. Waste sorting at disposal sites is often practised by informal waste pickers, however, this is undesirable due to the high occupational health risks **(X.4)** associated with this practice. In some cases, segregated waste may also require waste sorting, for instance, to further separate individual material types for further treatment or handling by the recycling sector. An example is the sorting of plastic types (e.g. PET, or HDPE) before sales to the recycling sector or for further processing. Sorting may even be a necessary pre-processing step in treatment facilities to, for example, remove undesired non-organic materials before organic waste treatment at the facilities. High-quality waste segregation minimises the need for further sorting. Mixed waste sorting is undesirable as it is a time-consuming task, requires numerous staff members to work in challenging conditions and typically results in materials of lower quality compared to waste segregation at source. Waste segregation should always be prioritised over waste sorting.

How to Facilitate Waste Segregation

2-Bin System: the most basic waste segregation is a separation into two main fractions: organic and non-organic materials (also referred to as 'wet' and 'dry' waste separation). Dry inorganic waste is collected and then undergoes an additional sorting step to recover valuable recyclable materials such as plastics, metals, or glass. Such intermediate sorting may be conducted at Transfer Stations **(C.5)** or disposal sites **(U.9)** before disposal. Segregated organic 'wet' waste can be further processed, for instance, to recirculate nutrients and carbon for the growth of plants **(T.1 and T.2)** or to produce alternative protein sources such as black soldier fly larvae **(T.4)**. Segregated organic waste can also be used to produce biomass-based energy such as biogas **(T.3)**. High-fibre materials may be suitable to produce biomass-based fuels for cooking or heating **(T.5)**. If organic waste is treated for agricultural use ensuring source-segregation and minimal impurities is essential. When used, the presence of inorganic waste in the products may jeopardise the health of soil and farmed animals.

3-Bin System: improved segregation uses three categories of separation: organic waste, recyclables and residual waste. This setup helps to keep valuable recyclables cleaner and easier to sort at a later stage.

Segregation in More Than 3 Fractions: segregating additional waste categories, such as different types of plastics, metals, glass or cardboard, is possible but increases the complexity of separate collection and transport. It can be difficult and requires behaviour change **(X.6)** for waste generators.

Collection Frequency: different waste segregation categories may have different generation rates, so they can be collected at different frequencies. Organic waste must normally be collected most frequently due to its rapid decomposition and resulting smell and attraction for animals. Collection approaches can vary according to how and from where segregated waste is collected **(see section C)**. If collected from communal storage, it is feasible to send vehicles dedicated to one or several waste categories. If collected directly from households, collections should ideally happen several times a week, if not daily. In this case, the different categories of segregated waste can be collected in one go. There are positive examples from door-to-door collections as operators observe each household's quality of segregation and can build up relationships with the different households. Operators can sensitise households about the importance of SWM and, if necessary, can directly correct waste segregation or instruct households on correct waste handling.

Waste Segregation and Behaviour Change: to facilitate the segregation of waste, raising awareness and introducing the concept of source-segregation in the communities is both a key factor for success as well as a challenge. Source-segregation fails if communities do not comply with the planned segregation practices and do not segregate waste correctly or at all. In these cases, a later sorting of waste within the SWM service chain is the only remaining option. However, this approach is commonly ineffective and costly and compromises occupational safety **(X.4)**. Awareness and sensitisation campaigns might be insufficient to introduce waste segregation to communities and behaviour change interventions will be required **(X.6)**.

Waste Segregation in Humanitarian Settings: waste segregation is particularly important in humanitarian settings for the reasons mentioned above: it reduces waste amounts and provides opportunities to boost local economies. Nevertheless, efficient waste segregation strongly relies on the participation **(X.2)** and correct practices of individuals and households as well as on functioning and intact services and infrastructure. As waste segregation might be new for targeted communities in humanitarian settings, behaviour change **(X.6)** may be even more challenging. It is therefore not usually feasible during and shortly after emergencies. In such settings, community members might be traumatised, busy with their day-to-day survival struggles and unlikely to be willing and able to consider specific and new waste-handling practices. In protracted and development settings, the likelihood of successfully implementing waste segregation is much higher.

Prerequisites for waste segregation include relatively stable living conditions, correspondingly adapted SWM services and infrastructure, a local link to the recycling sector and the possibility of processing recovered materials on-site. While the latter can be applied with simple means for biodegradable waste and the production of compost **(T.1)**, it can be more complex for recyclables. Successful waste segregation is also based on thoroughly trained staff. If staff are not sensitised about the importance of safe waste handling and resource recovery, there is a risk that source-segregated waste is mixed again during collection and transport. Given the challenges of waste segregation, it might be expedient for humanitarian settings to limit waste to only two (organics/inorganics) or three (organics/residual waste/recyclables) segregation categories.

Once waste segregation can be implemented in humanitarian settings – for instance in stable contexts where communities are ready to apply new disposal practices – the segregation of organic waste is advantageous in all cases. Even if agricultural reuse is of limited interest, removing organics helps to significantly reduce waste amounts, largely reduces odour nuisances and limits the attraction of animals. For all other segregation categories, SWM actors need to thoroughly assess **(PART 1: SWM Assessment)** the market interest for recoverable items and materials, as well as the feasibility of processing recovered materials in humanitarian programmes. It is unreasonable to create segregation categories for materials which are neither of value nor can be processed by humanitarian actors. The required storage for these materials until there is market demand might be too expensive and space-consuming. SWM actors also need to consider that local small-scale scrap dealers might not be aware of all potentially re-saleable recyclables as they are likely to focus only on the most valuable materials. If scrap dealers work together and pool their collected materials, the trading of less valuable recyclables may become profitable. Another approach to ensure higher prices is to pre-treat recyclables and facilitate their transport, for instance, through the hydraulic pressing of metals to compact batches or the shredding of plastic containers to allow a denser filling of transport bags. Before incorporating these processing capacities, it is advisable to consult recycling stakeholders to ensure that the quality requirements for handling recyclables are being met.

In humanitarian settings, the highest priority for recovered materials is always to hand them over to the local recycling sector. Even if recovered materials are handed over for free, SWM actors still financially benefit from the reduced amount of waste to be disposed of and the corresponding cost savings. Priority must also be given to the handover as the establishment of a parallel processing system by humanitarian or development actors leads to competition with the local private sector and a distortion of markets **(X.5)**. In almost all cases, this competition will be to the disadvantage of the private sector, as works conducted by humanitarian or development actors are not business-oriented and benefit from indirect subsidies. As a secondary priority, in the absence of private-sector activities, humanitarian and development actors may consider the processing of recovered materials themselves, such as plastic downcycling **(T.8)**. The output of such activities needs to be balanced with the likely lack of expertise amongst actors and the potential occupational **(X.4)**, public health and environmental risks. For waste originating from in-kind distributions such as food packages and food containers **(W.5)** there are good examples in humanitarian settings of waste segregation and the 'take-back' of distribution packaging by communities during distributions. In-kind distributions should ideally be designed to minimise waste generation and facilitate reuse and recycling. In some cases, in-kind distribution organisations also use returned packaging material and food wraps for upcycling **(T.7)** projects. These workshops can provide income, and the creative work might be a welcome distraction for affected communities. The distribution of new items or food must not be contingent on the return of packaging waste though communities seem to get used to storing packaging waste in their homes and bringing it back when new distributions take place. These recovered waste materials are then ready to be safely disposed of or can be used for recycling **(T.6)**, upcycling **(T.7)** or downcycling **(T.8)**.

In humanitarian settings, waste is generated from activities linked to humanitarian and development actors (e.g. in-kind distributions, food assistance, general operation) and from market-available consumer goods. For the latter, avoiding and reducing waste is more complex or potentially even impossible compared to waste generated by humanitarian actors. In both cases, reducing waste must be considered with the highest priority **(PART 1: Waste Prevention)**.

Potential activities and priorities to implement waste segregation in humanitarian settings include:

- Assessment of existing recycling initiatives and actors (at the local and national level, including humanitarian and development actors) and identification of materials with financial recycling value **(PART 1: SWM Assessment)**
- Review of national legal frameworks about waste management, waste segregation and recycling **(X.1)**
- In the absence of existing recycling sectors and treatment facilities for organic waste: evaluate the feasibility of corresponding projects onsite within the humanitarian setting or support relevant actors to expand their services. Define the financial, space and training needs
- Adapt SWM collection, transport and disposal to incorporate waste segregation. Create different, clearly marked segregation categories and maintain waste segregation throughout the SWM service chain

- Awareness raising, sensitisation and behaviour change campaigns for affected communities **(X.6)**
- Monitoring and constant improvement of waste segregation throughout the SWM service chain **(X.3)**

Waste Sorting by the Informal Sector

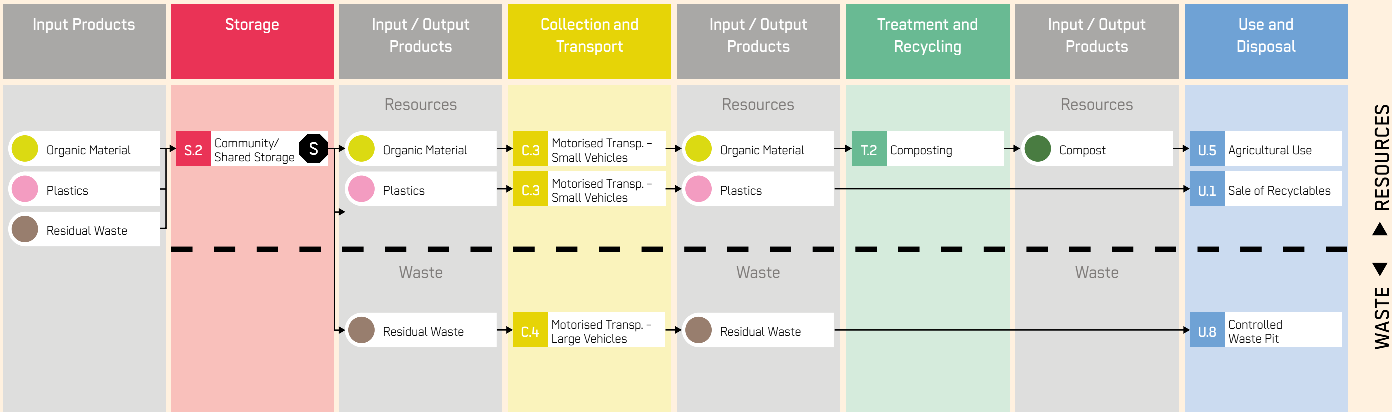
In humanitarian settings and in low and middle-income countries, valuable waste materials are likely to be recovered by the informal sector. Informal removal is usually limited to the most valuable and accessible materials and can happen directly at the household, communal and public storage levels as well as on informal disposal sites. Informal workers should not have access to controlled disposal sites and landfills **(U.9)**. SWM interventions must not create competition with the informal sector as it is a last-resort opportunity for income generation for the poorest of the poor. Instead, informal workers should be integrated into interventions **(X.2)** or at least strengthened so that their working conditions are improved, occupational health and safety **(X.4)** maintained and child labour prevented **(X.1)**. Informal workers might remove the most valuable materials before SWM providers can collect them. It is also possible that official operators remove valuables during collection or transport. While the practice of the official operators in particular may be condemned by SWM providers, it is recommended that SWM providers do not prohibit it. Removing valuables from waste might be a welcome side income for official SWM operators and is an essential livelihood for informal workers. In both cases, SWM providers still benefit from the handling of reduced waste amounts. For organisations, the financial value of the removed items might anyway have been limited.

Visual Representation of Waste Separation in the SWM Compendium

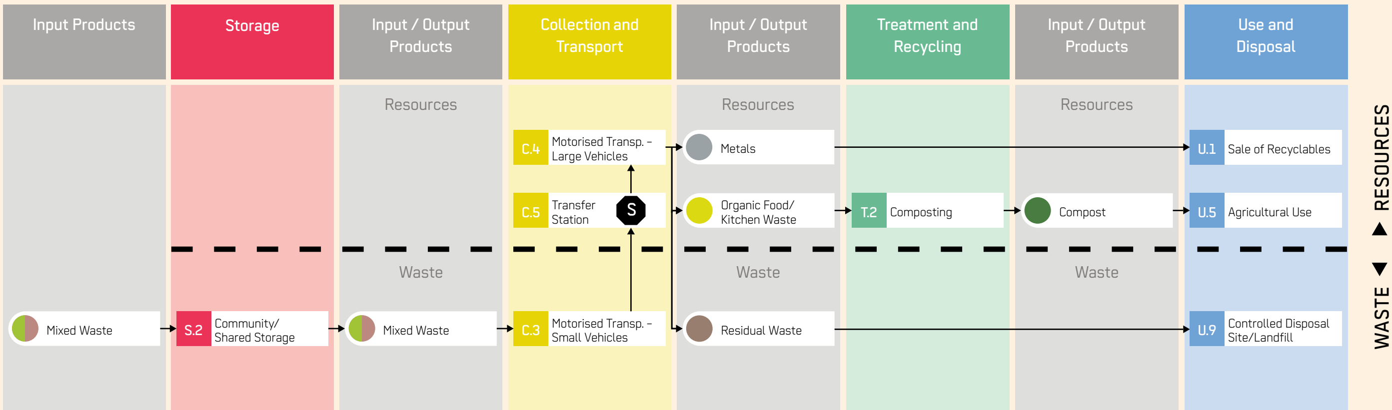
Waste separation, whether 'Segregation' or 'Sorting', is represented in this Compendium with the specific symbol S. When associated with storage technologies, the symbol represents waste segregation at source. Further along the waste service chain, the symbol represents waste sorting. Sorting can be associated with collection and transport, treatment or even disposal. Sites of combined waste sorting and waste transfer are commonly referred to as Material Recovery Facilities (MRF). After the sorting at the MRF, the different waste fractions are further transferred to treatment, processing or disposal.

Figure 7: Waste separation examples

Example 1: Waste segregation at source (as part of Storage)



Example 2: Waste sorting at transfer station (as part of Collection and Transport)



SWM Assessment

Assessing SWM services and gathering key baseline information is an essential step in developing an effective waste management strategy. For this, the recommended framework is the Integrated Sustainable Waste Management (ISWM) as it includes all the critical elements of a functional and sustainable SWM service. The ISWM includes the physical components of the service chain **(PART 2)** as well as its governance, including financial sustainability, stakeholder inclusivity **(X.2)** and the legal and regulatory framework **(X.1)**.

The Humanitarian Aid Solid Waste Assessment and Improvement (HAWAI) guideline is a practical and structured framework to assess and improve collection, transport, disposal, and organics and recyclables management through three key entry points:

Risk Assessment: a systematic approach to identify critical hotspots, prioritise immediate actions and pinpoint deficiencies requiring longer-term solutions.

Systematic Analysis: a thorough evaluation of each stage within the SWM system to identify weaknesses and make tailored recommendations for improvement.

Service Implementation: step-by-step guidance to establish or expand SWM services, ensuring sustainable and context-appropriate solutions.

Practitioners are encouraged to use this tool to implement data-driven, context-sensitive solutions. Data collection methods for an SWM assessment include: key informant interviews with local officials and waste sector actors, direct observation and transect walks, household surveys on waste practices, waste audits to analyse composition and a review of existing reports and data. Below, essential elements of an SWM assessment included in the HAWAI guidelines are described.

Existing SWM Systems, Infrastructure, and Legal Framework

Existing SWM systems, infrastructure, legal frameworks and key stakeholders should be among the first aspects to be assessed in the early phase of a humanitarian response. The technology sheets **(PART 2)** support the mapping of collection and transport **(section C)** as well as evaluating the condition and capacity of treatment **(section T)** and disposal facilities **(section U)** to enable a good understanding of the current management system. Identifying existing informal or formal recycling or reuse and disposal actors is also necessary, as they can be key partners in a SWM system. Connecting with existing local SWM stakeholders and authorities **(X.2)** early on is important as they are essential for any handover and exit strategy. Where possible, the focus should be to support and strengthen existing waste management systems rather than create parallel structures.

In addition to an evaluation of the existing SWM system, the local and national strategies, policies, standards and regulations **(X.1)** should also be reviewed as it is essential to develop SWM systems that are compliant with the institutional and regulatory environment.

Stakeholder Analysis

Map all the stakeholders relevant to SWM to ensure inclusivity, tailored solutions and good coordination. Mapping provides a list of potential actors who can support the assessment of the SWM system, including local authorities and municipal services, the informal sector, community leaders and residents, private waste management companies and other humanitarian actors that interlink with SWM such as WASH, logistics, shelter, health, settlement planning and livelihoods **(X.7)**. Identifying previous SWM service providers is key as they will have crucial experience and information available and can play a central role in the assessment. The affected population may include former waste managers or workers; they should be recruited or involved as their knowledge and experience can be key to improving or establishing new SWM systems. Coordination with other humanitarian sectors and local authorities is crucial to avoid duplication of effort and ensure alignment with broader response strategies **(X.7)**. Active community engagement is essential, involving affected populations in the assessment process to understand their priorities and leverage local knowledge **(X.2)**. Part of the process is to plan for the longer term, such as continuous operation and maintenance requirements, organisational issues and handover strategies that may include managing a (gradual) withdrawal of funds from external donors, early collaboration with local authorities, cost-recovery and the need to strengthen local capacity.

Health and Environmental Risk Assessment

An early evaluation of potential environmental and public health hotspots helps define priority actions (use HAWAI guidelines). Mapping the interaction between vulnerable elements such as water sources for drinking or irrigation or drains at risk of clogging and exacerbating floods and mismanaged waste can highlight the hotspots which need immediate action. Additionally, the direct public health threats of open dumping **(U.10)** or open burning **(U.11)** in the vicinity of where people live or work need to be assessed. This risk assessment will identify priority actions to protect public health and the environment. Existing assessment tools, such as the Nexus Environmental Assessment Tool (NEAT+) (which includes a specific module on WASH) can be utilised to identify and evaluate solid waste issues linked to specific interventions and to consider appropriate mitigation measures. Given the often volatile nature of humanitarian contexts, a phased approach may be necessary, addressing immediate needs while planning for longer-term sustainable solutions.

Waste Generation and Composition

A critical step of the assessment is to carry out a waste audit to characterise the amount and composition of the waste generated and requiring management. This data will inform the design and decisions about the SWM system. For municipal solid waste, the audit is commonly done of households and non-household waste generators (institutions, commercial and the public). The process involves characterising the waste at a representative number of waste generators for a week. As waste composition and generation can vary seasonally, it is advisable to repeat the waste audit in different seasons. Although waste audits are recommended to gather more accurate data, they cannot always be undertaken. In these cases, secondary information can provide estimated waste generation rates and composition by, for instance, gathering existing data from similar contexts. The SPHERE Handbook proposes an instant estimate of waste generation of 0.5 kg/person/day. This value is a rough first estimate and does not provide information about waste composition. The value can be used in contexts where no data is available and there is no time to perform a waste audit but should not be used for longer-term planning or the design of waste infrastructure requiring precise data.

Evaluating and Improving the Efficiency of the Service

An in-depth assessment of service quality and efficiency is important to optimise service provision, reduce costs, ensure public health is better protected and guarantee the sustainability of the service. The HAWAI guidelines can support the assessment of each stage of the SWM service: collection and transport C, treatment and recycling T, use and disposal U. The special case of self-management of waste in sparsely populated rural areas where service provision is not desirable or feasible is also covered in the guidelines. Assessing the efficiency of the service requires an analysis of the service chain from start to finish, focusing on how each step is linked to the next. For example, assessing the efficiency of waste collection and how the waste is loaded onto trucks requires an analysis of the loading time per stop, worker productivity, bin accessibility and truck capacity utilisation amongst other efficiency elements. The HAWAI guidelines allow for a comprehensive evaluation and guides practitioners by describing possible improvements for each stage of the SWM service chain. Improving the waste management service can also free up resources to expand to unserved areas. The HAWAI guidelines also provide step-by-step guidance when planning and designing new services from zero or for expanding existing services to new areas.

Forecasting in Waste Management

Planning SWM systems considers both current waste generation and composition and forecasting for the long term. Anticipated changes in population or consumption levels are significant factors that will change waste characteristics and quantities. Hence, it is important to understand the context and possible future scenarios early in the development of waste management services and solutions. This is challenging in humanitarian settings as the movement of populations can be unpredictable. Nonetheless, when possible, consideration of higher-capacity infrastructure (such as larger waste disposal sites) is advisable to meet increased future demand.

Available Resources and Financial Sustainability

Resources are required to run an SWM system. An assessment of the resources available for SWM at the current moment and in the future is essential. This includes financial resources as well as human resources and technical expertise, vehicles and equipment, infrastructure and land for waste management facilities. Waste management will always incur costs, so plan for the longer term as early as possible, facilitating the handover when humanitarian actors leave **(X.1)**. The technologies covered in **PART 2** of this Compendium indicate the anticipated costs for each technology as well as more detailed information on their operation and maintenance requirements.

→ **References and further reading materials on SWM Assessment can be found on page 173**

PART 2 :

Domestic SWM Service Chain

Technology Overview

S

Storage

This section describes how to safely store and contain waste at the household, communal and public level. Waste storage is the first, important, step of the SWM service chain after generation and segregation (PART 1). Without sufficient and appropriate storage at the point of generation, waste is scattered throughout settlements creating public health risks in close proximity to the population.

Waste storage is also a precondition for effective waste collection (section C). If waste generated is not safely stored and contained at the point of generation, it may never enter the SWM service chain (unless costly campaigns are run to collect scattered waste).

Waste can be stored directly at the point of generation, such as at an individual and household level, or as communal and shared storage, for instance, for multiple households. A third type is waste storage in public spaces such as markets or parks to facilitate the disposal of waste items outside of households. These three options are covered in more detail in the following technology sheets:

S.1 Individual and Household Storage
S.2 Community and Shared Storage
S.3 Public Litter Storage

Depending on the collection system (C), household waste storage is also an interface between the waste workers and the residents (i.e. waste producers) providing an opportunity for feedback (for example, waste workers may suggest improvements to household members about waste handling or waste segregation). In humanitarian settings, waste storage systems are usually provided free of charge to residents. Storage systems might be established in different forms, for instance as built infrastructure, equipment (bins or containers) or household items (bags, or smaller bins or containers). The type of waste storage container is a critical element for efficient collection.

Objectives of Waste Storage

Whether waste is stored at household, communal or public level, the design and use of a waste storage system must consider three key aspects:

Safety and convenience for individuals and households to deposit and store waste: for waste generators, such as individuals or households, depositing waste in storage facilities needs to be as simple, convenient and pleasant as possible. The locations of waste storage should be as close to the waste generation point as possible to reduce carrying distances. They should be designed for the different individuals depositing the waste (for instance, children cannot reach above a certain height to deposit waste or lift heavy lids). Storage locations and vessels should be kept clean to minimise smell, which can prevent their use. Cleanliness and containment with a lid or through closure of the storage system will prevent animal intrusion and potential disease vectors. Storage locations should not be (or perceived to be by the users) places of risk, either from the waste itself or as a location for criminal acts or sexual or gender-based violence. There should be no risk from depositing waste for users and bystanders, especially women, children, the elderly and persons with disabilities.

Facilitating the safe and efficient emptying of the storage system during collection of waste: for operators collecting waste from storage and loading collection vehicles, waste storage must enable safe, fast and efficient handling. For example, manual loads must not be too heavy, storage containers must be easy and fast to empty and workers' exposure to waste minimised. Without these measures, the waste may not be collected and the safety of workers may be jeopardised.

Safe waste containment during storage: waste storage capacity must be sufficient to store enough waste between collections. Storage must also minimise the exposure of individuals and operators to waste, prevent the scattering of waste, avoid environmental pollution and prevent access to animal and disease vectors. The storage must prevent surface water or rainwater coming into contact with the waste or wind dispersing it. Safely containing waste also requires durable vessels resistant to the liquid and corrosive nature of waste and able to withstand, as much as possible, UV light, heat, fire, mechanical damage and vandalism.

Choice of Storage Systems and Vessels

The choice and design of storage facilities must consider the availability of materials and equipment, the waste management system, waste practices, the spatial characteristics of the settlements, and affordability.

The appropriateness of storage solutions may change in different humanitarian phases. Emergency waste storage might be based on the simplest and most accessible designs and be at the community level (S.2). In protracted or development situations waste storage solutions can become more complex and extensive and are likely to be complemented by community sensitisation and information campaigns (X.6). At this stage, household storage (S.1) may be combined with community shared storage (S.2) and public litter storage (S.3).

The choice of storage solutions needs to consider the existing practices, waste management activities and services of nearby settlements and service providers. This increases the opportunities for synergies and may lay the foundation for better exit strategies such as handing over to local utilities and authorities. While addressing the three storage objectives described above, the selection of preferred storage solutions is best made using a participatory approach with the community (X.2).

Ideally, the storage vessels of choice are already used locally and are available at local markets and retailers. Nevertheless, durability, ease of use and costs are essential factors to consider. If vessels are perceived as too expensive to be used for waste storage, they might be repurposed for the storage of more valuable goods, such as food or, if received free of charge, may be resold. The volume of storage vessels must always include reserves to prevent overflows and to cover for potential delays in collection frequency and irregular service.

Waste storage must be appropriate for the next step of the SWM service chain: the collection and transport (chapter C) of waste. Whatever the means of transport – manual transport (C.1), animal transport (C.2) or motorised transport (C.3 and C.4) – storage must enable safe and efficient emptying and waste collection.

Waste segregation, an important measure to recover valuable materials from waste and reduce the amount of waste, requires different storage systems depending on the material segregated (PART 1: Waste Separation). It is essential to highlight the specific waste material each storage vessel should receive, with colour coding and clear descriptions. The number and design of vessels must match the number of segregation categories and their generation rate, volume and collection frequency.

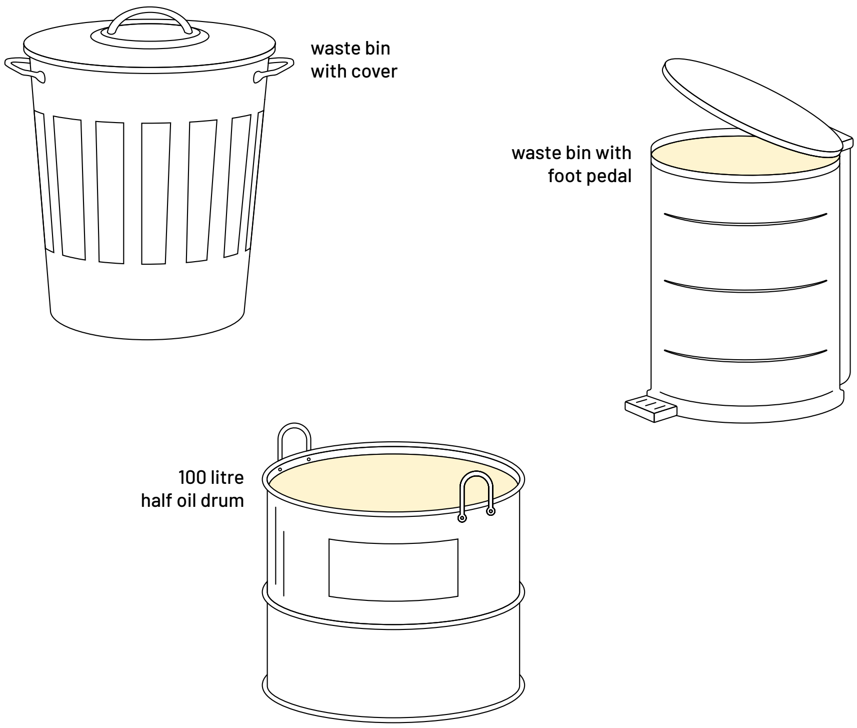
Social Considerations

Convenient, functional and economic waste storage facilitates cleanliness in communities and households, providing dignity and protection from public health and environmental risks. Affected communities in emergencies might be unfamiliar with waste management and, especially, waste storage. Individuals might be too traumatised and occupied with the after-effects of disasters and tragedies to consider SWM as a priority. SWM interventions which anticipate active roles for individuals and households must therefore be simple and as similar as possible to previous practices. Significant changes in behaviour (X.6) or different storage systems should ideally be introduced at a later stage with the participation of the affected population (X.2).

Before distributing items for household waste storage, other basic storage needs must be covered to avoid the diversion of waste storage vessels to other purposes.

Individual / Household Storage

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation * Recovery ** Protracted Crisis ** Development	** Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	** Household Shared Public	Safe waste storage at household level	Community participation in waste storage
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low		All primary input products	All primary input products



For the safe storage of household waste, different storage containers are appropriate depending on the context. Containing either segregated fractions or mixed waste, they are an important interface between households and waste collection and transport (chapter C). Waste workers empty them into collection vehicles or householders empty them into communal storages.

Adequate and safe waste storage at a household level is an essential element in the SWM service chain. It prevents the spreading of waste into the immediate surroundings of households, separates waste from contact with humans and animals and restricts environmental pollution from waste. Waste segregated at source requires one container for each segregated fraction. Containers are either picked up at households and emptied by waste collectors, or householders carry containers to a communal/shared storage facility **(S.2)** to empty. A variety of storage containers may be appropriate depending on material availability and the local context. Existing vessels, containers and bins can be repurposed and adapted for waste storage. Storage containers must enable convenient usage and their volume must align with the types of stored waste, the amounts generated and the collection and/or emptying frequency. Full vessels still need to be portable and liftable.

Design Considerations: Storage vessels should be durable, washable and convenient to use. Tapered shapes facilitate emptying. Handles facilitate carrying. Well-fitting lids reduce human exposure to waste, prevent access by disease vectors and reduce the potential leakage of waste into the environment. Clear marking of containers highlights their intended use. Waste separation **(PART 1: Waste Separation)** at source requires colour-coded and marked containers for each waste fraction. Containers with holes or mesh structures should not be used as they allow the leakage of liquids and waste. The lining of storage containers with plastic bags is feasible to avoid leakage and facilitate emptying. The total weight of a full container should not exceed 20 kg to allow carrying; dense and heavy organic waste will require smaller-sized containers. Depending on the amount of waste generated and emptying frequency, it may be possible to use multiple small containers.

Materials: Ideally, storage container materials are durable, low-cost, non-corrosive and UV-resistant. If hot ash is deposited, materials also need to be heat-resistant. Prefabricated bins made of plastic or steel are appropriate. Short-lived materials such as cardboard are not ideal as they break easily or leak. Lining hard-shell containers with removable plastic bag liners helps to keep bins clean and facilitates emptying but should not be used to store segregated organic waste as it disrupts organic waste recycling.

Applicability: Household storage can be implemented in rural, urban and camp settings. It can be collected from households or communal storage. Regular and reliable waste collection, an area-wide distribution of storage vessels and the corresponding training of households is required. During, or shortly after emergencies, the use of household storage containers might be challenging. Supplying single-use plastic bags in combination with communal/shared storage **(S.2)** may be more practical.

Operation and Maintenance: Householders must use and maintain their waste storage containers and either hand them over to waste collectors during collection or carry them to the communal storage facility for emptying. Storage containers require maintenance through washing and repair or replacement. Collection from households may require waste operators to enter premises, which might be inappropriate for male collectors in some contexts.

Health and Safety: Household storage must be safe for both household members and waste collectors, which means minimal exposure to waste. Regular cleaning of bins is required. Unsanitary double usage of waste containers (such as alternating use between food and waste) must be prevented. The weight of a full storage container should allow easy lifting and emptying by household members and waste collectors. Waste collectors must wear personal protective equipment when carrying and emptying waste storage containers and be trained in occupational health and safety **(X.4)**.

Costs: The cost of a household waste container depends on its material and availability. Ideally, procurement or production is done locally. If containers are provided to households free of charge, the total costs depend on the container unit cost, number of served households and number of vessels per household (in cases of waste segregation). A reserve of 20 % of containers should be available for additional distributions and equipment replacement. Prefabricated bins from plastic and galvanized steel tend to be more expensive. Durable vessels with long lifespans can reduce the need for regular replacements. Compared to the cost of waste collection, processing and disposal, the cost of containers is typically low.

Social Considerations: The correct use of household waste storage requires household members to be trained, especially if new waste management practices are being introduced **(X.6)**. Training should include correct container use and maintenance and explain how the storage management practice is linked to the waste collection system. It should highlight the public health and environmental risks of unmanaged waste. The value and cost of storage vessels must be appropriate relative to people's living conditions, income or cash assistance to reduce the risk of resale or alternative use for storing higher-value products such as food. Whenever possible, households should participate in the selection of suitable waste storage containers **(X.2)**. The needs of vulnerable persons, including the elderly and people with disabilities, must be considered **(X.9)**.

Strengths and Weaknesses:

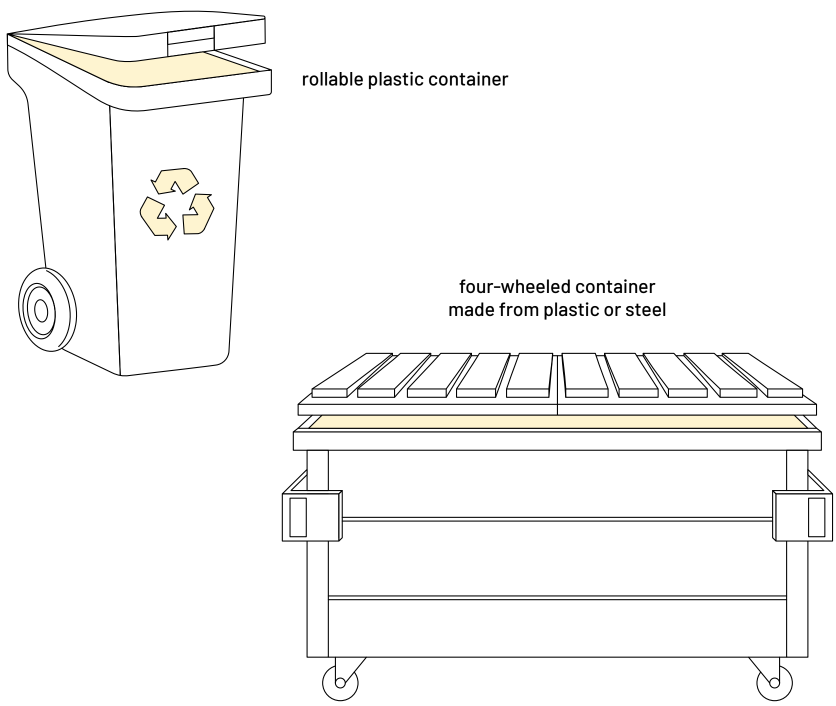
(+) Can help to contain waste at the point of generation
(+) Can facilitate the segregation of waste at source

(−) Strongly depends on community participation and reliable and regular waste collection
(−) Risk of vessel resale or alternative use

→ **References and further reading material for this technology can be found on page 173**

Community/Shared Storage

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
** Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	Individual / Household ** Community / Municipality * Institution ** Urban * Rural	Household * Shared ** Public	Safe shared waste storage used by several households	Community participation in waste storage
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	* Low	CCCM	All primary input products	All primary input products



Community or shared waste storage is used by several households at once. Householders themselves bring and deposit their waste at these locations. Storage can be permanently built structures or mobile containers; the latter simplifies collection and operation. Reasonable distances to households and accessibility for waste collection vehicles are essential.

Communal and shared waste storage vessels enable waste to be collected from fewer locations than household collections **(S.1)**. This reduces travelling distances for waste operators, avoids the need to access narrow residential roads and facilitates the use of vehicles with larger payloads. Due to the weight of mobile containers, collection vehicles must have automated emptying mechanisms. Built stationary waste structures commonly provide less protection from the intrusion of rain, wind and animals. Emptying them is more challenging, requires manual effort and puts operators in close contact with the waste. Shared waste storage requires householders to bring their waste to the facilities themselves. The depositing of waste in communal storage can be facilitated by the additional provision of household storage vessels **(S.1)**.

Design Considerations: The design of communal storage must consider the needs of households depositing waste, the operators collecting it and safe waste containment. To prevent potential nuisance from odours, it must not be too close to residential buildings but ideally should be less than 200 m from households to keep carrying distances short. To calculate storage volumes, the longest interval between collections must be considered as well as waste generation volumes, including potential seasonal fluctuations. Ideally, reserve capacity is provided for cases of delayed collections to prevent open dumping **(U.10)** or open burning **(U.11)** of waste when storage containers are full. Communal storage must be accessible to collectors and their vehicles and not put them at risk. Emptying must be fast and efficient. The selected designs should aim to reduce vandalism and theft.

Materials: Stationary structures can be built from concrete, brick or prefabricated concrete pipes. They are less effective for safe waste containment and are challenging to empty. Mobile containers are emptied on the spot or directly transported for further processing. They require collection vehicles with automated emptying and lifting mechanisms. These mechanisms must be compatible with the container types. Mobile containers are commonly made from plastic or galvanised steel; steel has the advantage of being fire and heat-resistant. Mesh structures or metal cages with multiple openings are not ideal for waste storage as waste is easily lost during storage and is more accessible for animals.

Applicability: Communal storage is ideally used in urban settlements or densely populated camps. Containers can be linked to several shelters or even to multi-story housings. Institutions, which create large amounts of waste, might use similar storage facilities. In existing built settlements, initiating new collection points can be challenging due to limited space and access. In emergencies, using communal storage is simpler than direct collections from households, as the planning and execution of collection routes are less complex and travelling distances shorter.

Operation and Maintenance: Communal storage requires dedicated caretaking and regular emptying as they will otherwise become locations for unsafe disposal practices. Supervision of communal storage is recommended and increases the likelihood of correct waste disposal, especially in the case of waste separation **(PART 1: Waste Separation)**. Once waste segregation has been compromised by a faulty waste deposit, it is almost impossible to correct and maintain adequate waste segregation. Householders must be thoroughly trained and introduced to the use of communal waste storage **(X.6)**. Storage vessels should be regularly cleaned and maintained, especially the space around them and user interfaces, such as lids. Maintenance and repair must be considered, particularly for movable containers, as they can be damaged during motorised lifting and emptying. If lids are too heavy, damaged or dirty, people may not use the storage facilities.

Health and Safety: Communal storage must allow for convenient and safe waste deposits for individuals and households and enable safe collection for operators. The attraction and presence of wild animals, and disease vectors in particular, must be prevented along with the ingress of rain and leachate of liquids. Light and conveniently movable lids are useful, and storage vessels can be protected with simple shelters. For waste operators, regular occupational health and safety **(X.4)** practices apply.

Costs: The cost of communal storage depends on the storage type, number of storage locations and materials. Financial trade-offs between materials and collection costs may occur as smaller and cheaper storage containers require more frequent emptying. Stationary storage is less expensive but has containment and safety disadvantages and requires a larger workforce. Mobile storage is simpler to operate but is typically more costly and requires mechanical emptying and lifting devices on collection vehicles.

Social Considerations: Communal storage must be in safe and welcoming spots and within a reasonable distance of households. Overall, they should give an appealing and clean impression. Otherwise, they are unused and waste is simply dumped. Assigning staff to communal storage can help people to deposit waste correctly. It is highly unlikely that householders themselves will rectify incorrectly deposited waste, compact the waste or call collection services if containers are full. Where waste segregation is applied at communal storage facilities, the different storage compartments must be clearly marked or colour-coded according to the segregation categories **(PART 1: Waste Separation)**. Training or behaviour change campaigns with the communities are likely to be necessary **(X.6)**.

Strengths and Weaknesses:

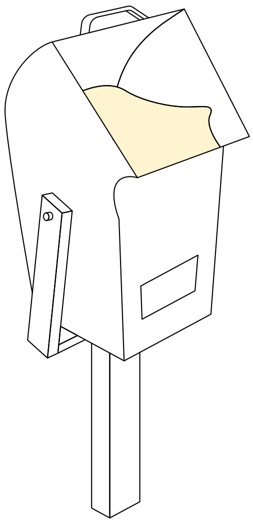
- (+) Can limit traveling distances and time for waste collection
- (+) Can simplify collection routes using larger roads

- (−) Need to be accessible for collection vehicles
- (−) Requires servicing and can require permanent supervision
- (−) Can become locations of unsafe waste deposits
- (−) Achieving waste segregation is challenging

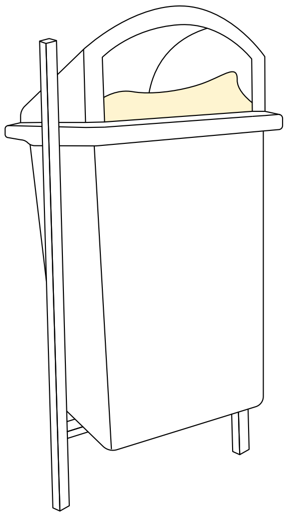
→ **References and further reading material for this technology can be found on page 173**

Public Litter Storage

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response Stabilisation * Recovery ** Protracted Crisis ** Development	Individual / Household ** Community / Municipality Institution ** Urban * Rural	Household * Shared ** Public	Safe storage of solid waste in public areas and prevention of littering	Community participation in waste storage
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low	CCCM	All primary input products	All primary input products



tiltable outdoor litter bin



outdoor litter bin

Public litter storage helps prevent the uncontrolled scattering of waste in public areas, especially in places with high levels of waste generation such as markets. A dense network of bins on streets and other public grounds fills the gap left by household and communal storage.

Public litter storage is used to dispose of waste generated by individuals in public areas. It complements household **(S.1)** and communal **(S.2)** storage systems. To collect and manage waste in public areas, a dense network of public litter bins is required, especially in and around markets and in parks. In residential areas, the density of the public litter bin network can be lower. Public litter bins may have similar or larger storage volumes to household bins but are much smaller than communal storage facilities. A dense network of bins provides frequent and convenient places to deposit waste near the generation of waste. Public litter bins are commonly managed along with the cleaning and sweeping of public spaces and streets.

Design Considerations: Public litter bins must be designed for convenient use by waste generators and safe and fast emptying for operators. The bin itself must contain waste safely and prevent access to animals. The bins must be frequently and systematically located, easy to find visually and clearly distinguishable from other infrastructure such as mailboxes. Public bins should not be easier to access than communal storage in residential areas and should not be used for household waste. A cover on public litter bins helps keep animals out and protects against rain. Safe and fast emptying can be facilitated by removable inner casings, or by pivotable bins which can be tipped during emptying. Rotary pivot mechanisms should be lockable and sufficient space left below the bins to catch waste with a movable container. Bins with inner casings should be lockable to prevent removal or uncontrolled emptying. Using plastic bags instead of inner casings is not recommended in humanitarian settings as high-quality bags are required to carry the weight of waste.

Materials: Public litter bins are ideally made of durable materials, such as plastics or galvanised steel, and resistant to the potentially liquid and corrosive nature of waste. For plastics, UV resistance must be considered. Steel bins have the advantage of being heat and fire-resistant. Repurposed vessels, such as plastic containers or cleaned oil drums, can also be used and customised for waste storage. Strong bins reduce the risk of destruction or vandalism but are commonly heavier and more expensive. Theft and vandalism can also be prevented by attaching bins to existing walls and buildings.

Applicability: Due to their large number and the corresponding effort required for installation, maintenance and emptying, public litter bins are not recommended during or shortly after emergencies. During these phases, larger, movable containers located in public areas are more likely to be suitable **(S.2)**. Communities need to be sensitised and motivated **(X.6)** to use public litter bins, which makes their use more appropriate in protracted or development settings. Public litter bins can be installed in rural and urban settings but may be more relevant in urban settings given the higher population. The density of urban public litter bins also facilitates their operation because of shorter travelling distances for collection and maintenance.

Operation and Maintenance: Public litter bins are commonly operated, emptied and maintained by waste workers engaged in street cleaning and sweeping. Maintenance is essential to keep bins clean and usable and to repair damage caused by vandalism, corrosion or fires. Regular emptying prevents bins from overflowing and attracting animals and ensures their convenient and safe usage. In hot and humid climates, litter bins should be emptied at least every second day, if not daily, as organic waste rapidly degrades and smells. More frequent emptying is also required in areas of increased waste generation, such as in or around markets. Community sensitisation is usually needed to facilitate the use of the bins **(X.6)**.

Health and Safety: Public litter storage must enable convenient and safe waste depositing. The attraction and presence of wild animals, and disease vectors in particular, must be prevented. The ingress of rain or loss of waste by wind can be prevented with lids or horizontal openings. As the release of leachate must also be prevented, holes in the bottom of bins or bins made of wire mesh are unsuitable. Regular occupational health and safety **(X.4)** measures are needed for operators.

Costs: The cost of public litter storage depends on whether industrially fabricated or locally produced equipment is used, or whether available containers are repurposed and customised for storage. Cost also depends on the bins' materials and auxiliary structure (e.g. for tipping bins). Overall costs must include the total number of bins, emptying frequency, spare parts, travelling distances and the workforce required for operation, maintenance and repair. In some settings, company advertisements placed on bins or branded bins provided by companies can reduce costs.

Social Considerations: The public's active use of public litter storage is key to its success. Sensitisation about the risks of scattered waste is usually required **(X.6)**. As a public service, the bins might not be seen as belonging to the community and its members, so the level of effort and interest in keeping them clean might be limited. The practice of littering might be averted by keeping public areas clean through street sweeping and cleaning campaigns. In the absence of enforced littering regulations or related social norms, experience shows that public litter bins can be neglected by communities.

Strengths and Weaknesses:

(+) Enables waste storage in public areas
(+) Complementary to storage efforts at the household and communal level
(+) Can be used to sensitise communities about waste management

(−) Require frequent emptying, maintenance and repair
(−) Active use strongly depends on community practices and social norms

→ **References and further reading material for this technology can be found on page 173**

C

Collection
and Transport

This section describes the different means of transport for the collection and transport of waste. The regular, safe, reliable and efficient collection and transport of waste is a key element in the SWM service chain, connecting the location of waste generation to the location where waste is treated or disposed of. If the equipment and infrastructure of waste collection and transport are not adapted to local contexts and needs, or their use is not adequately managed and operated, the performance of the entire SWM service chain is at risk. Collection and transport services must be available for all; be reliable and regular; and their capacity adjusted to the amount of waste produced. Otherwise, waste accumulates in households, neighbourhoods and public spaces. This discourages communities and can lead them to engage in unsafe practices such as open dumping (U.10) and open burning (U.11) of waste. During collection and transport, special care must be taken to avoid intentional or unintentional waste spillage into public spaces, endangering public health and the environment. The following five collection and transport technologies, including transfer stations (C.5), are described in more detail in subsequent sections. Transfer stations combine different transportation types and systems, covering the needs of both primary and secondary collection. Primary collection is the collection from the location of waste generation to a transfer station. Secondary collection is bulk transport from a transfer station to the site of disposal or use.

C.1 Manual Transport
C.2 Animal Transport
C.3 Motorised Transport – Small Vehicles
C.4 Motorised Transport – Large Vehicles
C.5 Transfer Station

Selecting Vehicle Types for Collection and Transport

Waste collection and transport must be as effective as possible which requires appropriate vehicles. Many factors determine the selection of appropriate vehicles including sufficient capacity (vehicle body volume) to transport the amount of waste required; appropriate vehicle width and weight to match road width, road surface quality and road slope; and the specific vehicle design and equipment measures to minimise loading time and exposure of waste collectors to waste. Other factors and aspects affecting vehicle choice and design include the transport distances (which influences the means of propulsion) and the widespread availability of vehicles in an area (which is linked to locally available skills and the supply chain for maintenance and customisation). Furthermore, the extent of waste segregation at the point of collection and the physical interface to load/unload waste at a transfer station, also influence the choice of vehicles. Finally, vehicle selection also depends on cost and/or the availability of capital and the operational budget of the service provider. Small and manoeuvrable vehicles (C.1, C.2, C.3) are typically used for collection in dense settlements with narrow access roads and when transport is limited to shorter distances. Bigger vehicles with large payloads (C.4) can be used for bulk transport over longer distances. Where the hauling distances from the point of collection to the location of treatment and/or disposal are long, it is often most economical to combine small vehicles for primary collection (delivering waste to a collection point or transfer station (C.5)) and larger vehicles (C.4) for secondary collection over longer distances to the point of use or disposal.
For these reasons, waste transport is almost exclusively based on the usage of differently powered vehicles. The volume of waste to be collected along a selected route will influence decisions on the body volume size of the vehicle. Density (defined by weight per volume), route distance, road surface quality and road slope will influence the selection of the vehicle's type of propulsion. The propulsion of the vehicles can be by humans, animals or engines. The efficiency of the loading is influenced by the vehicle's design. It is also affected by household waste storage practices and the interface between waste generation and collection (household, communal or public). Loading and unloading waste must be as efficient and fast as possible to ensure the productive use of vehicles and operators' work time. Collecting waste in bags or bins, for example, requires less loading time than manual loading by waste collectors from waste piles on the ground using shovels and rakes.

Point of Collection

At the point of collection, the design of the collection and transport system differs according to the needs and behaviour of the service users. It also depends on the finance available for the collection service.

Door-to-door collection service: when collectors knock on each door to request and obtain the waste.

Roadside collection service: when residents leave their waste at the roadside at a specified time for a scheduled collection. Similarly,

Summoned collection: a type of roadside collection but when residents are alerted (for instance by a bell) to bring their waste to the collection vehicle.

Self-delivered collection: when residents themselves bring the waste to a collection point or communal storage.

Door-to-door, roadside and summoned collection take the most effort and time as numerous collection points must be visited. Self-delivered collection is commonly more efficient as fewer collection points are needed. The applicability of the different means of transport is summarised in the following table:

Characteristics	Manual Transport	Animal Transport	Motorised Transport Small Vehicles	Motorised Transport Large Vehicles
Suitability for dense settlements	High	Medium	Medium (depending on vehicle type)	Low
Suitability for long transport distances	Low	Low	Medium	High
Suitability for large transport weights	Low	Low	Medium	High
Capital cost	Low	Low	Medium	High
Operational cost	Low	Low	Medium	High
Required size of workforce	Large	Large to medium	Medium to small	Small
Required skill level of workforce	Low	Low	Medium to high	Medium to high
Required vehicle fleet	Large	Medium	Medium to small	Small
Complexity of maintenance and repair	Low	Low to medium	Medium	High

Timing and Frequency of Collection

Regularity and reliability are key features of good waste collection. The collection frequency of a regular service depends on the waste amounts that accumulate at the point of collection, the vehicle capacity and the composition of the waste. Organic waste, for instance, rapidly decomposes in hot climates and should be collected daily or at least every second day to avoid smell and the attraction of disease-spreading animal vectors. Segregated inorganic waste can be collected less frequently (e.g. every two weeks). It is crucial to prevent overflow at waste storage facilities or collection points. Depending on the type of waste collection system, the timing of waste collection must match the accessibility of the point of collection or the residents' availability to hand over the waste. The planning and timing of collection routes should keep travel distances short and avoid heavy traffic.

Waste Segregation

The segregation of waste into different fractions, such as biodegradable waste, recyclable materials and residual waste, is an essential stage that happens before waste collection (PART 1: Waste Separation). Waste sorting happens during or after collection and transport. When waste is segregated, it is the responsibility of the collection and transport system to ensure that waste remains segregated. This can be achieved through separate waste collections – either different collection rounds collect the different fractions, or the collection vehicle is designed with separated compartments to collect the different fractions during the same collection round. Waste collectors must be trained to ensure that segregated fractions are not mixed. Door-to-door collection provides more opportunities for operators to verify waste segregation and, if need be, to provide feedback and instructions to households.

Involvement of the Community

Communities must be aware of the collection frequencies and timing as they may need to prepare the handover of waste to operators, especially for door-to-door, roadside or summoned collections. Clear and accessible complaints procedures and options can help identify inadequate collection frequencies or service levels (X.3).

Staff and Occupational Health and Safety

At a minimum, operators and drivers of waste collection and transport must be trained in occupational health and safety measures (X.4) and safe waste handling. Assigned vehicles and collection and transport routes need to be clearly communicated. Appropriate Personal Protective Equipment (PPE) must be provided for different staff duties. Personnel must have access to washing facilities at work to ensure personal hygiene. The workforce must be representative of sub-communities with different cultural backgrounds, origins etc. and should be, when possible, gender-balanced.

Supervision and Monitoring

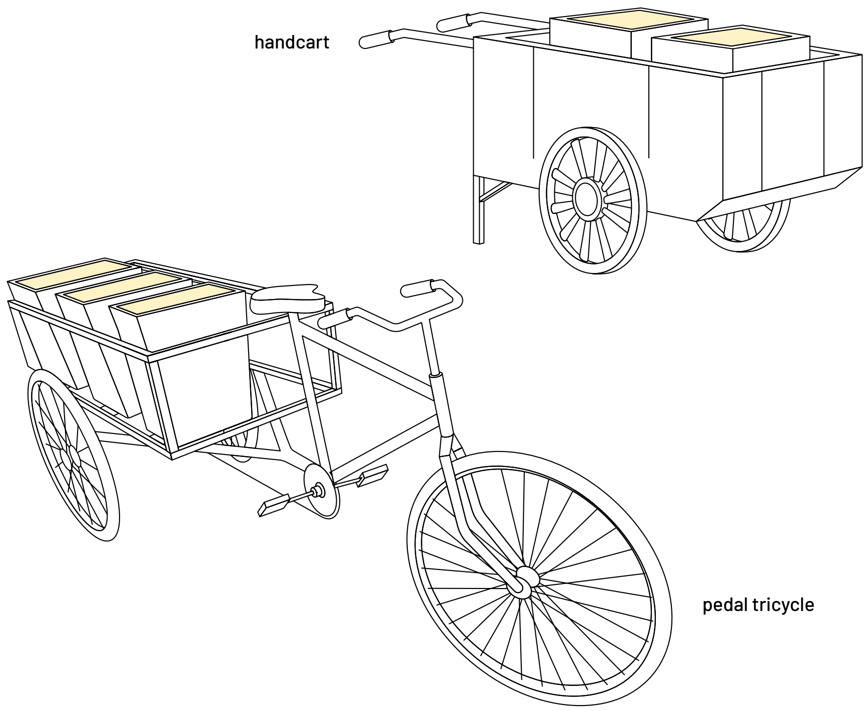
The provision of waste collection and transport requires careful supervision and monitoring. The amount of waste collected, number of loads and areas served must be recorded and analysed. This helps prevent the misuse of vehicles and fuel, assess whether transport capacities are sufficient and adequately distributed, and monitor whether storage locations and points of collection are served according to need. Drivers and operators should be actively consulted regarding potential improvements for collection and transport (X.2).

Cultural and Social Considerations

Cultural or social challenges regarding the collection and transport of solid waste must be considered from the onset. Granting household access to waste workers increases the associated risks for household members and workers (e.g. female waste workers) and must be carefully evaluated. To prevent the stigmatisation of waste handling, communities need to be informed about the importance of SWM (X.6). To create and maintain a positive impression, vehicles and PPE should be marked in an appealing and colourful manner and be regularly cleaned.

Manual Transport

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Waste collection and waste transport over short distances	
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low		All primary input products	All primary input products



Manually powered waste collection and transport vehicles are labour-intensive solutions which are suitable when the topography is fairly flat, roads are narrow or congested and distances are short. Given its limited load capacity, simplicity and low cost, it is often the default solution for household primary collection.

Manual collection and transportation of waste is defined as being powered by human strength alone. The wide range of non-motorised vehicles typically used for the transportation of goods can be adapted for waste transportation. This ensures local maintenance and repair. Manually carrying waste without any vehicle is rare and limited to very small and inaccessible footpaths and hilly terrains. Load volumes of manual waste transport vehicles are typically small and, given the slow speeds, travel distances are short. These vehicles are suitable for waste collection in dense neighbourhoods with limited road access for door-to-door, kerbside or communal storage collection. After collection, the waste transported by manually powered vehicles is ideally delivered to transfer stations **(C.5)** where it is handed over to larger, often motorised transport vehicles **(C.3 and C.4)**.

Design Considerations: Given the limited payload per vehicle, service coverage requires a large workforce and vehicle fleet. One person or a small team can operate one vehicle. Ideally, common local transport solutions, such as wheelbarrows, pushed or pulled handcarts or pedal tricycles with front or rear-mounted storage compartments, are customised for waste transportation. This can include different storage compartments (if waste is segregated) and extra hooks for bags. Handcarts with more than one axis facilitate stability and balancing of loads. Wheel width needs to be adapted to ground conditions with, for example, wider tyres for sandy paths. The loading height must not be above the workers' shoulder height. Unloading must be compatible with the design of the final destination and might be facilitated by individual containers placed in the vehicle. For segregated waste, the number and volume of compartments must correspond with the generation of waste fractions and ideally be colour-coded or marked with logos **(PART 1: Waste Separation)**.

Materials: The advantage of using locally widespread manually powered transport vehicles is that local procurement, maintenance and repair are readily available. The materials of storage compartments must be resistant to the corrosive nature of waste and its leachate. Lids on the storage compartments help avoid attracting insects and prevent the compartments from filling with rain.

Applicability: In humanitarian settings, locally available manual transport can be quickly mobilised at a very early stage of an emergency and continue into protracted contexts. It is applicable in all settings where road conditions and topography permit human-powered transportation. Sandy terrains without roads or hilly settings with steep slopes are less suitable. Manual transport can handle mixed and segregated waste; collection can take place at household, communal or public levels. Due to its manoeuvrability and small size, manual transport is ideal for primary collection, transporting waste to larger collection points or transfer stations **(C.5)**. Its low capital and operational costs make it suitable for settings with limited funding. Large workforces are required to operate vehicle fleets but the skills required are rather low.

Operation and Maintenance: The number of vehicles, required workforce and routing of waste collection rounds can be determined by the coverage area, waste generation, vehicle capacity and speed. Fleets ideally include reserve vehicles. Door-to-door service requires a larger fleet and workforce as loading times are longer. However, it can still be justified as waste may be better captured and waste segregation enhanced **(PART 1: Waste Separation)**. Because of its simple and local technology, service interruptions are rare as local repair is reliably available. The workforce can be made up of community members, whether employed staff or through cash-for-work programmes **(X.5)**. Operators must be well trained, especially if source-segregation of waste is in place, and be instructed on the collection routes and frequencies. Troubleshooting minor vehicle breakdowns during collection rounds is essential.

Health and Safety: Operators need to be equipped with personal protective equipment and trained on the public health and environmental risks of waste. Further training should cover occupational health and safety **(X.4)**, including the correct lifting of heavy items. The design and operation of vehicles should ensure the minimum exposure of workers to waste during loading, transport and unloading. Waste storage compartments used on the vehicles must be designed to prevent waste leakage during transport.

Costs: Context-adapted, low-tech vehicles and a local workforce lead to low capital and operational costs. The involvement of trained community members provides an opportunity for livelihood and income generation.

Social Considerations: The hiring of a large workforce creates opportunities for income generation within communities **(X.5)**. To prevent inequality, recruitment must be equitably balanced across sub-communities with different cultural backgrounds and origins. If possible, the workforce should be gender-balanced. Depending on cultural and social norms, the involvement of women in manual transport might be challenging (e.g. women might not be allowed to use bicycles, work with men outside their families or move around freely without family accompaniment).

Strengths and Weaknesses:

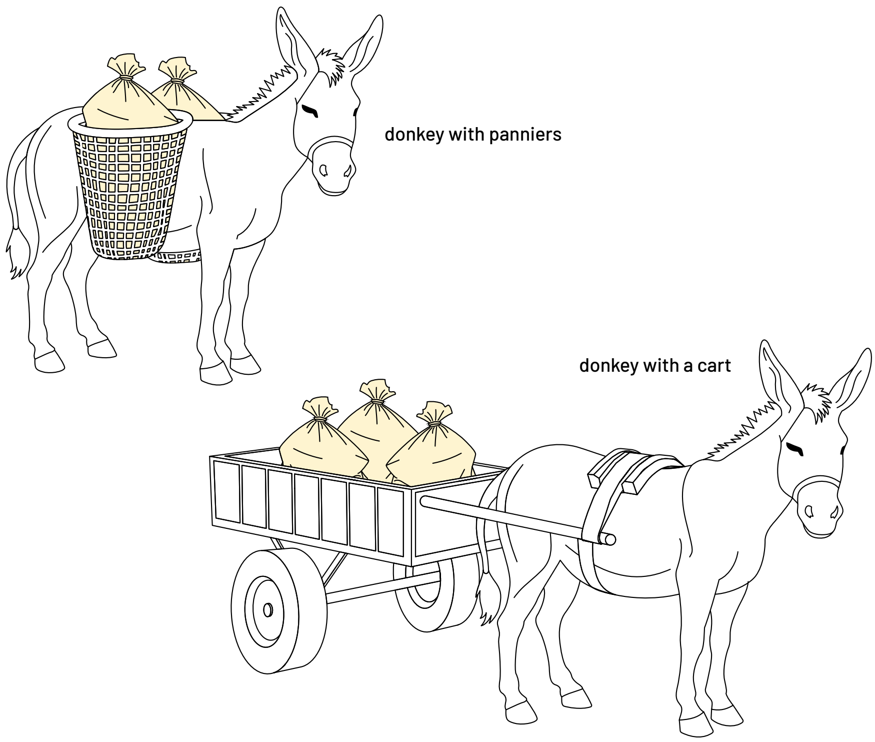
(+) Adapted to dense settlements with narrow access roads
(+) Simple and locally used vehicles are readily available and maintained allowing fast start up
(+) Low cost and suitable for settings with limited funding, especially protracted contexts

(−) Limited payload and distance per vehicle
(−) Large fleets require detailed operational planning
(−) Cannot be used in sandy terrain or on very steep roads

→ **References and further reading material for this technology can be found on page 173**

Animal Transport

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Waste collection and waste transport over short distances	History of use of draught animals
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low		All primary input products	All primary input products



Animal collection and transport refers to the use of draught animals for the collection and transportation of solid waste using a cart or panniers. A waste collection worker is always required to collect the waste, lead the animal and empty the carrier.

A cart or panniers are attached to a draught animal and used for the collection and transportation of solid waste. Donkeys, mules, horses or buffaloes are typical draught animals in various contexts. A worker collects the waste from the waste producers and fills the cart or panniers. The waste is then transported and tipped off the carriers at a transfer station **(C.5)**, a treatment facility **(section T)** or for final disposal **(section U)**.

Design Considerations: Harness design aims to distribute the weight evenly and prevent injury while allowing natural movement and preventing chafing and sores. Padding and appropriate fitting are needed to secure the harness and protect the animal. Carts or panniers must be securely attached to the harness but be easily detachable when needed. For carts, a low centre of gravity and a wide enough wheelbase prevent accidental tipping. Preferably, the load is positioned directly over the axle. A brake system is indispensable, especially for going downhill. A robust axle and simple suspension system can improve the cart's durability and ride quality. Suitable tyres for the terrain are required. A tipping mechanism can either directly tilt the body of the cart or use a manually operated worm and nut mechanism. For panniers, a robust but flexible structure with a system to secure them on the animal for stability is important. The maximum load capacity and size are defined by the animal; pulling should be comfortable throughout the whole collection route, especially while moving uphill with a loaded cart or panniers.

Materials: The draught animals used (such as horses, donkeys, buffalos or mules) are context-specific and should be adapted to the local conditions. Panniers and carts can be designed and constructed in many ways using various materials (such as metal, wood or various basket materials) depending on their availability locally.

Applicability: The radius of operation is limited to a maximum of around 3 km due to low speeds. Depending on the animal's level of fitness, travel distances of up to 5 km may be possible. The capacity of a cart can range from 1 to 4 m3, depending on its design, and should be adapted to the type of road, terrain and draught animal. For longer distances larger capacity motorised vehicles **(C.4)** or intermediate storage options like a transfer station **(C.5)** should be considered. Animals equipped with panniers can collect waste in areas with uneven terrain, unpaved roads and steep slopes. Nonetheless, the volume of panniers is limited, and several animals may be required to cover the collection needs. The small and adaptable size of the carts and panniers means the technology can be used in areas that are otherwise difficult to access (such as narrow streets or densely populated areas). Because of its slow speed, animal transport may not be suitable in highly urban areas as it can slow or obstruct the traffic.

Operation and Maintenance: The materials required to build the carts or panniers are often locally sourced and easy to maintain and repair. The equipment can be regularly inspected and repaired to maintain full functionality. Adequate grease should be added to moving parts. As only animal power is used, no fossil fuels or electricity are required. Care must be taken of the animal, including proper hoof care and protection, regular inspection, and maintenance to avoid injuries and infections. Adequate feeding should be ensured as well as shelter for rest periods. Animals might spend a long time in hot and sunny conditions, so proper hydration and sufficient rest is essential.

Health and Safety: As a draught animal is used, it is important that both the handler and the animal are well trained. Gentle commands, calmness and patience are beneficial to avoid stress and accidents. For the handler, Personal Protective Equipment (PPE) is necessary as they will be in direct contact with waste. Proper PPE includes gloves, boots, long sleeves, a cap, and trousers or an overall **(X.4)**.

Costs: Generally, the capital costs are relatively low and comprise the capital cost of the animal, cart or panniers. Operation and maintenance costs are also low as no fuel is required and maintenance can often be done using locally available parts. The animal must be fed and space is required for both the animal and the cart when not in use. Some expense is necessary to secure and maintain the health of the animal in an optimal state as the technology relies heavily on its capabilities. For small businesses in the informal sector (often run by very poor people), using animal traction can be relatively expensive.

Social Considerations: Animal collection and transport are most appropriate in areas with a history of using draught animals. This is linked to the social acceptance of draught animals and local knowledge to handle and care for the animals. The animals' welfare is an important consideration, ensuring that they have sufficient food, rest and adequate equipment, and only carry weights that match their capacity and the terrain. Animal excreta management is necessary to avoid it spreading, especially in denser urban areas. Faeces can be cleared from the ground or captured directly in a bag under the animal's rear.

Strengths and Weaknesses:

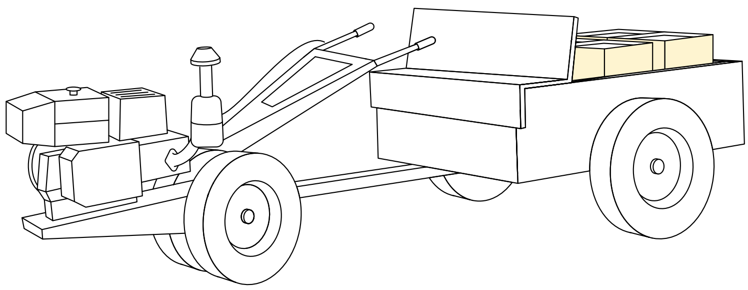
(+) No fossil fuels needed
(+) No driving licence requirement for the driver
(+) Suitable for narrow streets, unpaved roads and hilly terrain
(+) Low capital and operational costs compared to motor vehicles

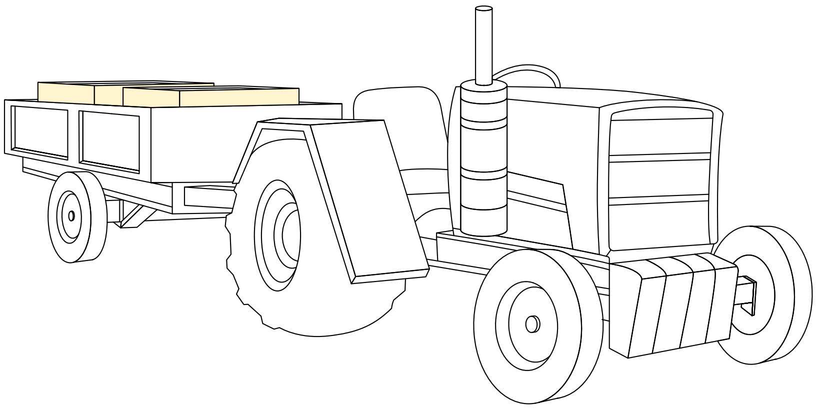
(−) Slow; traffic congestion/interference with traffic
(−) Limited capacity, short distances only, not adequate for long transportation routes
(−) Only appropriate if draught animals are commonly used locally

→ **References and further reading material for this technology can be found on page 174**

Motorised Transport – Small Vehicles

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
** Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Manoeuvrable and fast waste collection and waste transport over medium/longer distances	Accessible roads
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	** Medium	Private Sector Partners, Utilities, CCCM, Logistics Cluster	All primary input products	All primary input products





Small and medium-sized motorised vehicles are manoeuvrable in narrow roads and dense settlements, fast if road conditions and traffic permit and have significant payloads. As a result, they fill the gap between low-tech transport modes (such as manual (C.1) and animal (C.2) transport) and more complex, costly and less manoeuvrable large, motorised waste transport (C.4).

Various vehicle types exist for small and medium-sized motorised transport; they have different characteristics and a broad range of possible applications. The vehicles include two-wheeled tractors, three-wheeled motorbikes, auto rickshaws, customised pick-up cars and agricultural tractors with or without a trailer. Due to their manoeuvrability, small and medium-sized vehicles can collect waste from household, communal and public storage and are ideal for primary collection. Because of their limited size and lightweight, they can move on roads with limited load capacity and width. Smaller motorised vehicles can travel at higher speeds than manual **(C.1)** and animal transport **(C.2)** if road conditions allow. If larger trucks are unavailable, or if conditions do not allow their usage, small and medium-sized motorised vehicles can also carry out secondary collections, transporting waste over longer distances to processing and treatment facilities.

Design Considerations: Small and medium-sized motorised vehicles must suit local conditions such as accessibility, waste quantities, transport distances and the availability of fuel. Their availability locally must be considered. Vehicles that are commonly available and widely used may be better adapted to local conditions such as the climate and road quality. Furthermore, maintenance and repair services for local vehicle types are more likely than for imported vehicles. If vehicles for waste transportation are not readily available, locally used transport or agricultural vehicles can be customised. Additionally, small and medium-sized vehicles can be adapted with integrated storage compartments, and they can be used to move containers or pull trailers. As with all transport modes, loading and unloading must limit the exposure of operators to waste and be as easy and fast as possible.

Materials: Waste storage compartments must be resistant to the potentially corrosive nature of waste. Especially in bigger or closed compartments, cleaning can be a challenge, increasing the risk of corrosion. Vehicles are likely to be exposed to difficult road conditions; frequent stops during collection routes add to wear and tear. In humanitarian settings, with often limited means for maintenance and repair, the selection of simple, sturdy and long-lasting vehicles and engines is recommended.

Applicability: Small and medium-sized motorised vehicles are ideal for primary collection as they can be used on both narrow and big roads. They can travel relatively fast even on poor-quality narrow roads. Their use in humanitarian settings must be thoroughly assessed as more basic transport types, such as manual **(C.1)** or animal transport **(C.2)**, do not consume fuel, might be less costly and require less effort for vehicle maintenance. Particularly if locally available and context-adapted vehicles are used, these vehicles may be applicable during all intervention phases, from acute emergencies to protracted and development contexts. Key conditions for their successful use are the availability of local vehicle repair and maintenance, continuous fuel supply and adequate road conditions.

Operation and Maintenance: Waste collection using small and medium-sized vehicles requires detailed route planning to ensure that vehicles are productive and to justify higher operational costs from fuel consumption and vehicle maintenance. The planning of routes should aim to avoid potential traffic jams and ensure that all service recipients are served as needed based on their waste generation. Maintenance, repair and fuel availability must be ensured at all times. Drivers should be well-informed about collection and transport routes and trained on safe and low-wear driving. During trips, drivers must be able to carry out minor technical troubleshooting in case of engine or vehicle failure.

Health and Safety: Waste loss during journeys must be prevented with, for example, closable transport compartments, tarpaulins or nets, especially on longer trips at higher speeds. For longer journeys, crew accommodation on vehicles should be considered. Riding on waste must be avoided. The loading height must not be above the workers' shoulder height and vehicle payloads must not be exceeded. The reversing of vehicles must be avoided whenever possible or assisted by waste operators. Operators are required to wear personal protective equipment and be trained in correct waste handling and other occupational health and safety measures **(X.4)**.

Costs: The cost of small and medium-sized motorised transport greatly depends on the vehicle selected. Selecting locally available, context-adapted and sturdy vehicles minimises costs. Capital costs include the initial investment and the replacement costs once the equipment or entire vehicle reaches its end-of-life. The capital costs of small and medium-sized motorised vehicles might be much lower than large trucks but are still significantly higher than manual or animal transport. Operational costs include the salaries of drivers and operators, vehicle maintenance and repair and fuel. Operational costs for smaller vehicles can be reduced if the waste collection interface with storage, transfer or disposal sites is efficient and vehicle productivity is high.

Social Considerations: Communities need to be well-informed about collection times, especially for the collection of waste from households. Motorised transport requires skilled drivers, who might be in short supply or difficult to recruit if they are unfamiliar with the selected vehicles.

Strengths and Weaknesses:

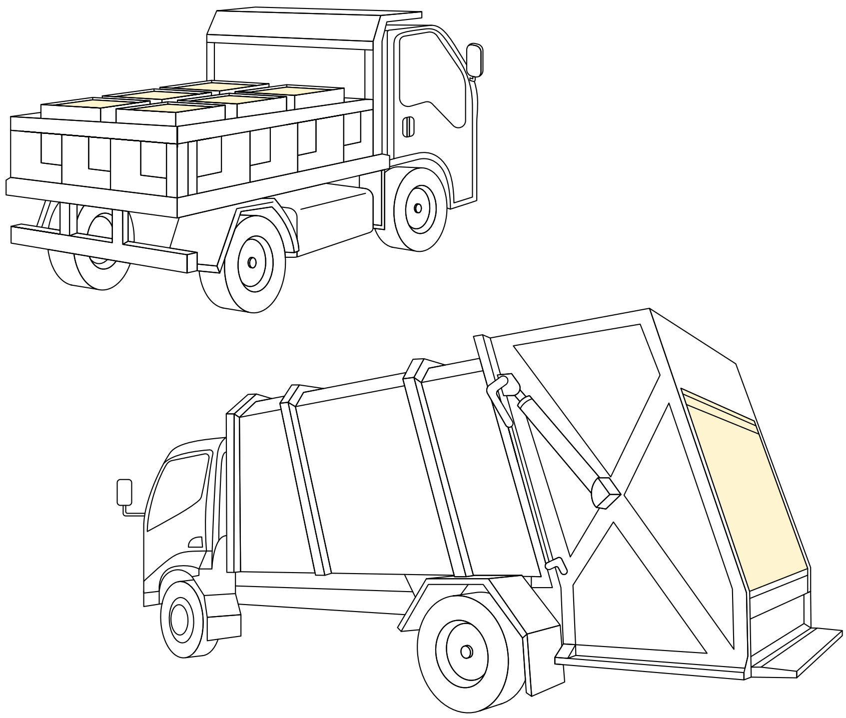
(+) High manoeuvrability in narrow roads and dense settlements
(+) Similar payloads but able to travel faster and, potentially, further than manual or animal transport

(−) Higher costs compared to non-motorised transport
(−) Increased need for vehicle maintenance compared to non-motorised transport
(−) Fuel consumption

→ **References and further reading material for this technology can be found on page 174**

Motorised Transport – Large Vehicles

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
** Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Fast waste collection and waste transport over longer distances with larger amounts of waste	Accessible roads
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	**/* Medium/High	Private Sector Partners, Utilities, CCCM, Logistics Cluster	All primary input products	All primary input products



Large-sized motorised vehicles such as trucks are ideal for long-distance and the bulk transport of waste. Due to their size and limited manoeuvrability, they are preferably combined with primary collection using smaller vehicles. The limited availability of suitable trucks, challenging road conditions, high costs and maintenance needs limit their use in some humanitarian contexts.

Large-sized motorised vehicles such as trucks have high payloads but limited manoeuvrability. This makes them ideal for secondary transport, which collects waste from transfer stations **(C.5)** and hauls it to often distant treatment and disposal facilities. A collection from household, communal or public storage is only feasible if roads are wide and strong enough to support the weight of full trucks. Large-sized waste transport uses different types of trucks according to the needs. Trucks have different weight categories and types of vehicle bodies such as high-sided open-top trucks, trucks with closed storage compartments and compactor trucks. Trucks can be customised with separate compartments to transport segregated waste. The advantage of large payload trucks needs to be balanced with their increased costs, more complex operation and greater risk of work interruptions due to high vehicle maintenance needs and smaller fleet sizes.

Design Considerations: The selection of large-sized motorised vehicles for waste transport must consider local conditions such as road width and quality, transport distances, waste amounts and local market availability. Using locally available and widely used trucks facilitates maintenance and repair. Imported vehicles may not be adapted to the width, strength and condition of the roads and local maintenance and repair might not be possible. Trucks require mechanical lifting and emptying systems as well as compatible containers (unless waste is collected directly from households). Manual loading of large waste quantities must be prevented to ensure productive vehicle usage and occupational safety. Compactor trucks are rarely feasible in humanitarian settings as waste density is often high due to high levels of organic waste. Further compaction is therefore not required or its benefits are offset by the weight of the compaction mechanism and reduced payloads.

Materials: A truck's waste storage compartments must be resistant to the potentially corrosive nature of waste. Cleaning can be challenging, especially in bigger or closed compartments; this increases the risk of corrosion. Vehicles are likely to be exposed to difficult road conditions; frequent stops during collection routes add to wear and tear. In humanitarian settings with often limited means for maintenance and repair the selection of simple, sturdy and long-lasting vehicles and engines is recommended.

Applicability: Large-sized motorised vehicles can be used in all intervention phases, from emergencies to protracted and development contexts. They are ideal for long distance and bulk transport. Collection from household, communal and public storage is also possible but requires sufficient vehicle access. This might be found in some urban contexts with larger access roads and in sparsely populated and widely extended settlements. Existing road strength and quality are important considerations for large truck use, especially during rainy seasons or other harsh weather conditions, as fully loaded vehicles can be very heavy. The trucks must be available to buy locally and local maintenance and repair services must exist.

Operation and Maintenance: The number of large-sized motorised vehicles in a fleet is typically small compared to other transport modes; the failure of a single vehicle therefore has a greater impact on overall service performance. The detailed planning of routes is essential to ensure a productive fleet that provides equal service to all service recipients, ensures accessibility for the trucks and bypasses potential traffic jams. Maintenance, repair and fuel availability must be ensured at all times to prevent the breakdown of collection and transportation services. Truck drivers must be well-informed about collection and transport routes and trained in safe and low-wear driving. During trips, drivers must be able to carry out minor technical troubleshooting in case of engine or vehicle failure.

Health and Safety: Especially for trucks with open storage compartments and on trips at higher speeds, waste loss during journeys must be prevented. Waste can be fastened down in vehicles with tarpaulins or nets. For longer journeys accommodation for the crew on the vehicles should be considered. Riding on waste must be avoided. Riding on rear platforms is only acceptable for short distances and slow speeds. Operators of vehicles with hydraulic lifting, emptying or compacting mechanisms must be properly trained to make use of these features and to prevent damage to the mechanism. The reversing of trucks must be avoided whenever possible or assisted by waste operators. Operators must wear personal protective equipment and be trained in correct waste handling and other occupational health and safety measures **(X.4)**.

Costs: Large trucks for waste collection and transport are the most expensive of all transport modes. Their use is therefore only reasonable if other transport modes have significant disadvantages in a particular context. Capital costs include the initial investment and the replacement costs once the equipment or entire vehicle reaches its end-of-life. The more specialised a truck, e.g. with lifting or compacting mechanisms, the more expensive it is. High operational costs are caused by high fuel consumption and the need for regular and complex maintenance. Operational costs can be reduced if truck usage is limited to specific and appropriate transport segments, e.g. secondary collection.

Social Considerations: Fast vehicle loading is critical to improved productivity of motorised vehicles. Therefore communities need to be well informed about collection times if such vehicles are used for household waste collection. Large-sized motorised vehicles require skilled drivers who might be in short supply and difficult to recruit if drivers are unfamiliar with the selected vehicles.

Strengths and Weaknesses:

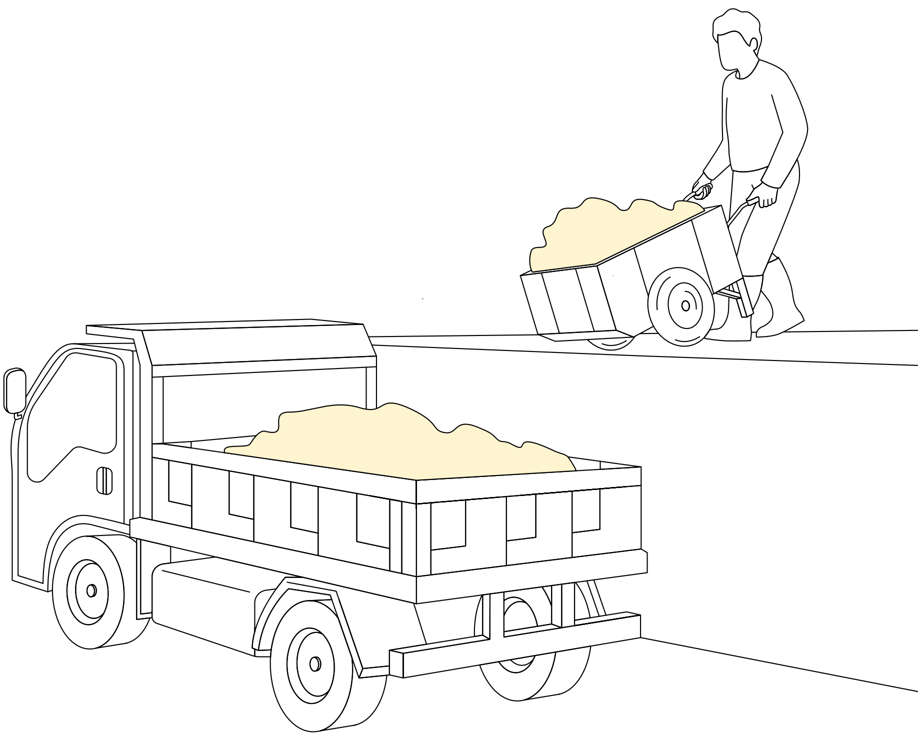
- (+) Ideal for heavy hauls over longer distances
- (+) Highest payload of all transport modes

- (−) High capital and operational costs
- (−) Requires sufficient road width and strength
- (−) Skilled drivers are required for safe and low-wear driving

→ **References and further reading material for this technology can be found on page 174**

Transfer Station

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation * Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Safe and clean transfer from collection to bulk transport vehicles	Means for primary and secondary waste collection and transport
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	** Medium	Private Sector Partners, Utilities, CCCM	All primary input products	All primary input products



Transfer stations are key facilities in waste management that enable the efficient transfer of waste from smaller to larger vehicles, optimising transport logistics. They ensure the systematic and safe movement of waste while addressing different transport needs and accessibility variations within an SWM system.

Different vehicle types are used for the collection and transport of waste depending on access and transport distances: smaller vehicles **(C.1–C.3)** for collection from storage facilities **(section S)** and large motorised transport vehicles **(C.4)** for bulk transport to treatment or disposal facilities. Transfer stations facilitate the transfer from one vehicle type to another. They must carry out this transfer as quickly and efficiently as possible to ensure the maximum productivity of all vehicle types. Transfer stations can combine transfer and waste sorting **(PART 1: Waste Separation)**, during which valuable materials are recovered and prepared for efficient further transport and processing. When sorting and transfer are combined, further soiling of recyclables can be prevented and the recovered valuables are closer to potential buyers. The disadvantage is that it can require more space, complicate operations and lead to dirtier facilities.

Design Considerations: Different transfer approaches may be appropriate in humanitarian settings. Bulk transport can wait for smaller collection vehicles (a "vehicle rendezvous") or temporarily deposit the waste on the ground, in containers or trailers. Temporary deposits on the ground are not recommended. The transfer of waste should prioritise gravity-based movement, for instance by using ramps, elevated platforms or reception areas below ground level. Movement by crane should be avoided due to potentially high waste loss. Manual movement should also be avoided as it is physically demanding and puts operators in close contact with waste. Transfer stations must be designed to maximise the productivity of vehicles; long waiting periods should be avoided. The retention time of waste should be low to prevent odour nuisance. Drainage systems should facilitate cleaning but solid pieces of waste should be prevented from entering the drains and be managed on the premises. More sophisticated transfer systems, such as stackable and retractable containers are not realistic for humanitarian settings due to their cost and complexity. Transfer stations should be positioned away from populated areas to mitigate disturbances.

Materials: Ideally, transfer stations are paved to facilitate cleaning and the collection of scattered waste. The road surface must withstand the weight of the vehicles. Cleaning materials and Personal Protective Equipment (PPE) need to be provided for staff **(X.4)**. Ramps, elevated platforms or below-ground reception areas should be paved and built with a gentle slope to allow the safe movement of heavy vehicles.

Applicability: Transfer stations and the use of different vehicle types are particularly useful if waste processing and disposal are located far from a settlement. They are less feasible in immediate emergency contexts due to the complexity of setting them up. The simultaneous need to set up the station and select different vehicle sizes and types to deliver to and from the transfer station might be too complex and the inefficient use of one vehicle type may be temporarily acceptable.

Operation and Maintenance: Efficient transfer station operation requires well-coordinated planning to harmonise vehicle capacities and routes, reduce delays and optimise usage. Planning should anticipate potential traffic jams and assess the travelling distances required. Regular, if not daily, cleaning of the transfer station prevents odour nuisance and ensures that scattered waste is not lost for further processing. Transferred waste amounts and vehicle movements should be recorded. If poorly managed, transfer stations can quickly become waste dumps. Access to transfer stations should be limited to staff to ensure safety during vehicle manoeuvrings.

Health and Safety: Faulty waste transfers must be prevented and scattered waste regularly collected to minimise the release of waste into the surrounding environment. The regular hosing down of temporary storage areas prevents odour nuisance and the attraction of flies. Vehicle reversing must be prevented or minimised. The operators' exposure to waste must be minimised. PPE, including reflective vests, and occupational health and safety training must be provided to personnel **(X.4)**.

Costs: If not in public ownership, the use of land for a transfer station can be costly. Building costs, such as for ramps, elevated platforms or below-ground receptions must also be assessed. Using cranes, wheeled loaders or storage and tipping mechanisms significantly increases costs. Operational costs mainly involve staffing.

Social Considerations: Whenever possible, transfer stations should be built at a distance from commercial or residential buildings to reduce odour nuisance and noise. The public acceptability of loading and unloading waste outside regular working hours and working days should be checked. Animals and the public must not have access to transfer stations to prevent accidents, waste picking and scattering of waste.

Strengths and Weaknesses:

(+) Enables the use of different vehicles adjusted to access and transport distances
(+) Can enhance operational productivity in waste management systems

(−) Can lead to the leakage of waste into the neighbouring environment
(−) Can increase traffic around transfer stations
(−) Can lead to odour nuisance within settlements

→ **References and further reading material for this technology can be found on page 174**

T

Treatment
and Recycling

Treatment and recycling are an integral part of the SWM chain; they promote circularity and recovery of value from waste and, more importantly, reduce the quantity of waste for disposal and its impact on the environment and public health. This aligns with the waste management hierarchy (PART 1: Waste Prevention), which advocates removing valuable and usable materials whenever possible.

This section presents eight different treatment and recycling technologies that can potentially be implemented in a wide range of humanitarian contexts. The selected solutions are feasible in humanitarian settings: they can be set up and operated at low cost, rely on simple equipment and, predominately, manual labour inputs. Nonetheless, the necessary prioritisation of immediate life-saving interventions makes their use unlikely during or shortly after emergencies. In these initial phases, the focus of SWM may be entirely on the collection, removal and safe disposal of waste.

Treatment and recycling capture the value of waste materials, repurposing, reusing, recycling or recovering their energy and nutrients and reducing the burden on waste disposal. If a treatment or recycling system already exists, separated recyclables or organic waste from humanitarian operations should be sold or handed over to the relevant local economic sector (U.1) rather than treated and used by the humanitarian sector to produce new items (U.2–U.4). This prevents market distortions and makes valuable resources available for local economies.

This section's eight technologies focus on organic waste treatment (T.1–T.5) and the recycling of plastics. Three approaches to recycling plastics are described; they are differentiated by the value and functionality of the end product compared with the initial material: Plastic recycling (T.6) is the process where the end product is of similar value and functionality as its source (e.g. waste plastic items make new plastic items); upcycling (T.7) refers to a higher value end product and downcycling (T.8) produces an end product of lower value and functionality.

Technologies for recycling other waste fractions (paper, metal, or glass) are purposely omitted here. Due to their sophistication, energy requirements or required processing scale, humanitarian actors are unlikely to implement these recycling processes. In this case, humanitarian actors should engage with the formal recycling sector, where it exists, for these waste fractions (see also U.1).

The technologies covered in this section are:

- T.1 Composting
- T.2 Vermicomposting
- T.3 Anaerobic Digestion
- T.4 Black Soldier Fly Waste Processing
- T.5 Making Fuel from Biomass
- T.6 Plastic Recycling
- T.7 Plastic Upcycling
- T.8 Plastic Downcycling

Composting (T.1), vermicomposting (T.2), anaerobic digestion (T.3) of organic waste and the production of solid biomass fuels (T.5) can be applied at both household and large-scale levels. The remaining technologies are likely to be limited to large, community-scale implementation. This limitation is often because of higher equipment costs, more complex work procedures, increased occupational safety requirements (X.4) or the size of the equipment (suitable for larger processing units). The point in the SWM service chain where treatment or recycling activities take place depends on the scale of the process. At a household level, it follows Storage (S); at a community level, it follows Collection and Transport (C).

Waste Separation as a Pre-Requisite

A key precondition for treatment and recycling is waste segregation or sorting (PART 1: Waste Separation). Waste segregation precedes waste collection and transport – the segregated waste is stored in separate containers at the point of waste generation. Thereafter, the segregated fractions can either be treated or recycled on-site or collected separately before treatment and recycling. The latter is typically carried out through a separate waste collection or by using separate compartments/containers in the collection vehicle during the same collection round. Waste segregation thus ensures that waste fractions of value are not soiled or contaminated by the rest of the waste and can be processed efficiently in the treatment and recycling step to ensure output products of high quality and value. By contrast, waste sorting is the process of extracting the materials of interest from mixed waste. Compared to waste segregation, sorting requires more effort and cost and yields lower-value raw materials for treatment and recycling. Sorting can be done during or after collection and transport or even after final disposal (e.g. mining a disposal site for materials of value). Sorting after disposal with subsequent treatment and recycling is not recommended given the low quality of resources obtained, the high costs and the higher risks to workers' safety and health (X.4). Segregation should always be prioritised over sorting. In some cases, a further sorting of segregated waste is conceivable, for instance, to generate higher purity waste fractions or to further separate materials (e.g. the removal of organic material with a high-cellulose content from organic waste prior to anaerobic digestion).

Stakeholders

The actors involved in treatment and recycling vary depending on the scale and location of the activity. Treatment and recycling at household and small-scale levels (e.g. home composting) is conducted by the household members; at a community scale it could be the responsibility of individual community members, community-based organisations, non-governmental organisations, small private sector enterprises or the SWM service provider. Actors engaged in larger, centralised processing are typically the formal and informal private sector or the responsible SWM service provider. In humanitarian settings, treatment and recycling activities also provide economic opportunities for affected communities through employment or cash-for-work programmes (X.5). Such engagement can provide immediate financial relief and contribute to local infrastructure recovery, community services and resilience-building. For all community and larger-scale treatment and recycling, well-trained staff, careful supervision and monitoring (X.3) are required. Staff must be trained in occupational safety and safe waste handling, be provided with personal protective equipment according to their different duties and have access to washing facilities for personal hygiene (X.4). Special attention should be paid to ensuring a gender-balanced workforce as well as the balanced engagement of different sub-communities with, for example, different cultural backgrounds and origins (X.10).

Outputs

Products from treated or recycled waste can be sold, distributed or used within humanitarian responses. Products can become consumer goods (U.3) for every-day needs, construction materials (U.4), inputs for use in agriculture (U.5), or an energy source in the form of biogas (U.6) or fuel from biomass (U.7). It is important to assess local markets and avoid distorting them with subsidised products from humanitarian interventions.

Financial Considerations

The cost and revenue associated with waste treatment and recycling can vary significantly depending on the size, location, type of waste and technology employed. Revenue streams from sales of treated and recycled waste may offset some of these costs. However, the income is unlikely to be higher than the costs. Planners and operators should not view treatment and recycling as a financially sustainable process but rather as an integral component of waste management which incurs costs but results in benefits to the whole solid waste system and the local economy. There are some direct financial benefits, such as reduced quantities of waste to dispose of, savings in landfill space and reduced costs of landfilling. Treatment and recycling can also reduce costs to society. Treating instead of disposing of organic waste lowers the risk of environmental pollution and greenhouse gas emissions at the disposal site. Recycling plastic reduces the risk of plastic being burned and causing ambient air pollution, the spreading of toxic compounds and greenhouse gas emissions. Recycling plastic can also prevent leakage into the environment, especially into drains and water bodies causing blockages, aquatic and marine debris or the formation of microplastic pollution.

Importance of safe material processing to prevent pollution

While the recycling and treatment of waste materials contributes to the protection of public health and the environment, it is essential that the processing itself does not create a new source of pollution. Treatment and recycling processes must be executed in the safest way possible, even in humanitarian settings. For instance, if plastic processing is not conducted in a safe and controlled manner, it can lead to the formation of microplastics, the release of toxic fumes or the spreading of plastic waste into the environment polluting soils and water bodies. If organic materials are not managed with care, they can become a breeding ground for disease vectors, create greenhouse gas emissions or pollute water bodies. In keeping with Do No Harm principles (Introduction: Principles and Standards) all those involved in the planning of treatment and recycling activities must assess the adequacy of their expertise and the potential negative impacts of their activities on the public health and environment.

Key Elements for Selecting an Appropriate Recycling and/or Treatment Option

Not every option suits every context, and it is therefore important to select the recycling and treatment options that fit the technical, economic and social context of the specific location and the expertise of involved actors. Typical questions to be answered are as follows:

Technical aspects:

- Are waste characteristics and amounts suitable for the treatment/ recycling option being considered?
- Is there access to internal or external expertise for the design and construction of adequate treatment facilities?
- Is sufficient expertise available from engaged actors to initiate the operation and maintenance of the facility? Is it possible to train local staff?

Economic aspects:

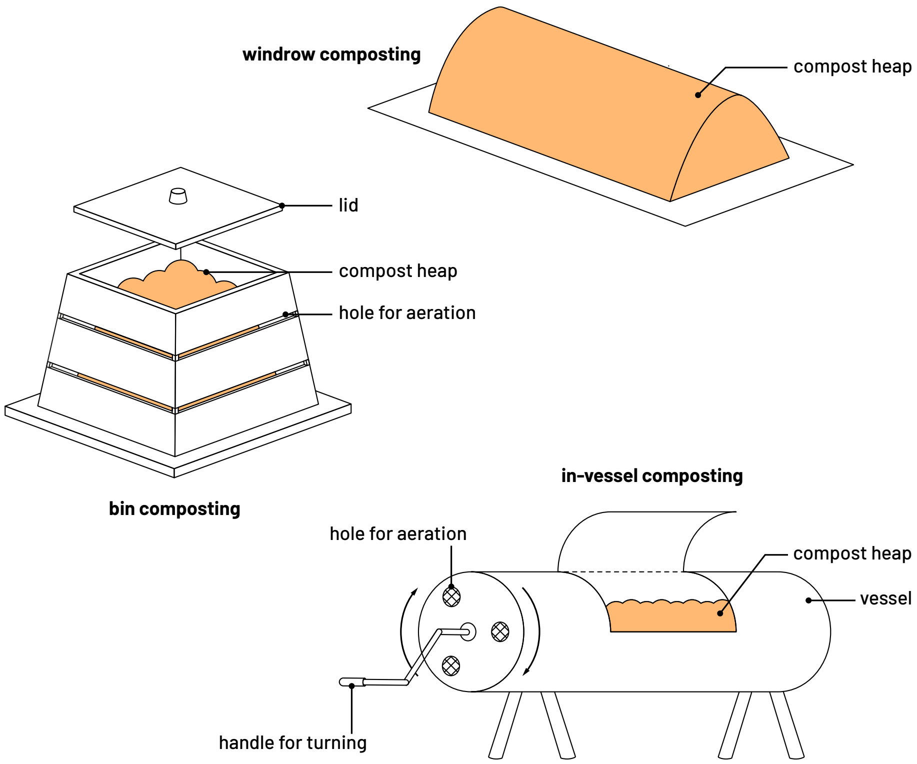
- Is there a market for the end product (inside or outside of the humanitarian setting)?
- Does the SWM budget cover the capital cost (CAPEX) and operational cost (OPEX) of treatment and recycling facilities?
- What would the expected revenue (or saving) be if treated or recycled materials were sold or distributed?

Social aspects:	• Is it socially acceptable in the given context to use the end product? (e.g. cook with biogas from waste source) • Does the community have any bad/good experiences with such a treatment/recycling option which could discourage or favour its use?
Legal aspects:	• Is there any legislation/policy preventing the use of such a treatment/recycling option? • Is there any legislation/policy preventing the use of the end product? • Are there any legislation/policy-setting standards for process or end product quality?

Composting

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	* Household * Shared ** Public	Compost production, nutrient recycling, waste diversion from disposal and GHG mitigation	Waste separation

Space Required	Technical Complexity	Link to other Actors	Input Products	Output Products
**/* Medium/High	* Low	Host Community, Farmers, Private Sector Partners, Food Security	Organic Food/Kitchen Waste, Organic Garden/ Wood Waste	Compost



Composting involves the controlled aerobic decomposition of organic waste that results in a soil-like material called compost. The process occurs because of microbial activity in the presence of oxygen. The agricultural use (U.5) of compost improves soil structure and increases the availability of nutrients in the soil.

The composting of organic matter is created by a diverse population of microorganisms and invertebrates. Basic parameters including moisture levels, carbon-nitrogen (C:N) ratio and aeration are managed, controlled and adjusted to achieve fast degradation and good compost quality. Co-composting refers to the adding of faecal sludge to the process. A typical characteristic of a well-functioning composting process is a high-temperature phase (50-70 °C). The high temperature contributes to the sterilisation of the material, partially eliminating pathogens and weed seeds. Under ideal operating conditions, compost is produced within three months. When conditions are sub-optimal, the process may be slower or even fail. The main output is compost, a stable dark brown, soil-like material with an earthy smell. Although the composting process is simple, a well-functioning facility requires careful planning, design and operation to avoid failure.

Design Considerations: Two commonly used composting methods are (1) open windows and (2) in-vessel (bin or box). In open windrows, organic waste is piled into heaps called windrows and left to compost. In-vessel composting uses vessels, bins or boxes to contain the waste during the process. Rotating vessels can also be used to improve aeration and accelerate the decomposition process. A key component of a composting facility's design is space. Space is needed for waste sorting and preparation of the waste; for the composting windrows or vessels; for screening the finished compost; storage of the final compost; for staff facilities and for a green buffer surrounding the location. Ideally, the facility (at least the area of the composting windrow or vessels) should be covered to better control moisture. The facility should be fenced to prevent animals from entering; the site should be as close as possible to where the organic waste is generated to minimise transport effort and cost. Robust grinders can shred large pieces of organic waste before composting. Windrows should be at least 1.5 m high and wide. In colder climates windrows of 2 m height and 2 m width are recommended. The composting pad (the ground surface where the windrows are located) should be sealed to avoid leachate infiltration and slightly sloped to collect the leachate. The leachate can then be recirculated into the windrows or treated before discharge.

Materials: Composting facilities can be constructed with locally available materials. The compost pad can be made of concrete or well-compressed clay. A cover/roof and fencing may be made from local materials such as bamboo, grass matting, wood, plastic or metal sheets. Water may be required depending on the climate to maintain compost moisture levels. Prefabricated composting vessels of different sizes are available on the market. Mechanised equipment to turn the compost, robust grinders for shredding large pieces of input material and rotating or shaking sieves can reduce manual labour, ensure a more homogenous end product and optimise the process.

Applicability: Composting can be carried out at different scales, using a variety of equipment and infrastructure and different levels of mechanisation. For small-scale home composting, bins are most frequently used. Bins rely on a passive aeration process. Medium and large-scale composting using open windrows, bins or in-vessels, typically rely on regular turning or active aeration using appropriate equipment. Managing a composting facility is complex. Its staff are required to operate the facility and monitor treatment efficiency. Consequently, this technology is unlikely to be practical in the acute response phase. However, it can be a viable option in the stabilisation and recovery phases. Experience has shown that composting facilities operate best when they are established as a business with compost as the marketable product that generates revenue to support cost recovery (although compost sales cannot be expected to cover the full cost of the service).

Operation and Maintenance: The operation requirements for composting facilities are high. Staff should carefully track turning schedules, temperature and maturing times to ensure pathogen removal and high-quality treatment. Organic waste must first be sorted so it is free of non-organic materials. Depending on the size of the composting facility, a compost windrow is turned with a front-end loader, or by hand using a pitchfork or shovel.

Health and Safety: Health risks can be minimised if workers adopt basic precautions and hygienic practices and wear personal protective equipment. Workers should wear masks to protect them from dust and fungi spores. If pathogen-containing input materials are used, special handling precautions must be taken **(X.4)**. To ensure the safety of the final compost, the World Health Organization (WHO) recommends that temperatures of 55–60 °C should be reached for at least one week throughout the mix.

Costs: The cost of building a composting facility varies depending on the method chosen, the cost of local materials and whether machinery, such as aerators and grinders, is included in the design. The main costs are the overall operation requirements, including transport and the supply of organic solid waste and labour.

Social Considerations: When composting is not properly controlled, it may attract rodents and flies. If too wet, anaerobic degradation can occur (i.e. the organic waste starts to rot) generating bad smells and greenhouse gases. Such emissions from the facility could decrease the social acceptance of composting. If compost is sold on the market, ensuring that the compost product conforms to local standards and regulations is a prerequisite **(X.1)**. Ensuring a market and use for the composting end product greatly increases the sustainability of a composting facility **(X.5)**.

Strengths and Weaknesses:

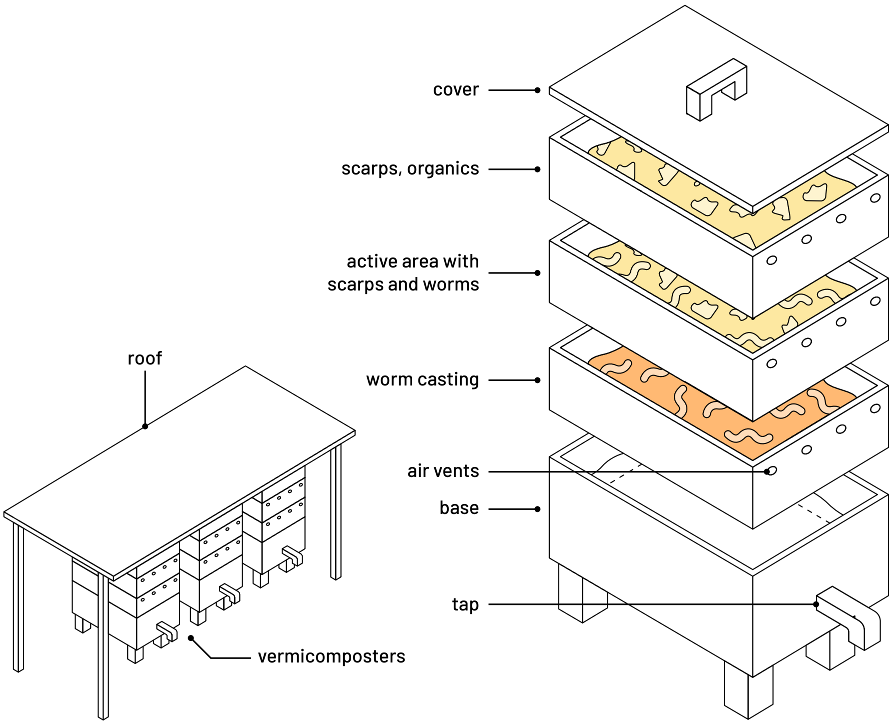
(+) Low-tech solution for organic waste management
(+) Proven effective treatment with a valuable end product

(−) Requires a large, well-located land area
(−) Long treatment times
(−) Can emit a smell and attract animals if not managed well

→ **References and further reading material for this technology can be found on page 174**

Vermicomposting

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	* Household * Shared * Public	Vermicompost production, Nutrient recycling, Waste diversion from disposal and GHG mitigation	Waste separation
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	* Low	Host Community, Farmers, Private Sector Partners, Food Security	● Organic Food/Kitchen Waste, ● Organic Garden/ Wood Waste	● Vermicompost, Worms



Vermicomposting is a biological aerobic process in which organic matter is digested by worms and microorganisms. The products are vermicompost (or worm compost). Vermicompost contains water-soluble nutrients and is an excellent, nutrient-rich organic fertiliser and soil conditioner.

Vermicompost is a mineralised, nutrient-rich, microbiologically active organic amendment. Vermicomposting depends on the interaction between microorganisms and earthworms. Microorganisms in the waste prepare it for the earthworms through the first step of aerobic degradation. Earthworms can process a broad range of organic waste but do not tolerate food waste such as meat and fish, grease and oils and salty and vinegary foods. They also dislike onions and spicy peppers. Appropriate earthworm species for vermicomposting are surface worms that easily adapt to different waste types and conditions, feed and digest rapidly and have a fast growth and reproductive rate. Among these, Eisenia fetida is the most frequently used species after Lumbricus rubellus, Eisenia andrei, Perionyx excavatus and Eudrilus eugeniae, popular in tropical and subtropical countries. The final products are vermicompost and the worms themselves. Worms can be sold or used as high-protein animal feed or even for their medicinal properties. Another vermicompost by-product is a liquid fertiliser which derives from leachate draining from the worm bins.

Design Considerations: Vermicomposting is done in bins or beds, which can be shallow containers. The surface area of the bin or bed depends on the amount of organic waste. Holes or mesh are needed for aeration. A spout or holes in the bottom can be added to drain excess liquid (i.e. liquid fertiliser) into a tray for collection. As worms prefer the dark, a cover for the bins is needed to keep them shaded and protected. To save space, bins can be stacked vertically but must still allow fresh air to circulate. Roofing for shade and rain protection is recommended but a walled enclosure is not required.

Materials: Vermicomposting bins and beds are often constructed of wood or plastic (recycled PET or polypropylene). Plastic bins require more drainage than wooden bins but wood will eventually decay and need replacing. Styrofoam and metal materials should be avoided, as well as cedar wood which contains resinous oils. Covers protecting the worms can be made from local materials such as wood, plastic or metal sheets. Robust grinders can shred larger pieces of input materials. Bedding materials, such as shredded newspaper, cardboard, coconut coir or peat moss, provide a habitat for the worms and help to manage moisture levels. It should be moistened before adding the worms and be damp but not soggy.

Applicability: Vermicomposting can be done at different scales, from household to large-scale facilities. It can be considered a viable option in the stabilisation and recovery phases where there is a constant source of well-sorted organic waste and space available. Experience has shown that vermicomposting facilities operate best when established as a business venture with vermicompost, liquid fertiliser and harvested worms as marketable products that can be sold and generate revenue to support cost recovery. The revenue, however, cannot be expected to cover the full cost of the service.

Operation and Maintenance: A vermicomposting facility requires staff knowledgeable about the worms' life cycle and preferences. The worms' conditions and operating parameters should always be carefully monitored. Key parameters include the quality and quantity of the input material, feeding rate, a stable temperature (worms like between 13–25 °C), moisture and oxygen content in the vermicompost and the general health of the worms. The worms can process their body weight of waste per day. However, a feeding rate of 50 % of worm mass per day is adequate for a good operation. It is important to introduce the waste as feed for earthworms in shallow layers (> 10 cm), balancing green (nitrogen-rich) and brown (carbon-rich) materials to maintain a healthy composting environment. The layers should be placed in the bins or beds and the worms fed at least weekly. Overly thick layers will increase the temperature in the waste layer or cause anaerobic conditions; both situations are unfavourable for the worms. If the bedding gets too dry, water needs to be added. If the bedding gets too wet, dry material can be added, such as paper strips. Of the volume of input material processed, about 50 % by mass can be harvested as vermicompost. The compost should be occasionally stirred to promote aeration and prevent anaerobic conditions which can lead to unpleasant smells and harmful bacteria.

Health and Safety: Unlike composting **(T.1)**, pasteurising temperatures cannot be reached as worms and bacteria are sensitive to extreme temperatures. Worms can greatly hasten a reduction in total coliforms, but pathogenic inactivation during vermicomposting depends on the worm species used. Although certain worm species can significantly reduce pathogen levels, complete elimination is not guaranteed. Hence waste containing high pathogen levels may require further treatment to produce a pathogen-free vermicompost. Health risks can be minimised if adequate control measures are consistently practised and workers adopt basic precautions and hygiene practices and wear personal protective equipment **(X.4)**.

Costs: The cost of building a vermicomposting facility varies depending on the size of the facility and the cost of local materials and earthworms. However, costs are generally low. The main costs to assess are for the overall operational requirements, including transport and the supply of organic solid waste.

Social Considerations: Ensuring that the vermicompost product conforms to local guidelines and standards **(X.1)** is a prerequisite for implementation; if not, different treatment processes should be identified.

Strengths and Weaknesses:

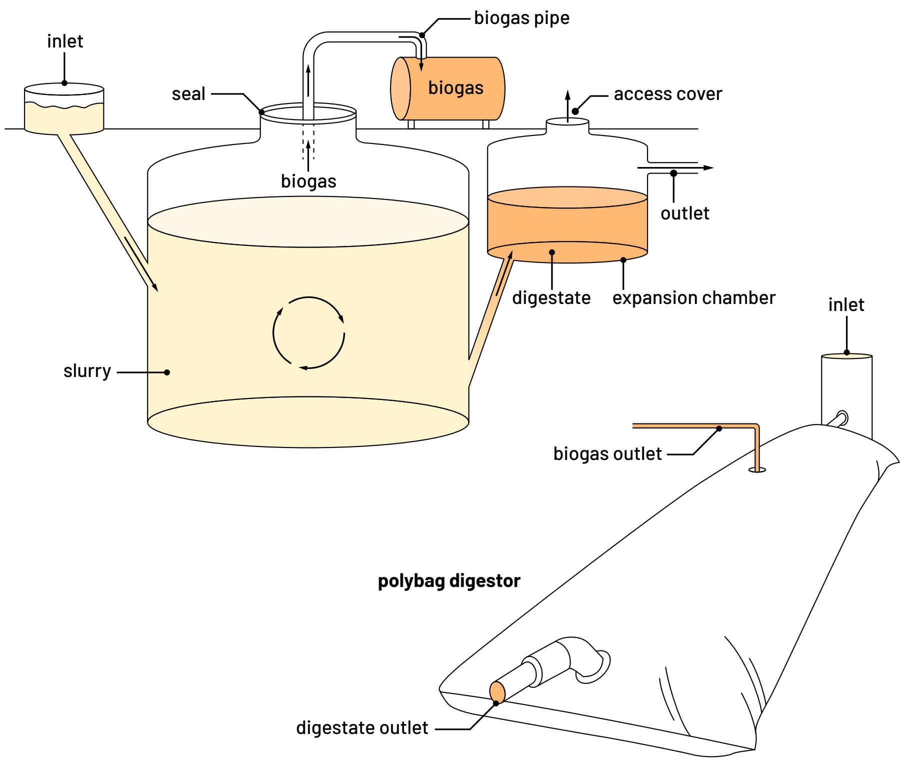
(+) Simple robust technology
(+) Can be built and maintained with locally available material
(+) High-value soil amendment

(−) Requires a larger, well-located land area
(−) Only limited organic waste types are suitable and a pre-composting phase is recommended
(−) Worms are sensitive to environmental conditions (too hot, too cold, too wet, too much sunlight and overcrowding) and these must be well controlled

→ **References and further reading material for this technology can be found on page 174**

Anaerobic Digestion

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	** Household ** Shared ** Public	Biogas production, Nutrient recycling, Waste diversion from disposal and GHG mitigation	Waste separation
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
**/* Medium/High	** Medium	Host Community, Farmers, Private Sector Partners, Food Security	Organic Food/Kitchen Waste	Biogas, Digestate



Anaerobic Digestion (AD) is a process through which organic materials decompose, generating biogas and a nutrient-rich digestate. Biogas is a mix of methane (CH_4), carbon dioxide (CO_2) and other trace gases, which can be used as fuel and converted to heat, electricity or light (U.6). The AD process occurs in oxygen-free air-proof reactor tanks called digesters, also known as biogas reactors.

A wide range of different organic waste can be used as the substrate (or feedstock) for biogas production including, (from the most to least potent biogas yield), energy crops, organic food/kitchen waste, animal manure and sewage sludge. Large amounts of fibrous material, such as straw, should be avoided. Most substrates require pre-treatment before digestion including sorting (if not already done at source), shredding to reduce particle size and adding water before the mixture is fed into the AD system. Feedstock with high water content (> 60 %) can be processed without pre-treatment. The main products of AD are biogas and digestate. The energy value of biogas derives from the contained methane and has typically lower heating values of 21–24 MJ/m³ or around 6 kWh/m³. Burning biogas in stoves is the easiest way of using biogas energy. The slurry (digestate) produced is rich in nitrogen. In a typical AD process temperatures do not rise above 40 °C and therefore only partly deactivates weed seeds and pathogens. If faecal sludge is used as feedstock, the digestate needs treating before being used as a fertiliser.

Design Considerations: In humanitarian settings, low-tech wet digestion systems operating in continuous mode are recommended. Biogas digester designs for such systems may be a fixed-dome, floating-drum or tubular polybag digester. Fixed-dome and floating-drums are built (partially) underground; tubular polybag digesters are implemented as prefabricated mobile equipment. In a fixed dome, the volume of the reactor is constant. As gas is generated it exerts pressure and displaces the slurry upwards into an expansion chamber. When the gas is removed, slurry flows back into the reactor. The pressure can be used to transport the biogas through pipes. As the dome is under pressure, this system needs experienced and skilled construction to ensure gas tightness and its underground construction means it should be considered as permanent infrastructure. In a floating-drum, the drum rises and falls with the production and withdrawal of gas; in a tubular digester, the digester inflates and deflates accordingly. The digester of a floating-drum is generally constructed underground but the drum is above ground; the exception is a digester for a smaller household-scale system which can be fully above ground. Tubular polybag digesters are mobile but quite fragile and susceptible to mechanical damage, reducing their life span to two to five years. The hydraulic retention time (HRT) in the reactor should be at least 15 days in hot climates and 25 days in temperate climates, requiring the reactor to contain 15–20 days of waste volume (including water if required). For feedstock with pathogens (e.g. faeces), an increase of HRT to 60 days should be considered. The size of digesters ranges from 1,000 L for a single family to 100,000 L or more for institutional or public applications. Because the digestate production is continuous, provision must be made for its storage, treatment, use and/or transport away from the site.

Materials: A biogas digester can be made of bricks, cement, steel, sand, wire (for structural strength), waterproof cement additives (for sealing), water pipes and fittings, a valve and a prefabricated gas outlet pipe. The gas-holding chamber must be constructed to be airtight (not allowing oxygen in or generated gas out). Prefabricated solutions from specialist suppliers include geobags, reinforced fibre plastic modules and router-moulded units.

Applicability: Before designing an AD system, the potential biogas yield must be assessed according to the type of substrate. Ideally, an AD reactor is located close to the source of waste generation (to minimise waste transport distances) and close to the biogas user (to minimise the gas transport distances). ADs can be constructed at different scales but require regular feeding. It is not suitable for the acute phase of an emergency as the microorganisms in the digester need time to establish. It is particularly suited to rural areas where animal manure can be added and digestate is needed as a fertiliser **(U.5)** and gas for cooking **(U.6)**. AD is less appropriate in colder climates (< 15 °C) as the rate of organic matter conversion into biogas becomes very low. Even though biogas digesters are watertight, they should not be constructed in areas with high groundwater tables or frequent flooding.

Operation and Maintenance: To start the AD process, the digester must be inoculated with anaerobic bacteria (e.g. by adding cow dung). Once the appropriate microorganisms have established, waste must be added regularly (ideally daily) or the bacteria will starve. Digestate is primarily liquid and should be removed from the overflow frequently; the amount and its characteristics will depend on the volume of the tank relative to the input of solids, the amount of indigestible solids and the ambient temperature. Gas production should be monitored and the gas used regularly. Water traps should be checked frequently and valves and gas piping cleaned to prevent corrosion and leaks. Depending on the design and the inputs, the indigestible materials accumulating at the bottom of the reactor should be emptied and the reactor cleaned and checked (with caution) every five to ten years.

Health and Safety: The digestate is partially sanitised but likely to still contain active pathogens; during digestate removal workers should therefore be equipped with proper Personal Protective Equipment (PPE). Depending on its end use, digestate may require further treatment before use in agriculture. There are dangers resulting from the flammable gases and cleaning the reactor can be a health hazard; appropriate safety precautions (wearing PPE and ensuring good ventilation) should be taken **(X.4)**.

Costs: This is a medium-high-cost option for humanitarian settings. Costs for capacity development and training of operators and users must be budgeted for.

Social Considerations: Social acceptance may be limited in communities unfamiliar with using biogas or digestate. Acceptability can be increased through shared management and shared benefits (gas and fertiliser) from AD though benefits may be unevenly distributed amongst users of a shared digester, leading to conflict.

Strengths and Weaknesses:

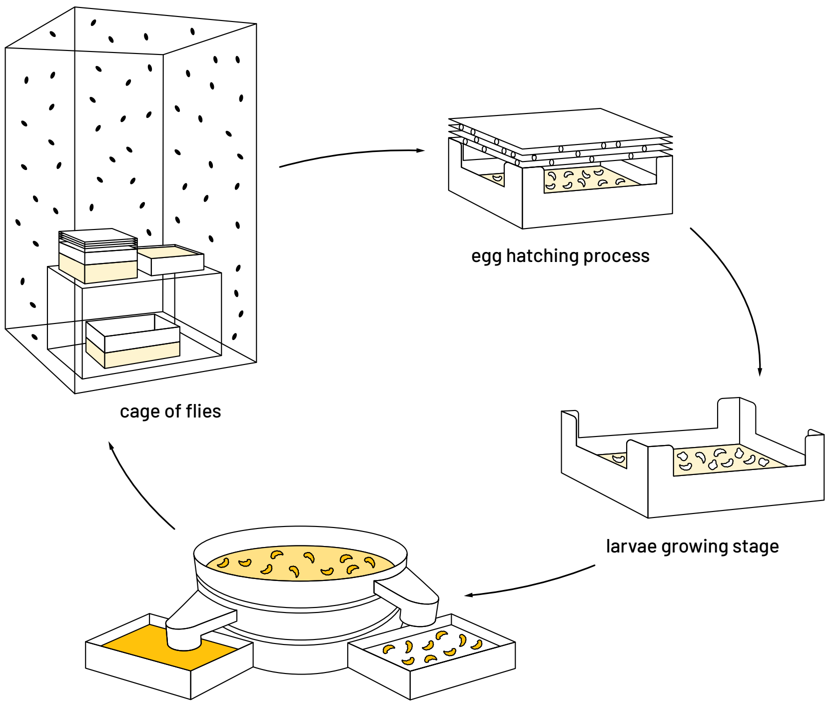
(+) Generation of biogas and fertiliser
(+) Small land area required (if the structure is built underground)
(+) Long service life (robust)

(−) Requires expert design and skills for construction
(−) Incomplete pathogen removal, the digestate might require further treatment
(−) Medium-high level investment costs

→ **References and further reading material for this technology can be found on page 174**

Black Soldier Fly (BSF) Waste Processing

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation * Recovery ** Protracted Crisis ** Development	Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	* Household ** Shared ** Public	Nutrient recycling and production of animal feed, Waste diversion from disposal and GHG mitigation	Waste separation
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	** Medium	Host Community, Farmers, Food Security	Organic Food/Kitchen Waste, Organic Garden/ Wood Waste, Animal Manure	Animal Feed, Frass



Black Soldier Fly (BSF) waste processing is a biological aerobic process in which BSF larvae feed on organic matter. The grown larvae are harvested for animal feed for fish, poultry or pets; the residue from the larval feeding process is a valuable soil conditioner or fertiliser.

The Black Soldier Fly Hermetia illucens is a tropical fly that converts organic waste into marketable, high-value products. The process involves rearing the flies in nets, egg production, hatching and growing the hatched larvae fed with organic waste substrates. BSF larvae are placed on organic waste in trays where they feed for one to two weeks. Of the processed waste, 20 % by weight can be harvested as grown larvae; 30 % remains as frass (a mix of waste residues and larvae faeces). Larvae can be used or sold as a component of animal feed for fish, poultry, pigs or pets; the frass is a valuable soil conditioner or fertiliser.

Design Considerations: A BSF facility contains three units: a unit where BSF are reared (larvae pupation, fly mating, egg laying and egg hatching), a unit where waste substrates are prepared and fed to young larvae in trays and a unit where grown larvae and frass are harvested and, if required, post-processed into animal feed and soil conditioner or fertiliser. The rearing unit is a covered area allowing sunlight in to enhance the mating of flies. The equipment is trays and netted cages. The number of nets depends on how many eggs and young larvae should be produced daily, which depends on the amount of organic waste available to be processed. The processing unit consists of an area for waste substrate preparation (shredding, grinding, fermenting) and shallow trays in which waste substrate is placed together with the young larvae. Trays can be stacked vertically. The third unit is an area where the harvesting and killing of larvae as well as post-processing takes place. Depending on the product intended, post-processing can involve drying or the fat extrusion of larvae and composting **(T.1)** of frass. The larvae should be fed regularly; feed levels should be monitored and adjusted.

Materials: BSF trays are commonly made of plastic (recycled PET, polypropylene), wood with plastic liners or concrete beds. Solid walls are unnecessary, but a roof for protection from rain and sun is required. The roof should be solid with an impermeable surface to enable regular cleaning. Other equipment such as shredders and sieves can be bought from suppliers. Temperature and humidity control equipment may be needed if ambient temperatures are unsuitable.

Applicability: BSF waste processing can be developed on-farm as a side activity, feeding harvested larvae directly to the chicken, fish or pigs on the farm. BSF waste conversion can also be developed as a small or medium business providing a livelihood opportunity by creating value from waste and selling the products to customers (retail or direct users). Waste substrates fed to BSF larvae should be purely organic so the waste must be segregated and prepared before use or come from pure organic waste sources. BSF waste conversion is most suited in climates with ambient temperatures between 25–30 °C.

Operation and Maintenance: Proper operation and maintenance of a BSF facility are essential to ensure efficient waste conversion, high larvae production and a hygienic environment. This means maintaining suitable temperatures and humidity, providing pupation materials, and appropriate mating and egg-laying conditions and materials. Eggs must be harvested regularly. Neonates and larvae should be fed with a well-balanced substrate (e.g. food waste, manure or agricultural residues) to promote good growth for harvest. Maintenance practices include cleaning and hygiene measures to prevent moulds, pests and diseases. Equipment maintenance includes regular checks of crates, nets or mesh screens. Regular monitoring is crucial to detect problems early and take appropriate action. A well-maintained BSF facility minimises its environmental impact. Best practices in hygiene and pest control are also essential for its long-term success.

Health and Safety: Health risks to workers are minimal; they are not a concern if workers adopt basic precautions and hygiene practices and wear personal protective equipment **(X.4)**. BSF are known for their ability to reduce pathogens in the waste they consume but improper handling or incomplete decomposition can still pose a threat if not managed correctly. Precautions should be taken to prevent the composting setup from attracting pests (including houseflies and rodents) and creating health and safety issues. To be safe and effective the final BSF compost and frass should not contain any undigested or partially decomposed materials; quality control is needed.

Costs: The main costs of building a BSF facility are the covered area and the equipment (shredder, sieve, nets and trays). Costs may vary depending on the price of local materials and the degree of mechanisation. Costs, however, are generally low. The main operational costs to assess are manual labour and the power supply to operate the equipment. If waste is not delivered to the facility, the cost of transport and supply of organic solid waste must also be considered.

Social Considerations: Low social acceptability may reduce the sale and use of BSF products (larvae and frass). However, local animal feed production promotes resilience and independence from animal feed markets and protects farmers from rising costs.

Strengths and Weaknesses:

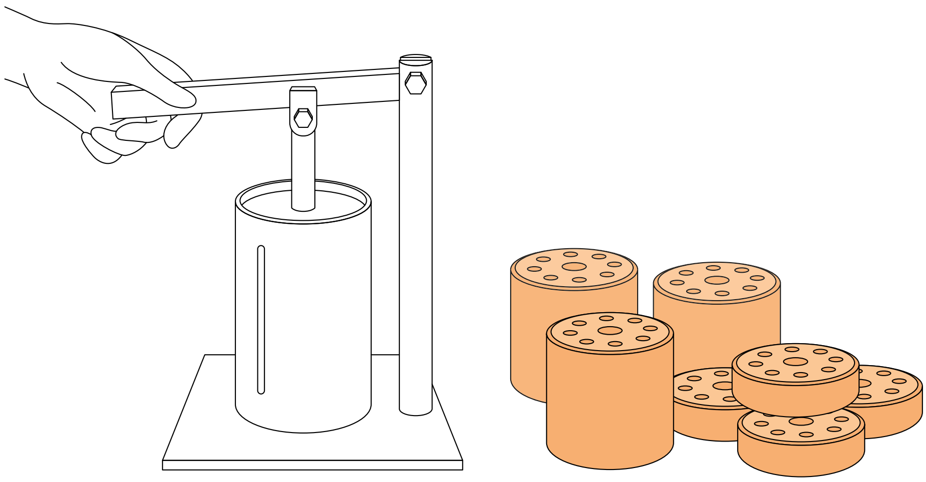
- (+) Simple, robust technology
- (+) Can be built and maintained with locally available materials
- (+) Fast production of high-value products

- (−) High-skill requirements for managing the reproduction unit (rearing of flies)
- (−) Larvae feed best on clean organic waste with a high nutritional value and cannot digest woody materials
- (−) Suitable climate conditions are between 25–30 °C

→ **References and further reading material for this technology can be found on page 174**

Making Fuel From Biomass

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation * Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution * Urban ** Rural	* Household * Shared ** Public	Transforming recovered biomass from waste into fuel, Waste diversion from disposal	Waste separation, Processing facility
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	*/* Low/Medium	Host Community, Private Sector Partners	Organic Garden/Wood Waste	Solid Biomass Fuel



briquette press

carbonized briquettes

Selected types of organic waste can be recovered from waste and used to produce solid fuel for cooking and heating (U.7). Organic waste can be compacted with binders into briquettes or pressed without binders into pellets. As a preliminary step, waste can also be carbonised into char, and the crushed char powder used to produce carbonised briquettes.

Segregated organic waste with high cellulose and low moisture content (such as fallen branches or wood waste) has a high heating value and can serve as fuel for cooking or heating **(U.7)**. Raw waste can be compacted to increase its energy density. Briquettes are formed with binders and at a lower pressure. Pellets are pressed without binders at high pressure. Alternatively, the raw waste can be processed by carbonisation into char before compaction to briquettes. Carbonisation is recommended as it kills the pathogens potentially found in the waste, increases the heating value of the product and reduces emissions when burned. Waste must be free from non-combustible materials and chemical substances (paint, glue and lacquering) that, when combusted, can emit hazardous gases. According to WHO guidelines, solid biomass fuels are not a clean cooking solution because the combustion produces air emissions that can cause respiratory and cardiovascular diseases. However, they can support the transition away from wood and its associated deforestation.

Design Considerations: Solid fuel production from organic waste requires thorough waste segregation or high-quality sorting **(PART 1: Waste Separation)** to remove impurities. Carbonisation converts organic materials into carbon or carbon-containing residues through heating in the absence, or limited presence, of oxygen. Shredded raw organic material or char powder can be mixed with organic binding agents such as starches before it is pressed into briquettes. Clay can also be used as a binder; however, it reduces the heating value and increases ash content. Pelletising involves compressing the material at high pressure into small, rounded cylindrical pellets. The applied pressure generates heat, which enables the naturally present lignin to act as a binder.

Materials: Carbonising requires a kiln. A crusher is needed to produce char powder, and a shredder to shred the raw waste into fine particles. There are several types of briquetting technologies and equipment that can be purchased or constructed. In humanitarian settings, non-motorised equipment is more common. While commercially available equipment may be used for production at a community scale, household-level production can use locally produced equipment. Pellet production usually requires automated equipment and includes shredders, drying ovens and screw extruders.

Applicability: Due to the training and equipment needs, fuel production from recovered biomass is more appropriate in stable, protracted or development settings, not in an acute response. It must be based on the local availability of suitable raw materials and not compete with cleaner cooking or heating solutions. The fuel produced should not compete with existing biomass fuel sales and cause market distortions. Pellet production is likely to be limited to community-scale interventions and locations with reliable access to electricity and the availability of more homogenous and specific raw materials. Briquettes can also be produced at a household level for self-consumption or sale.

Operation and Maintenance: Staff or communities engaged in pellet or briquette production must be thoroughly trained, including occupational health and safety **(X.4)**. Training needs for pelletising are more comprehensive than for briquetting. Fuel quality can be affected by humid and rainy climates as pellets can absorb moisture and the briquettes may not fully dry. The availability of biomass can fluctuate with the seasons.

Health and Safety: Carbonised briquette production should, ideally, be prioritised over raw waste briquettes as the product is more sanitised and generates fewer emissions when burned. Elevated temperatures during carbonisation or pelletising are necessary to eliminate potential pathogens. During production, heat and fumes are significant occupational risks. Operators must be trained and equipped with personal protective equipment **(X.4)**. Stocks must be safely stored to prevent fires. Solid biomass fuels are not a clean cooking solution because of their particulate matter ($PM_{2.5}$) and carbon monoxide emissions.

Costs: The cost of biomass fuel production depends on the fuel type. Charcoal briquettes can be produced using cheaper equipment and manual power. Pellet production is more expensive due to its automated equipment and electricity consumption.

Social Considerations: Solid biomass fuels from waste can be manufactured locally, supporting local livelihoods and creating employment. Competition with existing community-based or commercial biomass fuel production or sales must be prevented by humanitarian actors to avoid distorting the market. Communities might be unfamiliar with the correct use of biomass fuels and require training. The fuel types produced must be suitable for the food preparation preferences of end users. Briquette production using natural starches as binders (e.g. cassava or maize flour) may compete with food consumption in food-scarce contexts and affect the price or availability of food produce.

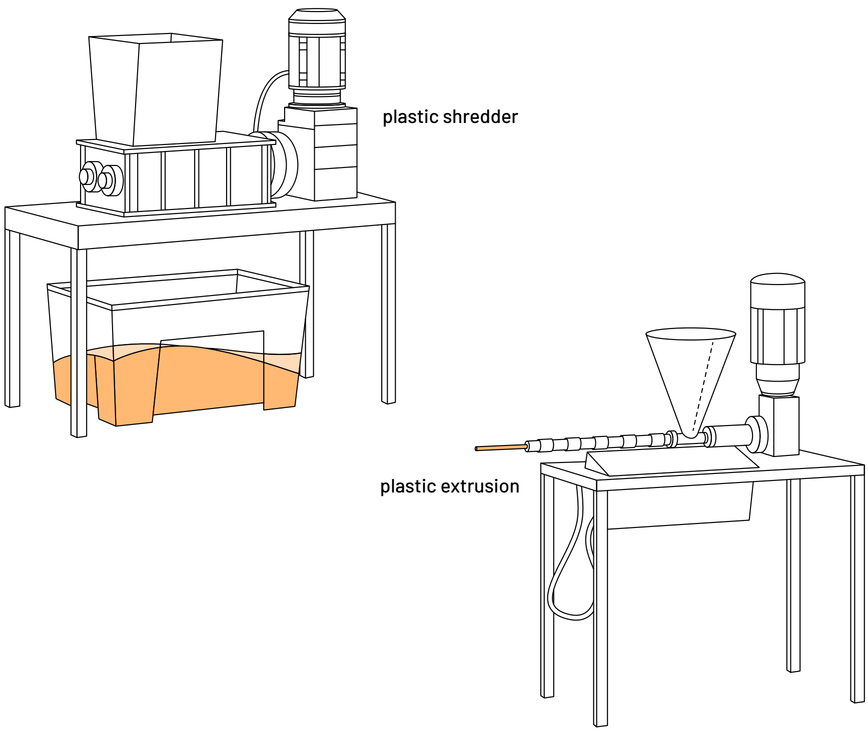
Strengths and Weaknesses:
- (+) Can increase access to fuel for cooking and heating
- (+) Can reduce the exploitation of natural vegetation
- (+) Can create income generation and economic opportunities

- (−) Solid biomass fuel can lead to ambient air pollution and health risks
- (−) Suitable biodegradable waste is often unavailable
- (−) Potentially conflicting uses of waste biomass

→ **References and further reading material for this technology can be found on page 174**

Plastic Recycling

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response Stabilisation * Recovery * Protracted Crisis * Development	Individual / Household * Community / Municipality * Institution ** Urban * Rural	Household Shared ** Public	Small and non-industrial scale processing of recovered homogeneous plastic, Waste diversion from disposal	Waste separation, Processing facility
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	*** High	Private Sector Partners	Plastics	Products from Processed Plastic



Plastic recycling transforms homogeneous plastic types through thermal modification and re-moulds them into new recycled items of various shapes and functions. In humanitarian settings, it is likely to be limited to small and non-industrial scales and requires expert knowledge to ensure adequate product quality and to prevent occupational, public health and environmental risks.

Homogeneous and recyclable plastic waste – such as high-density polyethylene or polypropylene – can be recovered and used to replace virgin materials in the production of new plastic items. During recycling, the material properties are maintained and thermal modification is used to mould new items of similar value; the recovered plastic waste is sorted into homogenous plastic types, cleaned and shredded into flakes. Flakes are heated up to specific temperatures, extruded into long threads and cut into granules. Granules are the base for any plastic recycling and facilitate the feeding of different moulding machines. Safe plastic recycling requires expert knowledge, otherwise, it can lead to the release of microplastics and the formation of toxic fumes, causing occupational safety, public health and environmental risks.

Design Considerations: Plastic recycling must produce a useful end product and give the highest consideration to occupational safety **(X.4)** and the protection of public health and the environment. It should focus on producing items that are not available in local markets to prevent market distortions. For safety reasons, children's toys, food containers or load-bearing items should not be produced. Outdoor applications should be avoided as products are unlikely to be resistant to UV light. In humanitarian settings, plastic recycling is typically confined to the production of small and non-industrial scale items and manual or hydraulic extrusion, injection and compression mouldings. It must use only homogeneous recyclable plastic types, as processing temperatures vary for each type and overheating them can generate toxic fumes. Dirt and impurities in the plastics must be prevented as they affect the final product quality. Differentiating between plastic types might be difficult, especially if Resin Identification Codes are no longer visible. Low-density polyethylene is less often industrially recycled so it might be available for recycling by humanitarian actors. Composite materials containing different plastic types or other materials cannot be recycled; they might only be used for plastic upcycling **(T.7)** or downcycling **(T.8)**.

Materials: Low-tech plastic recycling often uses manual sorting and cleaning with water. Shredders are required to produce flakes, extruders with water baths and rotating blades to produce granules and moulding equipment to produce the end products. Extrusion moulding can be used to generate long items with a consistent shape along the product, such as bar or beam-shaped items. Injection moulding can produce various shapes through the injection of plastic into negative moulds made from steel. Compression moulding produces heavier and bulkier items by pressing melted plastic into forms.

Applicability: If a local recycling sector exists, recyclable plastics must be handed over to them **(U.1)**, to avoid the market being distorted by humanitarian interventions **(X.5)**. Even if handed over for free, SWM projects can still reduce their costs by handling smaller waste amounts. The suitability and feasibility of recycling by humanitarian actors must be thoroughly assessed. Due to the complexity of the process, it is more appropriate in stable contexts of recovery, protracted or development. Humanitarian actors are unlikely to have the relevant expertise, so close engagement with specialist organisations or the private sector is necessary. The public health and environmental impacts of production and the end product must be evaluated. Plastic recycling should not be used solely for the sake of reducing waste amounts, as the reduced disposal quantities might be low. The incentives are the creation of livelihood opportunities and the production of useful items.

Operation and Maintenance: Thermal processes must take place under controlled temperatures suitable for the properties of the plastic being processed. Plastic recycling uses a lot of electricity which limits its application to locations with a steady and reliable energy supply. The equipment can be sensitive to harsh environmental conditions such as dust, heat or humidity and operators must be thoroughly trained.

Health and Safety: Plastic recycling must always use only homogenous and well-cleaned recyclable plastic. Processing mixed plastics can generate poisonous fumes. Facilities must prevent the release of microplastics and toxic fumes into the environment. Workers are required to wear personal protective equipment and need to be trained in occupational health and safety **(X.4)**. Items produced from recycled plastic must be thoroughly tested to ensure that they are of adequate quality and do not pose a risk to end users.

Costs: Significant costs are incurred by adequate and safe processing facilities, the procurement and maintenance of equipment, and electricity needs. Assuming non-industrial production in humanitarian settings, the process is likely to lead to limited production numbers and items with a low sale value. Financial sustainability is challenging for plastic recycling in humanitarian settings. Savings in SWM costs by recycling plastics are unlikely to outweigh processing costs.

Social Considerations: Humanitarian interventions must avoid establishing parallel plastic processing facilities, creating competition with private sector actors and distorting local markets. Plastic recycling requires the operation of sophisticated equipment, for which the capacity might not exist in humanitarian settings and remote locations. Communities might not be aware of the public health and environmental risks of plastic recycling and the risk of using poor-quality end products.

Strengths and Weaknesses:

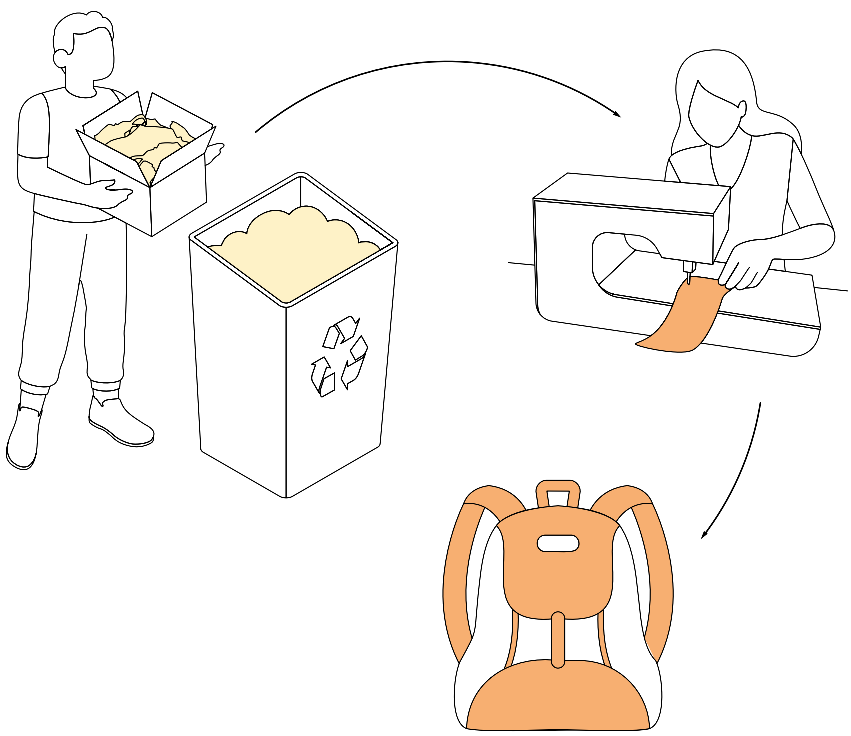
(+) Possible treatment option for recyclable plastics which do not have an existing local market
(+) Can help to sensitise communities for better waste handling
(+) Can provide raw materials for livelihood projects or local economies

(−) Requires expert knowledge unlikely to be available among humanitarian actors
(−) Sub-standard implementation can create occupational, public health and environmental risks
(−) Financial sustainability is highly unlikely in humanitarian settings

→ **References and further reading material for this technology can be found on page 175**

Plastic Upcycling

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response Stabilisation * Recovery * Protracted Crisis * Development	Individual / Household * Community / Municipality * Institution * Urban * Rural	* Household * Shared * Public	Small and non-industrial scale processing of recovered plastic into higher value products, Waste diversion from disposal	Waste separation, Processing facility
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	** Medium	Private Sector Partners	Plastics	Products from Processed Plastic



Plastic upcycling is the creative transformation of plastic waste into new items (U.3). Products from upcycled waste are functional and serve a purpose but also have artistic value and make a statement. While upcycling can be an important auxiliary to sensitise communities about waste issues, it is of limited relevance to SWM.

Upcycling creatively reuses waste materials to produce new items with a unique appeal, artistic touch and statement. The original state, shape or design of the plastics are usually conserved and intentionally displayed; production by specific community members can further add a story. Examples include backpacks from sewed-up packaging waste or toys from food containers. Upcycling can sensitise affected communities about waste issues, provide livelihood opportunities and foster positive, fulfilling and creative activities. Based on the product's perceived value and statement, customers may be willing to pay higher prices; a sale in high-value markets such as charity shops for tourists is ideal. Due to the small production capacities and limited market potential, upcycling is of limited relevance to SWM, particularly in humanitarian contexts, and does not significantly reduce waste amounts. Nor is upcycling a circular economy approach – the need for disposal of upcycled goods is simply delayed.

Design Considerations: A variety of processing techniques and products for the upcycling of plastic waste are available; the only limitation may be the creativity of designers. Ideally, materials for upcycling are collected at source before they enter waste streams. This helps ensure that they are clean, uncontaminated or soiled by other waste and that further processing is simplified. Preferably, materials are collected from point sources (such as shops, restaurants and returned waste at in-kind distributions) enabling a more efficient collection of larger quantities of adequate quality.

Materials: Existing equipment, such as sewing machines or heat transfer presses for textiles, can be repurposed for the upcycling of plastic waste. Various plastic materials can be used for upcycling, including recyclable, non-recyclable and composite plastic. Upcycling can use all sorts of waste materials and plastics can be combined with other materials such as wood or metal.

Applicability: Plastic upcycling is more appropriate in stable recovery, protracted or development settings. As upcycling does not significantly reduce SWM efforts, implementation during or shortly after emergencies is inadvisable. The primary reason for upcycling is not to enhance SWM but to facilitate livelihood opportunities, establish creative workshops in safe spaces or provide a day structure and distraction for some community members. Such interventions might particularly support women and highly vulnerable people who cannot access other interventions. If there is an existing recycling sector, most recyclable plastics should be handed to them **(U.1)**.

Operation and Maintenance: Most local communities and humanitarian and development actors lack expertise in the upcycling of plastic waste. Engaging with specialist organisations or private sector entities is therefore advisable. Upcycling equipment may require electricity, which can limit workshop locations. The limited size and operation of the electrical equipment could, however, enable energy needs to be covered by stand-alone solutions such as photovoltaic systems. Community members engaged in the processing need to be adequately trained, including in occupational health and safety **(X.4)** so that the equipment is used safely.

Health and Safety: When upcycling waste materials, consideration must be given to occupational health and safety **(X.4)** and the protection of the environment and public health. If plastics are thermally treated (for example stiffening food packaging with heat transfer presses) materials must not be overheated as toxic fumes may be produced. As plastic upcycling does not use all the waste material, scrap pieces require adequate disposal. End products from upcycling must be safe to use. Workers receiving and cleaning waste products must wear adequate personal protective equipment.

Costs: Upcycling can be low-tech and low budget. Depending on the type of plastic upcycling and the intended end products, investment costs are mainly for a processing workshop and equipment. Operational costs can be low; they may only include staff and energy costs as most of the raw materials are free waste. Financial sustainability for plastic upcycling is challenging in most settings, as the quantities produced and the sale value on local markets are usually low. It is always advisable to identify potent niche markets, such as supplying charity shops in larger cities, to generate higher revenue.

Social Considerations: Upcycling facilities can be creative, safe and inclusive spaces for targeted communities **(X.9)**. Upcycling can also sensitise communities about waste issues and safe waste management **(X.6)**. It is essential that upcycling by humanitarian actors does not compete with regular market products and distort local markets **(X.5)**.

Strengths and Weaknesses:

(+) Can offer creative and inclusive activities in safe spaces
(+) Can create livelihood opportunities
(+) Upcycling products can sensitise communities about waste issues

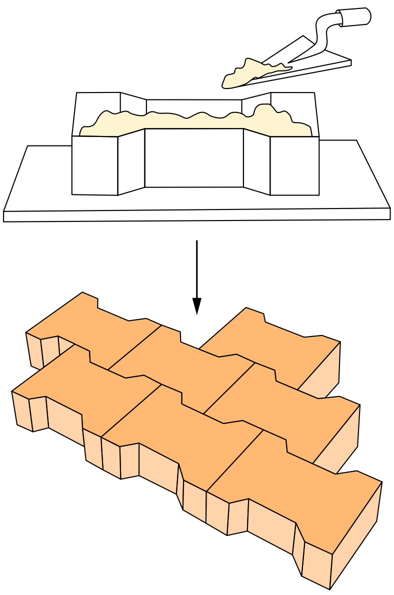
(−) It has limited impact on reducing waste amounts
(−) There is usually a limited market for upcycling products

→ **References and further reading material for this technology can be found on page 175**

Plastic Downcycling

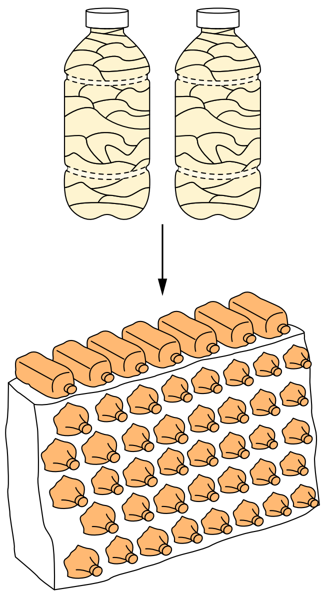
Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response Stabilisation * Recovery * Protracted Crisis * Development	* Individual / Household * Community / Municipality * Institution * Urban * Rural	* Household * Shared * Public	Small and non-industrial scale processing of recovered plastic into lower value products, Waste diversion from disposal	Waste separation, Processing facility
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	*/* Low/Medium	Private Sector Partners	Plastics	Products from Processed Plastic

pavement stone



pavement stones made from a mix of melted plastic waste and sand

ecobrick



ecobricks made from plastic bottles filled with plastic waste

Downcycling is a process in which plastic waste is mixed with other materials and transformed into new products with a lower value and reduced material properties. The products can be used for different purposes, for example, as construction materials (U.4). Expertise and care are required as it can lead to microplastic pollution and jeopardise occupational safety (X.4), public health and environmental protection.

Downcycling is the process of transforming materials into products of lesser quality, value and functionality than the original. The mixing of different materials leads to a gradual loss of material value, ultimately rendering products impossible to recycle and, as a result, subsequently contributing to landfill waste. The reduction in functionality occurs as the downcycled materials are used for less demanding purposes, such as filling bottles with sand instead of drinking water. Plastic downcycling requires expert knowledge; it is controversial as it can create risks to occupational safety **(X.4)**, public health and the environment. Thermal processing can generate toxic fumes and the use of downcycled plastics can accelerate microplastic pollution. Microplastics are generated from the disintegration of plastics through abrasion or UV-light-induced decomposition. Although microplastics have been found in human food chains, and even human blood, the health risks remain unclear.

Design Considerations: Plastic downcycling is achieved with or without thermal modification. 'Ecobricks' are an example of a product without modification in which bottles are filled with sand or compacted plastic waste to replace ordinary construction materials. Fillings can include non-recyclable plastic waste. With-thermal modification products include pavement stones or tiles for which plastic is melted, mixed with sand and pressed into shapes.

Thermal processing must be restricted to homogeneous plastic types. Different plastics have different melting temperatures, and overheating can lead to weakened material properties and toxic fumes. Outdoor applications need to be evaluated as products might not be resistant to UV light or suffer from abrasion from vehicles and pedestrians. Both can lead to microplastic formation.

Materials: Equipment requirements depend on the type of downcycling. Without thermal modification, the required equipment is usually limited to simple hand-held tools. 'Ecobricks', for instance, only require bottles, sand or plastic film for the filling and a hard stick to compress the plastics into the bottles. Thermal modification requires equipment for melting and compressing the plastic-sand mix into moulds and must include temperature controls to prevent overheating the plastic.

Applicability: Plastic downcycling is more appropriate in stable, recovery, protracted or development contexts, especially for thermal modification. Its implementation by humanitarian actors should be restricted to contexts without plastic recycling services or to plastic types without market interest. Competing with the private sector and distorting the market must be avoided **(X.5)**. Implementation in urban or peri-urban settings is more feasible as the availability of suitable waste materials may be limited in rural areas. In all cases, better and safer management options need to be assessed first, such as the handover of recyclables to the private sector **(U.1)** or their safe disposal **(U.8 and U.9)**. Although Plastic downcycling can create livelihood opportunities, it must respect the "Do No Harm" principle **(Introduction: Principles and Standards)** and never compromise occupational **(X.4)**, environmental or public health safety.

Operation and Maintenance: Plastic downcycling without thermal modification is straightforward and does not require special skills. However, specialised expertise and equipment are needed to safely conduct thermal downcycling and to ensure end product quality. Such expertise is unlikely to be available in local communities or humanitarian actors. Partnerships with, and guidance from, specialised organisations or the private sector is required. If downcycled products are used for construction, adequate training is needed to ensure the structural integrity of the constructed buildings **(U.4)**.

Health and Safety: Plastic downcycling must consider occupational, public health and environmental risks and confine thermal modification to clean and homogenous plastic types. It is essential that processing facilities prevent the uncontrolled release of plastic particles or toxic fumes. Staff must be thoroughly trained and equipped with personal protective equipment **(X.4)**. The quality and safe use of the end products should be evaluated.

Costs: The infrastructure, equipment and energy required for thermal downcycling incur significant costs. The cost of non-thermal downcycling is much lower. For both thermal and non-thermal downcycling, the sale value of produced items can be low. Financial sustainability is lower for the typically small or medium-scale production viable in humanitarian settings.

Social Considerations: Establishing parallel plastic processing facilities and creating competition with private sector actors must be avoided. Thermal downcycling requires skilled staff who may not be available in humanitarian settings and remote locations. Communities may be unaware of the public health and environmental risks of plastic downcycling and the risk of using poor-quality end products.

Strengths and Weaknesses:

(+) Can reduce waste amounts in humanitarian settings to a limited degree
(+) Products can be used in selected fields of application, such as construction

(−) Can lead to occupational hazards and risks to public health and the environment
(−) Products can lead to microplastic pollution

→ **References and further reading material for this technology can be found on page 175**

U

Use
and Disposal

Use and Disposal (U) is the last step in the SWM service chain after Storage (S), Collection and Transport (C) and Treatment and Recycling (T). It consists of options to make productive use or safely dispose of the output materials produced earlier in the SWM chain. Recommended use and disposal technology options are listed in descending order of priority: whenever possible, the use of recovered valuable and usable materials is prioritised over safe disposal. Safe disposal of waste is prioritised over unsafe disposal. Unsafe disposal methods, such as open dumping or burning (U.10–U.12), might happen, especially in the early stages of a humanitarian response, but should be rapidly replaced by safer options (U.1–U.9). In the early stages of humanitarian responses, health protection and rapid implementation take precedence, so the use of the recommended technologies may not initially be feasible. These options should be introduced as soon as possible, but often become more relevant in later, more stable phases when longer-term solutions can be implemented more effectively.
The order of the seven Use technologies (U.1–U7) also partly reflects their priority use: whenever possible, recyclables or biomass should be sold or handed over to the local private sector (U.1) instead of the humanitarian sector treating or producing new items (U.2–U.4). This prevents market distortions and makes valuable resources available for local economies (X.5). Whenever appropriate, the agricultural use of biomass (U.5) should take priority over its use as solid biomass fuel (U.7) as it enables nutrients and soil carbon to recirculate, helps to maintain soil quality and can enhance agricultural productivity.

Use

U.1 Sale of Recyclable Materials
U.2 Reuse of Waste Materials
U.3 Consumer Goods
U.4 Construction with Waste Materials
U.5 Use in Agriculture
U.6 Use of Biogas
U.7 Use of Fuel from Biomass

Safe disposal

U.8 Controlled Waste Pit
U.9 Controlled Disposal Site/Landfill

Unsafe disposal (not recommended)

U.10 Open Dumping
U.11 Open Burning
U.12 Contained Burning

Use: in accordance with the principle of the waste management hierarchy, valuable and usable materials should be removed from waste whenever possible (PART 1: Waste Prevention). This reduces the quantity of waste requiring safe disposal. In humanitarian settings, useful and valuable materials should, whenever possible, be sold or handed over to the local economy (U.1) or be reused (U.2). This includes recyclables (which can be transformed by local enterprises into new items) and biomass, which the local agricultural sector and community can put to use. Only in contexts where no relevant local private sector exists, or if there is no market interest, should humanitarian actors engage in the use or sale of products derived from waste. Products from recovered waste materials can be sold, distributed or used within humanitarian responses in the form of consumer goods for everyday needs (U.3), as construction materials (U.4), for agricultural activities (U.5), or as an energy source (U.6 and U.7). Local markets should be assessed to avoid distorting them with subsidised products from humanitarian interventions (X.5). To plan the use of products from recovered waste materials, the following should be assessed:

- Existence of local markets, local demands and local economic interests
- Type and quality of available raw materials from waste
- Potential production rates and the product quality of new goods
- Socio-cultural acceptance of products derived from waste materials
- Relevant regulatory frameworks
- Availability of equipment, space and the availability and capacity of local labour
- Potential impact on soil, groundwater and air

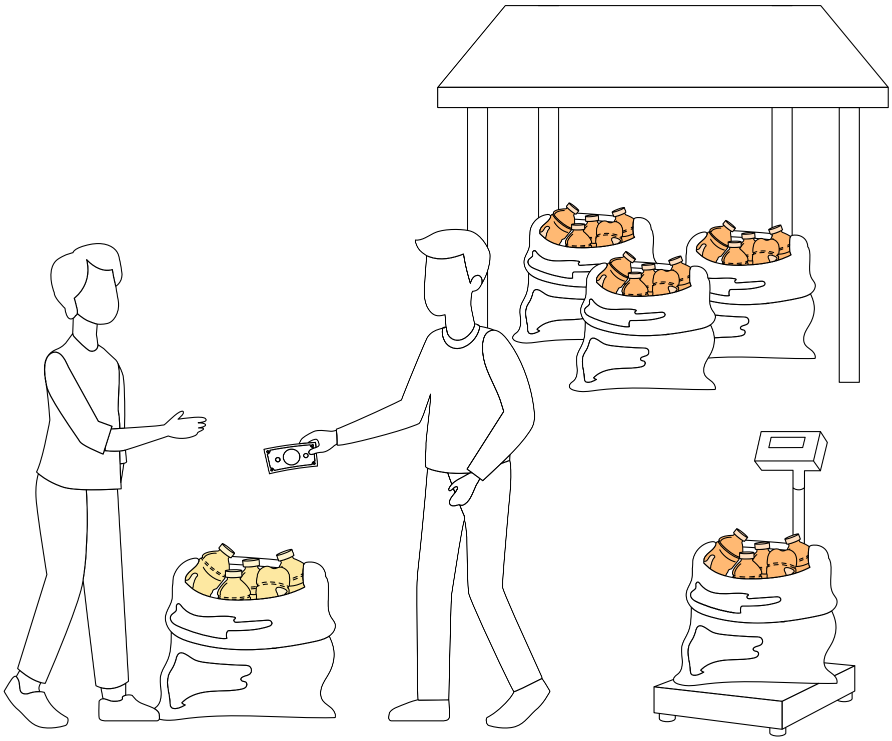
Safe disposal: despite efforts to reduce the amount of waste by using as much of it as possible, there will always be a fraction of residual waste requiring disposal. Safe disposal of waste aims to contain and isolate the impact of the waste within a specific location. Mitigation measures prevent the spreading of waste or the contamination of air, soil or water. In humanitarian settings, the use of existing disposal facilities and their potential improvement and enlargement should be a priority. This ensures that the local infrastructure benefits from humanitarian activities, prevents the creation of parallel systems and can facilitate the handover and exit of humanitarian actors. Furthermore, it is usually challenging to find new suitable locations for waste disposal due to public opposition, environmental concerns, limited space, financial constraints and regulatory challenges, including the need for approval from the authorities (X.1). Safe disposal ideally happens at Controlled Disposal Sites or Landfills (U.9). If controlled and managed disposal at centralised sites is not possible and if non-organic waste amounts are small (for example in sparsely populated rural areas) the use of Controlled Waste Pits (U.8) at a household level is feasible. For centralised disposal sites and sanitary landfills, it is of critical importance to reduce the amount of waste to be disposed of to increase the lifetime of the disposal facility. Avoiding waste, segregating it at source or sorting waste through the SWM service chain to recover valuable and usable materials is a priority (PART 1: Waste Prevention). Municipal Waste Incineration technology is not included as a safe disposal method in the Compendium as it is not adapted to humanitarian contexts.

Unsafe disposal: Open dumping (U.10) and open burning (U.11) of waste are globally widespread methods to dispose of waste, including in humanitarian settings. However, these practices are inadvisable due to their adverse impact on public health and the environment. In humanitarian contexts, these practices might be used at the onset of emergencies due to the lack of suitable SWM services and infrastructure. Nonetheless, a shift to more controlled and safe disposal options should be initiated as soon as possible. Existing open dumpsites might also be rehabilitated and transformed into controlled disposal sites (U.9). If an upgrade to a safe disposal site is not possible, open dumpsites should be decommissioned, considered as contaminated sites and remediation initiated.

The final disposal method described in this Compendium is the contained burning of waste (U.12). It is listed as an unsafe disposal method and is not recommended for mixed or residual waste due to its health and environmental impact. Contained burning is the combustion of waste in a specially designed furnace to promote the complete combustion of the waste. Often, the equipment does not reach the complete combustion conditions required to reduce toxic emissions and they do not offer flue gas cleaning to remove harmful pollutants. Contained burning is not the same as waste incineration. Incineration is a highly sophisticated, technical and complex waste treatment approach that fully controls fly ash, gas and slag emissions with specific technical and monitoring measures to limit environmental and health impacts. Incineration is expensive, requires specialist skills and is not considered a feasible solution for humanitarian situations. It is often used in municipal waste incineration plants or in hazardous waste incineration facilities. The SWM Compendium does not, therefore, describe high-tech incineration and the terms incineration and incinerator are avoided. Instead, the terms contained burning and furnace are used to differentiate between high-end (incinerator) and low-end (contained burning) technology. The only exception is the use of low-tech incinerators for hazardous medical waste (W.1). Contained burning is also presented as a technology for the treatment of menstrual and incontinence waste (U.12).

Sale of Recyclable Materials

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality ** Institution ** Urban * Rural	* Household ** Shared ** Public	Handover of recyclables	Waste separation, Existing recycling sector
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	* Low	Private Sector Partners	Glass, Metals, Plastics, Paper and Cardboard, Textile	



Whenever possible, recyclables recovered from waste must be handed over or sold to the recycling sector. Its market value depends on economic interest as well as the quantity, quality and purity of the recyclables. Market assessments are needed to identify existing recycling initiatives, relevant stakeholders, selling prices and required quality and pre-processing.

Recyclables recovered from waste must be sold or handed over to existing recycling sectors. The range of recyclables and selling prices depend on local economic interest and may include glass, paper, cardboard, textiles and different types of metals and plastics. Clean and well-sorted recyclables typically achieve higher prices and larger amounts can facilitate trading. Enhanced transportability, through pre-processing techniques such as crushing, shredding or baling of recyclables, can further increase prices and expand the range of tradable materials. A thorough market assessment is needed to identify existing recycling initiatives, relevant stakeholders, materials of interest, required quality and pre-processing and selling prices. Ideally, recyclables should be segregated at source to achieve higher recovery rates and ensure cleaner materials **(PART 1: Waste Separation)**. Source-segregated fractions or mixed waste can be handled in centralised sorting, pre-processing and storage facilities often called Material Recovery Facilities (MRF).

Design Considerations: Before the sale or handover to traders, recyclables may have to be further sorted, cleaned or pre-processed (e.g. crushing, shredding or baling) to enable trading and enhance resale value. Large storage spaces allow the accumulation of larger quantities. This facilitates the efficient use of further transport means and the possibility of waiting until the optimum time to sell. The space can also serve as a showroom for interested traders. High-density plastics are ideally shredded into smaller pieces and lighter metal containers compacted. Both can be stored and transported in jute bags or industrial big bags. Crushed glass or metal can be stored and transported in metal containers. Paper and cardboard can be tied up into piles which are then, ideally, fixed onto wooden pallets. Piles of hydraulically compressed metals can also be stored and transported on pallets.

Materials: Sorting, pre-processing and storage requires a sufficiently sized, roofed and fenced facility. A table can be used to sort the waste. Conveyor belts for sorting are typically not recommended unless very large amounts of waste are being sorted. Different containers are required for the storage and transport of recyclables and to meet the requirements of traders. A weighing system, such as industrial floor scales or crane scales, is needed to monitor the in and out-flux of recyclables. Such recorded data can help in future negotiations with traders and in recycling market exploration. Pre-processing equipment may include shredders and hydraulic baling presses. Trucks and forklifts can provide internal transport in the facility. Further transport might be delegated to the trader. Regular high-sided open-top trucks used in construction can be deployed for bulk transport.

Applicability: The handover or sale of recyclables is predominantly limited to stabilisation, recovery, protracted and stable contexts as they require effective waste segregation and a functional recycling sector. The latter is unlikely to be operational during or shortly after emergencies. While the sale of recovered materials will not cover the overall operational costs of the SWM service, it can still contribute to lower costs and the cross-financing of its activities, while supporting the local economy. For these reasons, the implementation and improvement of waste segregation **(PART 1: Waste Separation)** and the subsequent sale or handover of recyclables to a centralised facility should be continuously considered and evaluated by SWM service providers.

Operation and Maintenance: The sale of recyclables requires the continuous monitoring of the recycling market, including potential buyers, selling conditions (e.g. minimum amounts, pre-processing, packaging) and price ranges. Regular cleaning of the facility is required to avoid the accumulation of waste in an uncontrolled manner. Recyclables must be adequately stored to prevent odour nuisance and attraction of disease vectors. The use of pre-processing equipment requires regular maintenance as well as staff training.

Health and Safety: Safety precautions are necessary to limit the exposure of workers to waste, ensure safe equipment use and prevent injury, especially in the presence of (medical) sharps or when dealing with heavy loads. Personal protective equipment must be provided to operators involved in the handling of recyclables and staff must be sufficiently trained in occupational health and safety **(X.4)**. Facilities must have changing rooms and access to water for personal hygiene.

Costs: The cost of selling recyclables depends on the amounts handled and the facility size. Capital costs are mainly linked to land acquisition, the construction of a roofed and fenced facility with all necessary installations and vehicles and the equipment required for the pre-processing and packaging of recyclables. Operational costs are mainly staffing, water, fuel and electricity needs. Revenue might be generated from the sale of recyclables, which can reduce or offset the operational costs of the recyclable trading. Negotiations should be undertaken with recyclables buyers to cover any transportation costs.

Social Considerations: The informal waste sector is often involved to some extent in the collection and sale of recyclables. Creating competition with the informal sector must be avoided. Instead, efforts should be made to formalise the informal workforce and integrate it with SWM initiatives **(X.1)**. Establishing parallel recycling markets, competing with existing recycling sector actors and distorting local markets as a result, must always be prevented **(X.5)**.

Strengths and Weaknesses:

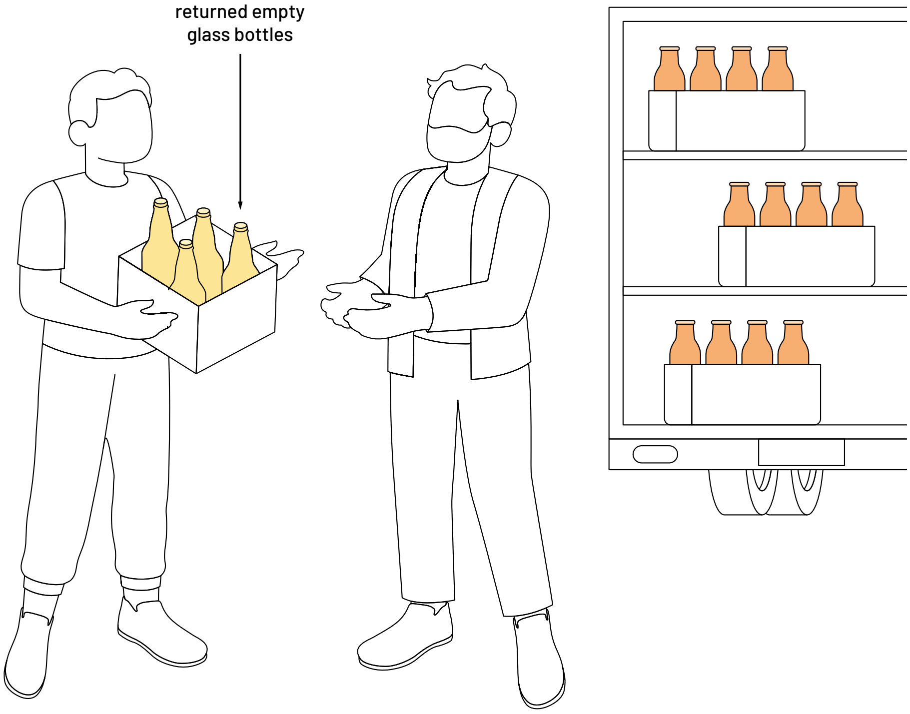
⊕ Creates revenue which can help to cross-finance SWM efforts
⊕ Reduces the amount of waste to be disposed of
⊕ Can supply inexpensive raw materials to local economic initiatives

⊖ Can distort local recycling markets if not carefully implemented
⊖ In humanitarian settings, local recycling markets may not exist, or only to a limited degree

→ **References and further reading material for this technology can be found on page 175**

Reuse of Waste Materials

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response Stabilisation Recovery * Protracted Crisis * Development	* Individual / Household * Community / Municipality * Institution * Urban * Rural	Household Shared * Public	Handover for reuse	Waste separation, User demand
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low	Private Sector Partners	Glass, Plastics	



The systematic and formal reuse of domestic solid waste materials is commonly limited to the return of specific items of a single type, such as glass bottles. It is mainly implemented at a commercial level, where companies re-use holding vessels such as glass jars. Formal reuse can save waste management efforts and make usable goods available for private sector entities.

Reuse is the prolonged use or repurposing of recovered waste materials without material transformation processing. Reuse contrasts with recycling where items are broken down into raw materials and used to generate new products **(T.6)**. Without the need for material transformation, reuse is a resource and energy-efficient approach. At a household or community level, reuse normally happens before items enter the waste stream and is a kind of waste prevention **(PART 1: Waste Prevention)**. Materials are repeatedly used for the same or similar task or repurposed for a new function. The reuse of discarded domestic solid waste is usually carried out by commercial enterprises using a systematic and formal approach in which specific items of a single type are returned and then re-enter production streams. Examples include glass bottles or jars that are collected, cleaned, refilled and reused again in new sales. The formal reuse of recovered waste materials at a household or community level can create challenges, including entitlement to the recovered items, cleanliness and social acceptance.

Design Considerations: Systematic and formal reuse requires the collection of specific, separate unused items which are of value to commercial entities. Waste segregation at source **(PART 1: Waste Separation)** at household, public and institutional levels is essential to ensure the availability, cleanliness and intactness of reusable items. If initially mixed with other waste, reusable items might be contaminated or damaged, which significantly reduces or prevents their reuse. Systematic and formal reuse requires collaboration with specialised commercial entities interested in collecting packaging materials or vessels to use for their own or comparable products. In such cases, commercial entities normally engage directly in the collection of items and execute any further processing of them.

Materials: Companies typically collect used packaging materials or holding vessels separately and feed them back into their production streams. Consequently, SWM providers are not involved in the reuse and are not required to provide equipment. The companies normally supply suitable trays or crates for bottles and holding vessels.

Applicability: Because of the need for waste segregation and commercial interest, systematic and formal reuse is likely to be limited to stable or protracted contexts or development settings. The overall viability of reuse depends on the cleanliness, intactness, quality and perceived value of the recovered materials as well as the interest and need of commercial entities to reuse or repurpose the materials. Implementing formal reuse mechanisms in humanitarian settings is unlikely. The availability of reusable materials can be low as the items are often directly reused or repurposed before entering the waste stream. Additionally, reusable items require thorough source-segregation and industries capable of processing reusable items located within manageable distances.

Operation and Maintenance: Systematic and formal reuse requires adequate cleaning and the sterilisation of returned items, but that is usually done by the commercial entities and is not part of the work of SWM providers.

Health and Safety: Qualified commercial entities are required to adequately clean and sterilise the items and check whether their structural integrity has been compromised. This prevents cross-contamination from other waste, the spoiling of refilled food produce and reused vessels from breaking or leaking. Occupational health and safety **(X.4)** is the responsibility of the commercial actors.

Costs: Formal reuse does not cost SWM service providers, as the return and processing of reusable items is organised and executed by commercial entities. The separate return of reusable materials to commercial entities can, however, reduce waste amounts and corresponding waste management efforts and may reduce costs.

Social Considerations: Commercial reuse relies on individuals and households returning specific items such as packaging materials and holding vessels. They must therefore be sufficiently informed about the option and process of returning used items as well as the types of items required.

Strengths and Weaknesses:

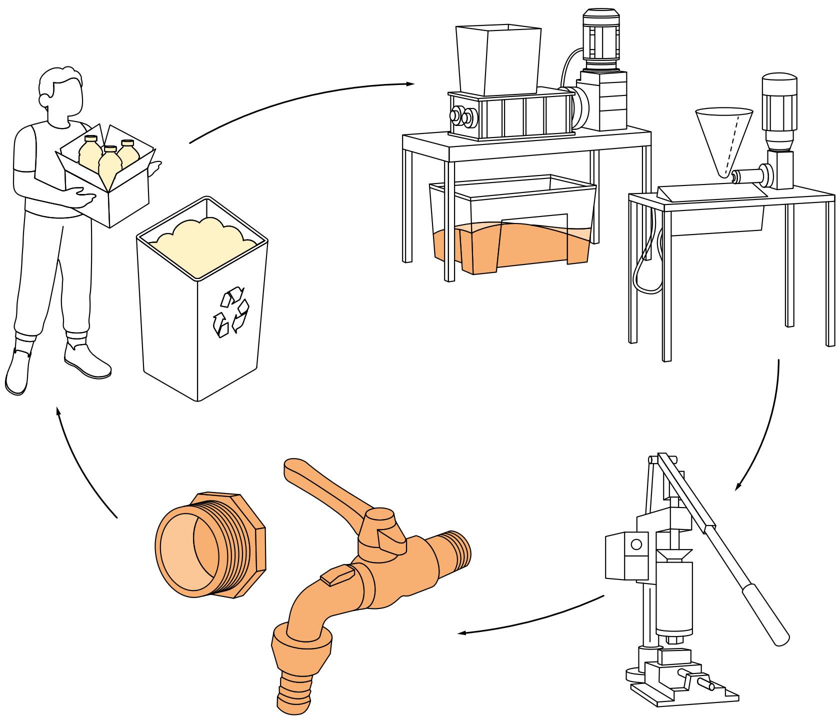
(+) Helps to reduce the amount of waste requiring disposal
(+) An energy and resource-efficient approach for commercial entities
(+) Makes usable goods available for commercial entities

(−) Requires the presence and involvement of commercial entities
(−) Requires sensitisation and instructions for individuals and households

→ **References and further reading material for this technology can be found on page 175**

Consumer Goods

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	* Household ** Shared ** Public	Repurposing and use of recycled materials	User demand
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	** Medium	Host Community, Private Sector Partners	Products from processed plastics	



Discarded recyclable materials, transformed through crafting and upcycling (T.7) into new products and everyday consumer goods, can be sold to generate income.

Consumer goods can be created from waste by transforming recyclable materials into new products. By diverting clean, recyclable waste from disposal sites, this resourceful process reduces the environmental burden and promotes resource conservation. Examples of recycled consumer goods include household items (such as plastic cups and dishes), furniture (such as injection-moulded plastic chairs) and rugs, blankets and clothing made of recycled textiles. The products can be sold to generate income. The approach is particularly relevant in areas with limited access to conventional consumer goods or where waste materials are abundant. Using clean and non-hazardous materials is crucial to ensure the safety and quality of the finished products. Particular attention must be paid to the presence of hazardous materials (such as asbestos) and the prevention of microplastic pollution. The selection and preparation of suitable waste materials are essential steps in this process. Repurposing waste materials fosters creativity and innovation while contributing to economic development and self-reliance in humanitarian and development contexts.

Design Considerations: Several factors should be considered in the design process. The types and quantities of clean waste materials available locally should be assessed, ensuring they meet safety and hygiene standards and are suitable for creating functional and durable consumer goods. Local needs, preferences and cultural appropriateness must be considered in the design process as well as the availability of skilled labour and appropriate tools for working with waste materials. Collaboration with local artisans, designers and community members can enhance creativity and the relevance and effectiveness of the produced goods. Competing with the local consumer material markets must be avoided as this can negatively affect local economies **(X.5)**.

Materials: Creating consumer goods with waste materials utilises locally available resources and promotes self-sufficiency. Depending on the product and implementation scale, the tools and machinery required can range from simple hand tools (such as scissors, hammers, saws, sewing machines and adhesives) to heavy machinery such as circular saws, injection moulding machines and extruders. Workers must be trained and protected using suitable personal protective equipment **(X.4)**. Not all materials are suited to being transformed into new products due to their chemical-physical properties.

Applicability: Creating and selling consumer goods from waste is suitable for many contexts, especially those with limited access to conventional consumer goods or where waste materials are abundant. This approach is applicable in more stable phases following acute response and through to development, offering a resourceful and sustainable solution for addressing basic needs and generating income. A thorough assessment of the available materials and associated risks is essential to ensure the safety, hygiene and quality of the products; factors such as the availability of materials, community needs, local conditions, local markets, cultural acceptance and skill availability must be considered. This adaptable approach can be scaled from individual household-level to community workshops, promoting self-reliance and stimulating local economies.

Operation and Maintenance: Using waste directly to craft consumer goods requires continuous sourcing, sorting and (potentially) conditioning of the waste. This may require ongoing community involvement and the establishment of collection points; or partnerships with waste management companies or small processing industries producing a specific waste stream of consistent quality, reliably unmixed with other materials. The crafting process requires the use of skilled labour or training. Regular inspection and maintenance are essential to ensure the quality and longevity of the products and manufacturing tools. The workforce size depends on the project's scale and complexity. Some solutions, such as repurposing plastic bottles, are straightforward, while others may require more in-depth knowledge. Common pitfalls include poor material selection, limited product lifespan, inappropriate techniques and lack of maintenance, compromising safety, stability and durability.

Health and Safety: To ensure the safety of both the producers and users of consumer goods, the further spread of waste must be prevented; used waste items and waste-based materials must be clean and free from contamination; hazardous materials **(W.2)** must be avoided. During production, workers must be equipped with suitable personal protective equipment **(X.4)**. Training in occupational safety and production techniques is essential and must include the particular risks of hazardous materials and the public health and environmental risks of waste in general. Regular inspections and maintenance at the production site are essential to mitigate potential hazards and ensure the safety of all personnel.

Costs: Utilising waste materials to craft consumer goods can be cost-effective. The repurposing of existing resources is typically cheaper than buying virgin materials, provided that the items made from waste materials are of a comparable quality to virgin materials. The total expenditure is influenced by several factors, including the scale and complexity of the project, the availability and suitability of local waste management infrastructure and the labour requirements. While using waste materials can reduce material costs, it may lead to increased training needs and corresponding costs. However, utilising waste materials has advantages beyond financial gain, such as waste reduction and income generation opportunities.

Social Considerations: The utilisation of waste materials to craft consumer goods may encounter cultural barriers or prohibitions related to waste and its perceived value. Some communities may view waste as unclean or unsuitable for consumer goods. Furthermore, user preferences and habits are a significant factor as individuals may be accustomed to traditional materials and methods. These perceptions can be addressed through educational initiatives that foster awareness and understanding of the potential benefits of incorporating waste materials into new products **(X.6)**. Demonstrating the advantages and safety of such consumer goods can facilitate acceptance. It is essential for successful project implementation to consider local capacity, including their skills, knowledge and available resources. Training programmes and knowledge-sharing initiatives can empower communities to adopt and adapt these techniques, enhancing their long-term sustainability and ownership.

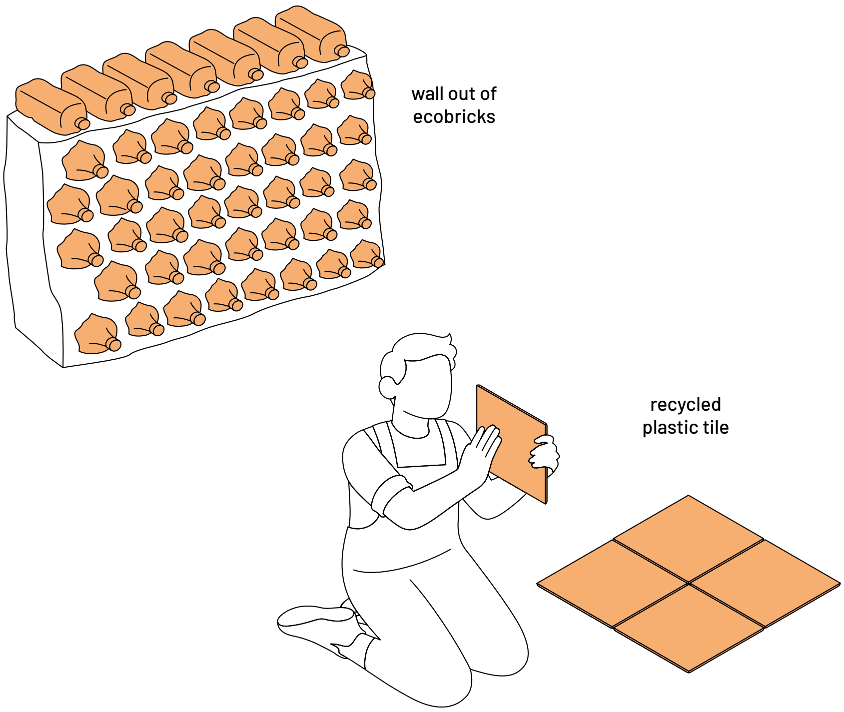
Strengths and Weaknesses:

- (+) Reduces waste and promotes resource conservation
- (+) Fosters creativity, innovation and community engagement
- (+) Creates economic opportunities and supports livelihoods

- (−) Requires access to suitable waste materials and tools
- (−) May face challenges in terms of quality control and standardisation
- (−) Requires ongoing training and skill development to ensure product safety and quality

Construction with Waste Materials

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	* Individual / Household ** Community / Municipality * Institution ** Urban ** Rural	Household * Shared ** Public	Repurposing and use of recycled materials for construction	User demand
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
** Medium	** Medium	Private Sector Partners	Products from processed plastics	



Construction with waste materials recovers and repurposes discarded construction materials and those produced from recovered waste and building debris (W.3). It can reduce waste, conserve resources and offer cost-effective solutions, especially where construction materials are scarce and expensive. The materials used must be safe, free from contamination and not contribute to the spreading of waste.

The utilisation of waste materials in construction can be a sustainable approach to building, diverting waste from controlled and uncontrolled disposal sites **(U.8–U.11)** and reducing the consumption of virgin materials. It can be a cost-effective solution, especially where construction materials are scarce and expensive. Waste-based construction might include the recovery and repurposing of clean, (ideally) non-recyclable, construction materials, construction materials produced from waste or the repurposing of debris and rubble **(W.3)**. Using recyclables as construction materials is a last resort; they should, ideally, be handed over to the local recycling sector. The cost and risks of construction with waste materials should be compared to construction with conventional materials and the safe disposal of the waste. Materials used for construction must be clean, free from contamination and prevent the further spreading of waste. Particular attention must be paid to the presence of hazardous materials, such as asbestos in debris **(W.3)**, and the prevention of microplastic pollution **(T.8)**. Suitable waste materials are, ideally, collected at source to prevent soiling or contaminating the remaining waste. Points for collecting suitable waste for construction include households, institutions and debris management sites. Various waste materials can be used for construction, such as plastic and glass containers, tyres filled with sand and recovered wood, bamboo, tarpaulin or metal. Construction materials made from waste include plastic containers filled with plastic waste (Ecobricks in **T.8**) and pavement stones or tiles moulded from a plastic-sand mixture. Some products have reduced lifespans and are susceptible to UV-light degradation. Waste from rubble and debris can replace virgin bricks and stones or be crushed and used to produce recycling concrete aggregate **(W.3)**. Ash can be used as a structural filler or to replace virgin raw materials in cement.

Design Considerations: Planning must consider the types and quantities of waste materials available locally, their suitability for the intended construction purpose and the way they can be used that minimise breakdown and adverse effects on health and the environment. Evaluate the materials' structural properties to determine their load-bearing capacity and durability and consider the effect on their performance and longevity of the local climate and environment. Assess the availability of skilled labour and appropriate tools and whether the use of waste-based materials in construction complies with national regulations, construction norms and building codes. Avoid competing with local construction material markets and negatively affecting local economies **(X.5)**.

Materials: Depending on the chosen construction technique and the scale of the project, tools and machinery range from simple hand tools (shovels and pickaxes) to heavy machinery (excavators and trucks). Workers must use suitable Personal Protective Equipment (PPE) **(X.4)**.

Applicability: Construction with waste materials is suitable in many contexts, especially those with limited availability of regular construction materials or excess waste due to conflicts and disasters. It is best applied in recovery and development phases, offering a cost-effective and sustainable solution for rebuilding infrastructure. The availability of materials, construction needs, local conditions, community acceptance, and skills must be considered. It can be scaled from individual houses to larger infrastructure, promoting resilient construction, creating livelihoods and stimulating local economies.

Operation and Maintenance: Using waste directly for construction requires continuous sourcing and sorting of waste. This may require ongoing community involvement and the establishment of collection points, or partnerships with waste management companies. The construction process requires skilled labour or training though some solutions are simple (such as earth-filled tyres). Others, such as Ecobricks, require new skills. Regular inspection and maintenance are essential to ensure the structural integrity and longevity of the constructions. The size of the workforce will depend on the size and complexity of the project. The most common pitfalls include poor material selection, the limited lifespan of waste-based construction materials and inappropriate construction techniques and lack of maintenance, compromising the safety and durability of the construction.

Health and Safety: To ensure the safety of construction workers and users of the built structures, the further spreading of waste must be prevented and waste materials for construction must be clean and free from contamination. Workers must be equipped with PPE **(X.4)**. Training in occupational safety and construction techniques is essential and must address the risks particular to waste such as hazardous materials, including asbestos **(W.2)**, and the public health and environmental risks of waste in general. Construction sites must be fenced off, and access limited to designated personnel only. Regular inspections and maintenance are essential to mitigate potential hazards and ensure the safety of all personnel.

Costs: Construction with waste materials can be cost-effective. The repurposing of existing resources is often cheaper than buying virgin materials. Cost is influenced by factors such as the scale and complexity of the project, the availability and suitability of local waste management infrastructure and the labour requirements. Though using waste materials can reduce the material costs of construction, it can increase training needs and corresponding costs. However, utilising waste materials has advantages beyond financial gain, as it can reduce waste and create income-generation opportunities.

Social Considerations: The use of waste materials in construction may confront cultural barriers related to waste and its perceived economic value. Some communities may view waste as unclean or unsuitable for construction. Individuals may also be accustomed to traditional building materials and methods. Their perceptions can be addressed through educational initiatives that foster an awareness and understanding of the potential benefits; demonstrating its advantages can increase acceptance **(X.6)**. It is essential for the success of a project to consider local capacity, including skills, knowledge and available resources. Training programmes and knowledge-sharing initiatives can empower communities to adopt and adapt these techniques, increasing their sustainability and ownership **(X.2)**.

Strengths and Weaknesses:

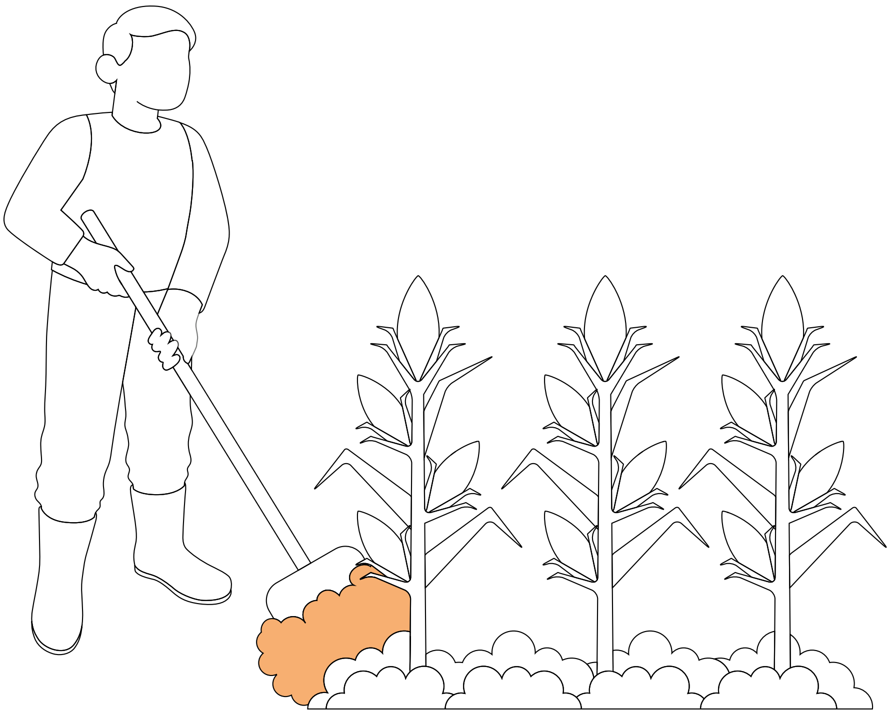
(+) Reduces waste and promotes resource conservation
(+) Can offer a cost-effective and accessible construction option

(−) Requires careful planning and consideration of material suitability and safety
(−) May face cultural barriers or resistance
(−) Requires training and skill development for proper implementation

→ **References and further reading material for this technology can be found on page 175**

Use in Agriculture

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household ** Community / Municipality * Institution * Urban ** Rural	** Household ** Shared ** Public	Fertiliser and soil improvement for plants and crops	User demand
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low	Host Community, Farmers, Private Sector Partners, Utilities, Food Security	● Compost, ● Vermicompost, ● Digestate, ● Frass	



Depending on the type of treatment of organic waste, the resulting products, such as compost, vermicompost, digestate or frass, can be applied to public or private land or to pots for agriculture, gardening or landscaping.

Organic wastes that have been treated by composting **(T.1)**, vermicomposting **(T.2)**, anaerobic digestion **(T.3)** or black soldier fly treatment **(T.4)** can be used as a soil conditioner/fertiliser in agriculture, home gardening, forestry, sod and turf growing, landscaping, public spaces/ parks, land reclamation, as a landfill cover material, or for erosion control. Although these treated waste products have lower nutrient levels of nitrogen, phosphorus and potassium per mass unit than commercial chemical fertilisers they can replace some part of the fertilisers needed. More importantly, however, when applied to soil and crops they have additional properties to fertilisers, such as carbon supply to soil and carbon sequestration, increased water retention properties, suppression of soil pathogens and plant diseases and a slow, steady release of nutrients.

Design Considerations: These organic waste-derived products are either spread on the surface of the ground, mixed into the soil before planting or used as a mulch around plants. Spreading over the soil surface, around plants or across entire fields improves soil fertility, water retention and erosion control. Incorporating the products into the soil improves soil structure and nutrient content. Mulching is typically used to retain moisture and suppress weeds; its slow incorporation into the soil eventually enriches it with nutrients.

Materials: Using these treated organic waste products involves transporting the products to the fields by hand or motorised vehicle and then using shovels, rakes and manual labour to apply the products onto or into the soil. Digestate can have a higher water content, resulting in a slurry-like product that requires tanker trucks with pumps and pipes for spreading onto the fields. Personal Protective Equipment (PPE) is required **(X.4)**.

Applicability: The use of treated organic waste is applicable in all phases of humanitarian aid, although agricultural activities are less likely during an acute response. Use is applicable to all scales of agriculture and farming. It is also applicable for household-level agricultural activities such as small gardens, backyards or even pot plants; or at a commercial level for forestry, landscaping, public areas/parks and even as a landfill cover material. Application in commercial or institutional situations is, however, more likely in protracted crisis and development situations.

Operation and Maintenance: Spreading equipment must be maintained to ensure continued use. Application rates and usage should account for the concentration of nutrients in the products so that they are used at a sustainable and agronomic rate. Compost typically has a balanced but relatively low nutrient content compared to chemical fertilisers, providing nitrogen (N), phosphorus (P), and potassium (K), along with micronutrients. The nutrient release is slow, making it a long-term soil amendment. Vermicompost is richer in nutrients than regular compost, especially in nitrogen, phosphorus, potassium, and micronutrients like calcium and magnesium. It also contains plant growth-promoting hormones and enzymes. Anaerobic Digestate is typically rich in readily available nitrogen, phosphorus, and potassium, with a higher concentration of nutrients than compost. Finally, frass (such as from black soldier fly larvae) is rich in nitrogen, phosphorus, and potassium, often with a balanced NPK ratio. It also contains chitin, a natural compound found in insect exoskeletons that can boost plant immunity and stimulate beneficial microbial activity. Frass has a fine, powdery texture and can act as a natural pesticide due to the presence of chitin.

Health and Safety: All treatment products derived from organic waste, especially if improperly processed, may contain harmful pathogens like E. coli, Salmonella, and Listeria, depending on the source material used. These can pose risks to human health if users handle the products without protection. Compost can harbour fungi such as Aspergillus, which produces spores that can cause respiratory issues, particularly for individuals with compromised immune systems or pre-existing respiratory conditions. If the products are very dry, the application can create dust that could be inhaled, causing respiratory irritation or allergic reactions. Lightly moistening the product before handling can help reduce dust generation. Users should wear appropriate PPE **(X.4)** and maintain rigorous hygiene practices during and after applications (avoid ingestion and practice regular hand washing). As the use of these products improves soil health, it can lead to the growth of healthier plants. In household or community gardens, this means fresh, nutritious food for people, improving overall community health and wellness.

Costs: The costs depend on the chosen transport and application method but are generally considered to be low. Manual labour is the main cost when applying these products. Their use will reduce the cost of purchasing commercial fertilisers. The application of treated waste products to improve soil quality and crop growth can enhance income generation through the sale of produced food.

Social Considerations: In general, users have a positive perception of the use of compost, vermicompost, digestate or frass if the products do not contain harmful or visually unappealing substances (e.g. glass shards and plastic). Training and orientation on their use should be given to support user acceptance. Use of these products can help reduce dependence on chemical fertilisers and contribute to a community's self-reliance. Promoting the use of these products can form part of larger sustainability and environmental education initiatives in communities or schools, contributing to a culture of environmental stewardship **(X.6)**.

Strengths and Weaknesses:

(+) Can reduce the use of chemical fertilisers and improve water retention in the soil
(+) Can reduce soil erosion
(+) Low cost

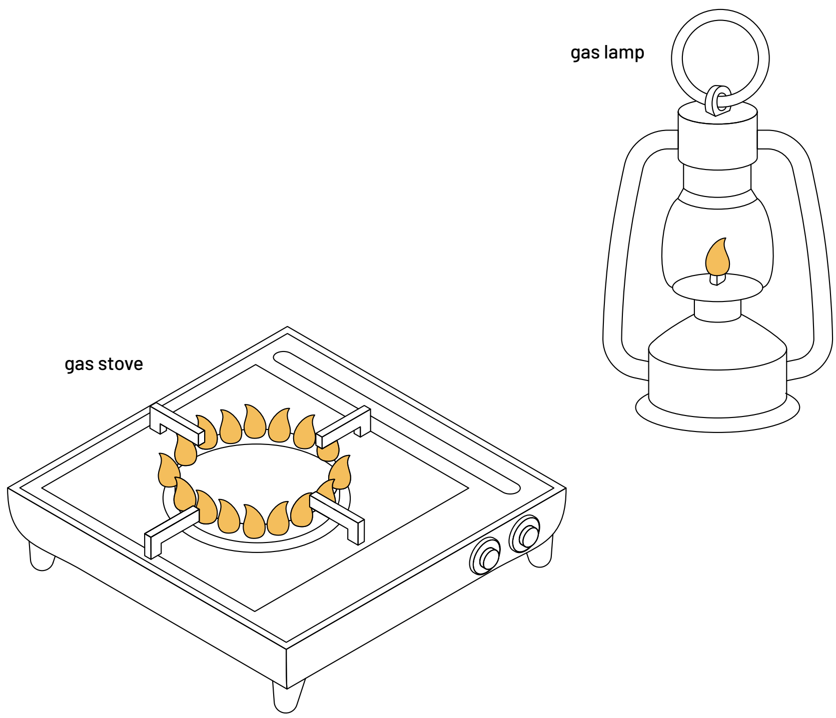
(−) Supplies reduced levels of nutrients to crops and soils compared to chemical fertilisers
(−) Requires significant manual labour for spreading
(−) May create public health risks, depending on its quality and application

→ **References and further reading material for this technology can be found on page 175**

Use of Biogas

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	** Household ** Shared ** Public	Biogas for cooking/lighting, Productive use or generation of electricity	User demand

Space Required	Technical Complexity	Link to other Actors	Input Products	Output Products
* Low	** Medium	Private Sector Partners, Utilities	Biogas	



Biogas produced from anaerobic digestion (T.3) can be used at a household level for cooking and lighting. At larger scales, it can be used with various biogas-powered appliances such as cooking stoves, refrigerators, water boilers or radiant heaters for poultry or livestock farming. Biogas can also be converted into electricity by gas-powered generators.

Biogas from anaerobic digestion **(T.3)** mainly consists of flammable methane. It can be used in cooking stoves, for lighting and can be converted to electricity for powering appliances. As a power source, a variety of biogas-powered appliances are market-available, including refrigerators and agricultural equipment such as radiant warmers for poultry and livestock farming. These biogas-powered appliances differ from other gas-powered equipment, as biogas is commonly supplied in an unpressurised form. The calorific value of biogas is around 6.0–6.5 kWh/m^3, which corresponds to about 1 litre of diesel or 1.3 kg of wood. For cooking, 150 to 300 L of biogas are needed per person and meal, depending on the food and food preparation practices. The preliminary soaking of dry beans and other hard foodstuffs or using pressure cookers can reduce energy needs.

Design Considerations: How biogas is used is best defined by the existing access to energy and amounts of biogas available. Biogas produced in low-tech reactors **(T.3)** is only available at low pressure and consumption should take place as close as possible to the reactor. Unpressurised transport with inflatable gas bags is possible but only conveys limited volumes. The volumes produced in humanitarian settings are commonly too small for bottling into pressurised cylinders or for using gas pumps for transport. At low pressure in pipes, moisture traps at low points are required to prevent clogging from condensed water.

No biogas pre-treatment is necessary when it is directly combusted. If used in engines or generators, biogas pre-treatment is required for the removal of water vapour and corrosive compounds such as hydrogen sulphide (H_2S). This complex step makes it less applicable for humanitarian settings. While biogas generators might be directly used to power electric appliances, feeding into existing electrical grids, even mini-grids, is likely to be too complex for humanitarian settings.

Materials: The extraction and use of biogas requires pipes and valves. The piping system connects the biogas unit with the gas appliances. Galvanised steel (GI) pipes, polyvinyl chloride (PVC) pipes or polyethylene (PE) plastic pipes are most often used for this purpose. Pipe diameters depend on the required flow rate of biogas through the pipe and the distance between the biogas digester and gas appliances. Biogas-powered stoves, lamps, appliances, engines or generators are all typically available to buy on the market. However, more specific or sophisticated appliances may require importation.

Applicability: The implementation of biogas reactors and the use of biogas are likely to be limited to stable conditions in protracted or development settings **(T.3)**. In households, biogas is most suitable for cooking or lighting. Biogas produced at scale in large anaerobic digesters at the community or institutional level can be used as a source of power or to generate electricity. Larger-scale biogas production is more likely in agricultural settings. Where sufficient organic waste is available, the digestate can be used for fertilisation and the biogas for various kinds of agricultural equipment.

Operation and Maintenance: Biogas is usually fully saturated with water vapour, causing condensation. To prevent blocking and corrosion, the accumulated water must be periodically emptied from the installed water traps. The gas pipelines, fittings and appliances must be regularly monitored by trained personnel. If biogas is used in engines or generators, biogas pre-treatment is required to remove water vapour and corrosive agents. The following consumption rates in litres per hour (L/h) can be assumed for the use of biogas: household burners: 200–450 L/h; industrial burners: 1,000–3,000 L/h; refrigerator (100L) depending on the outside temperature: 30–75 L/h; gas lamp, equivalent to a 60 W bulb: 120–150 L/h; biogas/diesel engine per horsepower-hour 420 L/h; generation of 1 kWh of electricity with biogas/diesel mixture: 700 L/h.

Health and Safety: According to the World Health Organization, biogas is considered a clean cooking fuel with minimal emissions affecting human health. Operating errors or equipment failure can cause uncontrolled biogas accumulation. This risks sudden ignition or an absence of oxygen in natural or built depressions. As biogas combustion consumes oxygen and generates carbon dioxide, fresh air ventilation must always be ensured. Households must be adequately trained to use biogas household devices (stoves, lamps). Staff using biogas-powered appliances and generators must be trained in occupational safety.

Costs: The cost depends on the type and number of selected biogas-powered appliances. The cost of gas piping and all auxiliary equipment of the reactor, such as water traps, are generally included in the cost of the biogas plant. Biogas cooking stoves are inexpensive and widely available. More sophisticated biogas-powered appliances, such as agricultural equipment, are much more costly, may need to be imported and can increase operational costs due to maintenance needs.

Social Considerations: In general, users enjoy cooking with biogas as it can be immediately switched on and off (as compared to wood and coal). Using biogas as fuel relieves women and children from the challenging responsibility of gathering firewood, thereby reducing their exposure to potential protection-related risks. Training and orientation on biogas production, safety and piping should be given to support user acceptance, ensure efficient use and maintenance of the stove and facilitate rapid identification of leakages and other potential issues. Depending on social and cultural norms, users might reject cooking with biogas produced from waste. Concerns about safety may also inhibit acceptance; projects should demonstrate to users that biogas is not dangerous (due to its low concentration of methane). The production and use of biogas can partially reduce dependence on other fuels and contribute to a community's self-reliance.

Strengths and Weaknesses:

(+) Fossil-free source of energy
(+) Independence from external sources for energy supply
(+) Reduction of indoor air pollution and deforestation
(+) Little operational skills or maintenance is required

(−) May not fulfil the total energy requirements thus requiring a backup system
(−) Can't replace all types of energy
(−) Can't be easily stored (low energy density per volume) and hence needs to be continuously used

→ **References and further reading material for this technology can be found on page 175**

Use of Fuel from Biomass

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household * Community / Municipality * Institution * Urban ** Rural	** Household ** Shared * Public	Fuel for cooking and heating	User demand
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low	Host Community, Private Sector Partners	Solid Biomass Fuel	

Solid biomass fuels, such as carbonised or non-carbonised briquettes or pellets, are produced from recovered organic waste. They can be used for cooking, heating or other energy applications. The use of these energy-efficient technologies ensures minimal fuel consumption and can reduce ambient air pollution.

Biomass with a high cellulose content can be used to produce solid biomass fuels such as briquettes or pellets **(T.5)**. While these fuels can be used for heating and other energy applications, they are often used for cooking. Cooking represents an essential and often underserved energy need in humanitarian settings. In cold climates, cooking and heating are often combined. Biomass fuels produced from organic waste can replace traditional biomass fuels such as wood and reduce the time, effort and exposure to risk from biomass gathering. Replacing traditional biomass fuels can help reduce deforestation, environmental degradation, the risk of gender-based violence and other public health concerns. However, an efficient use of biomass fuels is essential. This can be achieved, for instance, through improved or forced-draft cooking stoves or energy-retaining heating systems. According to the World Health Organization, solid biomass fuels are not a clean energy solution. Therefore, potential ambient and indoor air pollution should be assessed and minimised by using adequate stoves, heating systems and chimneys.

Design Considerations: The use of biomass fuel should consider fuel-related characteristics and the need for sufficient or enhanced airflow to ensure complete combustion and heat retention. Briquette and pellet stoves and heating systems differ from wood-based solutions due to the fuel size and an increased need for ventilation. Technology selection preferably considers the Multi-Tier Framework (MTF) developed by the World Bank which measures access to energy using multiple criteria (such as efficiency and ventilation) and applies to space heating and cooking solutions. Selecting low-tier solutions will increase fuel consumption and air pollution while reducing affordability, safety and convenience at the same time. Whenever possible, the use of locally produced technologies is preferred. If these do not meet the desired tier-level, access to adequate cooking or heating solutions might have to be provided through in-kind donations or the creation of a market supply.

Materials: Various materials are used to make cooking stoves and heating systems. Cooking stoves may be produced from virgin or recycled metals, repurposed metal items (such as cans or car wheel rims), clay or a combination of all three. Heating systems and chimneys can be built from concrete, brick and mortar, metal or heat-retaining stones or firebricks. Where possible, biomass fuel cooking stoves and heating systems should be constructed with locally available materials using local manufacturing capabilities to reduce costs and encourage local economic development. The materials should be durable and heat-resistant to prevent breakdowns or failure during use.

Applicability: The production of biomass fuel **(T.5)** and its use is likely to be limited to stable contexts in protracted or development settings. Energy-efficient cooking or heating solutions that use solid biomass fuels may not be locally available or widely used.

Operation and Maintenance: Solid biomass fuels must be stored in a safe and dry place to prevent the outbreak of fire and the absorption of moisture, which can lead to reduced heating values and increased smoke emissions. Plastic waste should not be used as kindling or fuel in stoves or heating systems. Proper training on the use and maintenance of improved biomass fuel systems ensures efficient and safe use; it should include management of the ashes. Chimneys might need regular cleaning of ashes and deposits to allow sufficient airflow and prevent chimney fires.

Health and Safety: According to the World Health Organization, solid biomass fuels are not clean cooking or heating solutions. Selecting the highest MTF tier solution for a given context helps to reduce ambient and indoor air pollution and increases affordability, safety and convenience of use. Ventilation and proper smoke extraction are crucial to ensure complete combustion and the removal of noxious fumes and gases, including carbon monoxide.

Costs: The cost of biomass-based solutions for cooking, heating or other energy appliances depends on the type of technology and the number of implemented units. In humanitarian settings, these solutions are commonly provided as in-kind donations or through subsidies, which allow market-based approaches. Both cases can be expensive for householders. Innovative approaches, such as carbon finance, pay-as-you-go or the leasing of mobile cooking equipment, can reduce upfront costs. Operational costs are mostly from the procurement of relevant fuels. Households often cover these costs themselves with their own funds or with the support of subsidies or cash and voucher assistance.

Social Considerations: Although the use of biomass fuels for cooking, heating or other energy applications is widespread, communities may still reject the introduction of new fuels and new combustion technologies. This can be because traditional food preparation methods are deeply ingrained or the use of recovered biomass from waste is socially and culturally unacceptable. Access to waste-derived biomass fuels provides an alternative to sourcing other solid biomass fuels such as wood. It can reduce the time and effort needed for biomass gathering which is commonly a burden for women and girls. The freed-up time can be redirected to education or income-generating activities. Improving access to fuel can also have a significant positive impact on protection outcomes. When introducing new cooking or heating solutions, existing private sector actors should be integrated with the implementation to prevent competition and market distortions **(X.5)**.

Strengths and Weaknesses:

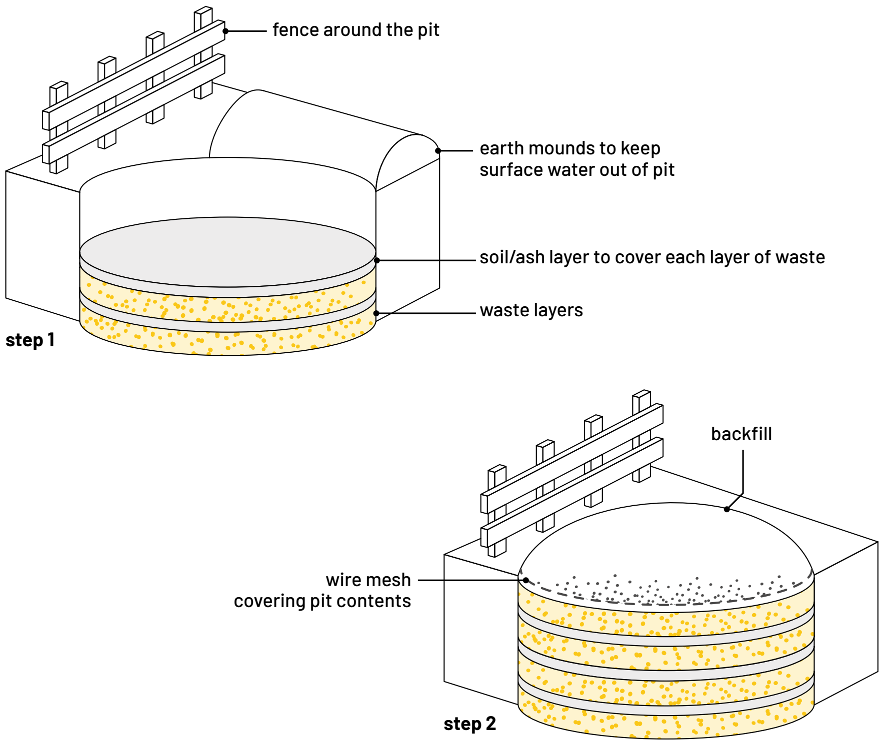
(+) Can replace traditional biomass fuels and reduce deforestation
(+) Can have a positive effect on protection outcomes
(+) Solid fuels from recovered biomass are renewable and carbon neutral

(−) Solid biomass fuels are not considered a clean energy source
(−) The availability of biomass fuel may be limited

→ **References and further reading material for this technology can be found on page 176**

Controlled Waste Pit

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response ** Stabilisation ** Recovery ** Protracted Crisis ** Development	** Individual / Household Community / Municipality Institution Urban ** Rural	** Household * Shared Public	Safe disposal of solid waste at household level	Separation of waste to only dispose of residual waste
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low	CCCM	● Residual Waste	



A controlled waste pit is a disposal method for household residual waste. The residual waste is deposited in a pit in layers. Each layer is covered with soil until the pit is full.

A controlled waste pit can be dug to dispose of residual solid waste. It is especially appropriate at the household level in rural areas where population density is low. A pit is dug in the ground and waste is deposited in layers. Each layer is covered with soil to prevent smells and animals or pests from accessing the waste. Although it is common practice, the waste should not be burned. A fence is used to protect the pit and avoid accidents and rainwater infiltration is avoided as much as possible to reduce leachate production. For a pit to last longer, and to avoid methane generation, organic waste should be separated at source and treated separately **(T.1 to T.5)** and recyclables should be separated whenever possible. Only residual waste should be deposited in the pit.

Design Considerations: A controlled waste pit is dug using simple tools; it can be done manually. A round-shaped pit is preferred as it is more stable. For a household, a suitable pit may have a diameter of 1 m and a depth of 1 to 1.5 meters. The bottom of the pit should be at least 1.5 m above the highest level of the groundwater table. The location of the pit should be at least 15 m away from dwellings and any water source. A typical family of five generates a total waste of 0.5 kg/person/day. If all organics and recyclables are segregated and not disposed of in the pit, it can last between one and two years. Without segregation, the same family would fill their pit in about six months. Once full, the waste is thoroughly compacted, covered with a wire mesh and backfilled with at least 0.5 m of soil cover to close.

Materials: Locally available and simple tools are required to excavate the pit (shovel, pickaxe); the same soil that is excavated is stored next to the pit and used as cover material on the layers of waste. A fence can be constructed with any locally available materials.

Applicability: This technology is more suitable in rural contexts where the population density is low, space is available and, because of the rural way of life, waste generation is low. As waste collection may be difficult to implement in such settings, self-management can be promoted using controlled waste pits. The solution is quick to implement as, once the pit is dug, it is ready to use. It is appropriate when the groundwater table is low and at least 1.5 m deeper than the bottom of the pit. It is most suitable for individual households but could also be shared by multiple households, although this reduces the lifespan of the pit.

Operation and Maintenance: A controlled waste pit is operated and maintained directly by the household or the group of households using it. Its operation includes regularly depositing the household's solid waste in a layer in the pit. The waste is then covered with 5 cm of soil once a week. If organic waste is properly separated and not added to the pit, the covering can be less frequent than weekly. The controlled pit works best when organics and recyclables are managed separately; otherwise, the pit fills very quickly and a new pit is required. Pit walls can collapse, especially during heavy rain; reworking the pit shape may then be necessary.

Health and Safety: During construction, attention should be paid to soil conditions to prevent wall collapse. If the conditions are unfavourable, the pit should not be dug too deep. As people and animals can fall into the pit, it should be protected with a fence to limit the risk. The proliferation of pests is a concern if organic waste is disposed of and/or waste is not covered. Using the pit incorrectly as a burning pit negatively impacts the health of the surrounding population. Personal protective equipment (such as gloves and boots) is recommended if contact with the waste in the pit is expected but this is rare and should not happen in normal operations.

Costs: Investment and operation costs are low. The cost of training households to operate and maintain the pits should be included. When used in the long term, this technology implies hidden costs: each time a new pit is opened, the land for each pit becomes unusable for any other future uses.

Social Considerations: The technology relies heavily on the households operating it properly. This includes segregating organic waste and recyclables to avoid filling the pit too quickly and not burning the waste inside the pit. Proper training and monitoring **(X.3)** of good practices are required to ensure the safe and controlled use of the pits.

Strengths and Weaknesses:

(+) Safely disposes of waste at a household level in rural areas with low population density and low waste-generation rates

(+) A low-cost, easy solution

(−) Unsuitable for mixed waste as it would fill too quickly requiring a new pit each time

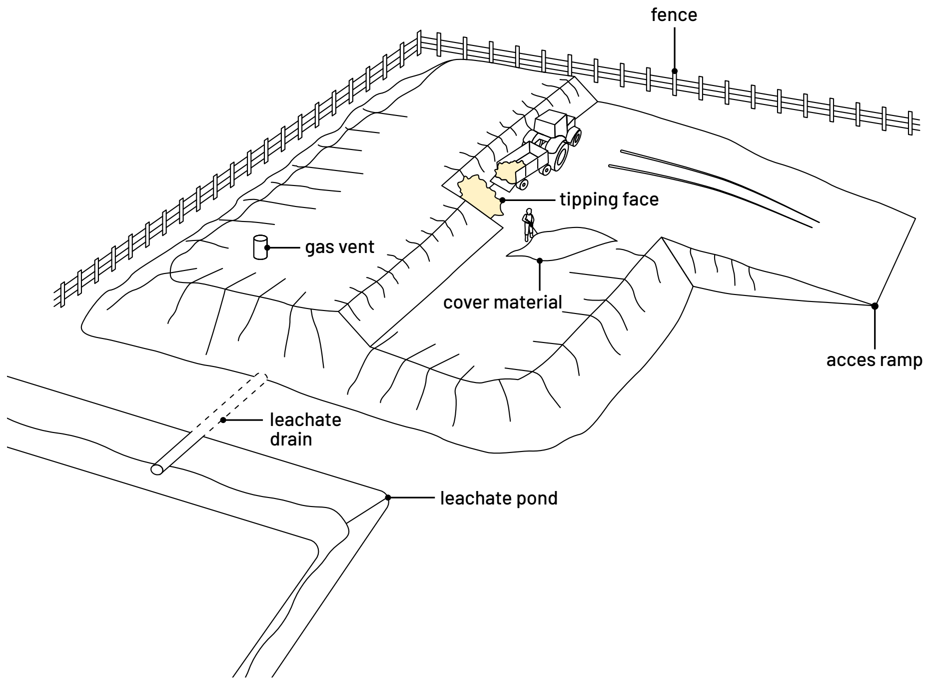
(−) Unsuitable in urban settings

(−) Maybe misused as a burning pit **(U.11)**

→ **References and further reading material for this technology can be found on page 176**

Controlled Disposal Site/Landfill

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response * Stabilisation ** Recovery ** Protracted Crisis ** Development	Individual / Household ** Community / Municipality ** Institution ** Urban ** Rural	Household Shared ** Public	Disposal of waste with mitigation and containment measures to reduce spreading and impacts	
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
*** High	** Medium	Host Community, Private Sector Partners, Utilities, CCCM	Residual Waste, Mixed Waste	



Controlled waste disposal uses mitigation measures to minimise the environmental and health impact of waste. At a designated disposal site, waste is systematically managed in 'cells' where it is spread, compacted and covered through manual or mechanised force. Whenever possible or necessary, controlled disposal sites are lined and waste leachate is collected and managed.

Unlike open dumping **(U.10)**, a controlled disposal site is a designated, government-approved area for safe waste deposit. Measures are taken to minimise negative impacts on public health and the environment, such as restricted access (fence, gate and guards) and diverting rainwater surface runoff into a peripheral drainage system. An impermeable bottom liner further prevents the infiltration of waste leachate into the groundwater. The collected leachate is transferred through internal drains into treatment, evaporation or recirculation ponds. Vent pipes ensure that flammable gases created in the deposited waste are safely released. In developed settings, these gases are flared to prevent methane emissions. In controlled disposal sites, waste is unloaded at the tipping face. There, it is spread, compacted and covered to create a cell. Waste cells are the building blocks of the disposal site.

Design Considerations: Site selection must minimise environmental and public health risks. It should assess the presence and flow direction of water bodies (both subsurface and surface), wind direction, distance to settlements and how neighbouring lands are being used. If possible, interventions should enhance and improve existing sites and avoid establishing new disposal sites. Shared use for displaced and host communities can facilitate approval. Disposal sites are either artificially prepared and excavated, built into the natural topography or a combination of both. The groundwater table's ten-year high should be at least 1.5 meters below the excavation base. The waste is deposited at the tipping face, spread, compacted in layers and covered with material to form a cell. The disposal site is designed and constructed cell by cell, layer on layer. The size of cells can vary but should be 1 to 1.5 m high to allow for proper compaction. The need for a liner depends on the risk of soil and groundwater pollution. Leachate ponds and potential recirculation systems must be sized according to local climate conditions to contain leachate within the site. Fences limit access to the site and prevent the loss of waste by wind. Vegetation can reduce surface wind speeds and act as a visual barrier. Covering with soil reduces odour and loss by wind and minimises the risk of fires. For manually operated landfills a height of three to six meters is recommended. In all cases, safe slopes for waste and cover materials are essential. As an example calculation of the surface area needed, a site four meters high serving 50,000 people over 10 years, generating 0.2 kg/person/day of residual waste requires a surface area of ca. 26,000 m² (2.6 hectares).

Materials: Heavy excavation and compaction vehicles may be required to prepare the site and, if a bottom liner is necessary, additional vehicles and equipment. Impermeable liners include geomembranes (typically used in leachate ponds) or geosynthetics which might have to be imported or brought in from further away. Compacted clay layers can act as a local and inexpensive alternative. Clay-rich soil is preferred as a cover material, but any locally available soil types and excavation materials are adequate. Manual operations require wheelbarrows, shovels, rakes and compaction equipment (hand tamper or manual roller). For mechanised operations, a landfill compactor, road roller or a track-type tractor is required to move, compact and cover the waste. Drains filled with gravel can ensure leachate drainage to the storage pond. Perforated vertical pipes can be used as vent pipes to safely release gases.

Applicability: Safe and controlled disposal sites must be prioritised over uncontrolled and unsafe waste dumping. In humanitarian settings, it should be considered at an early stage. Even if initially limited to improvised and non-ideal solutions, they can be improved and converted into controlled disposal sites over time. Waste should be separated at source **(PART 1: Waste Separation)**; though mixed waste can be disposed of it greatly reduces the lifetime of the disposal site; organic waste attracts pests and produces flammable methane gas; fast uncontrolled outgassing can lead to the collapse of piled waste. Most special wastes must be disposed of separately **(W.1–W.7)**. Controlled disposal sites can be used both in urban and rural contexts.

Operation and Maintenance: All incoming waste must be verified (to prevent deposits of prohibited materials). Truckload weights or numbers must be recorded (ideally with their origin). As the waste will settle over time, regular monitoring and maintenance are essential to address the changes and ensure the integrity and stability of the site. Staff requirements depend on the site design; if motorised transport of waste and cover material to the tipping face is possible and motorised compaction is used, staffing needs can be minimised. Whenever possible, environmental parameters such as air or groundwater quality should be monitored.

Health and Safety: All operators involved in waste deposits must be adequately trained in waste handling and occupational safety and require personal protective equipment **(X.4)**. To stabilise the disposal site and prevent the collapse of waste and landslides, slope gradients must be determined by an expert. Gas emissions can be safely evacuated with vent pipes and daily covering of waste reduces fire risks; smoking or fires must be prohibited on the disposal site. Access to unauthorised individuals, waste pickers and animals must be prevented with fencing and a gate.

Costs: Capital costs include the cost of the land, potential road extensions to the site, the preparation of the site and the implementation of protective measures. Operational costs include the recording and monitoring of received waste as well as its handling. Additional costs should be anticipated for the decommissioning and closure of the site. The site's lifetime influences costs as economies of scale apply to infrastructure in long-term use. In low and middle-income countries, costs can be estimated at around 10 to 30 USD per ton of waste, assuming the site operates for over 20 years. The siting of the facility also influences the cost of transporting waste to the site.

Social Considerations: If controlled disposal sites are poorly managed, they can become uncontrolled sites **(U.10 and U.11)**. Community engagement **(X.2)** is essential as disposal sites are not typically well accepted by neighbouring populations; identifying and obtaining approval for new sites might be challenging. Strategies for mitigating potential conflicts arising from the site's location or operation should be in place, as well as monitoring and addressing concerns such as odour, pests, property values and environmental impacts **(X.3)**. Women and marginalised groups must have a voice in decision making and their specific needs addressed **(X.9)**. Alternative income opportunities for informal waste pickers are essential as they must not allowed on disposal sites.

Strengths and Weaknesses:

(+) Can reduce the public health and environmental risks of solid waste disposal

(−) Has large space requirements and prevents or severely constrains the repurposing of land after closure
(−) Land acquisition can be challenging due to low political interest and acceptance from local communities
(−) Requires constant supervision and management to avoid becoming a dumpsite

→ **References and further reading material for this technology can be found on page 176**

Open Dumping

Not recommended!

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response * Stabilisation Recovery Protracted Crisis Development	* Individual / Household * Community / Municipality Institution * Urban * Rural	* Household * Shared * Public	Undesirable way of getting rid of waste	
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low		● Mixed Waste	

Open dumping is the uncontrolled disposal of waste in unauthorised areas causing health and environmental hazards.

Open dumping is waste disposal without control measures in locations unintended for waste management, such as natural landscapes, vacant lots, rivers and streams, drains and ditches, backyards, waste collection points (but outside the bins or containers) and illegal dumping sites. Open dumping is a consequence of a lack of proper waste collection, inadequate disposal infrastructure or even misuse of existing infrastructure. Open dumping creates severe environmental and public health risks such as soil and water contamination, air pollution, disease transmission and habitat destruction. Although it is practised in many places across the globe it is NOT a recommended solution and is unacceptable. As an open dump grows, waste removal and cleaning become a bigger and more complex task. The act of removing the waste must be accompanied by awareness and behaviour change campaigns to ensure the practice is phased out and waste does not re-accumulate.

Design Considerations: Open dumping has no design and should never be considered a possible solution. Nevertheless, depending on the location, the impact of open dumping can be less – or more – disastrous. Locations close to ground or surface water will severely contaminate these sources. For those located far away from any water bodies, the extent of the water pollution may be reduced or be less direct. The impact concerning distance is similar with respect to health risks to people: open dumping far from any residential areas, or where there is very limited exposure of people to waste, creates fewer or less direct health threats to people. The space use of an open dump depends on the amount of waste and the height of the waste pile.

Materials: Open dumping typically lacks infrastructure and should not be supported in any way with built infrastructure as this can accidentally signal acceptability.

Applicability: Open dumping is never an appropriate solution. Nonetheless, it might be a measure in the early stages of an emergency response when there are no other options; it might be the only way to temporarily concentrate waste in one place away from affected communities. However, humanitarian and development actors should always quickly plan for other safer disposal options such as controlled waste pits **(U.8)** or controlled disposal sites/landfills **(U.9)**. If open dumping happens, it must only be for a very short period and be phased out and rehabilitated as soon as possible.

Operation and Maintenance: A challenge of open dumping is that once it starts, the site attracts others to openly dump at the same place. The practice then becomes the perceived solution and can lead to increased illegal dumping and further complications and difficulties in managing the waste. Openly dumped waste also requires laborious and costly clean-up activities combined with behaviour change at a later stage to prevent it from happening again **(X.6)**.

Health and Safety: Each year, up to one million people in low- and middle-income countries die from diseases linked to improper waste management practices, such as open dumping. The open dumping of waste creates several health and safety risks, including fostering mosquito breeding that can spread diseases, such as malaria and dengue fever. Fungal growth on the waste can cause respiratory problems and sharp objects like needles and broken glass can cause injuries. Additionally, leachate or waste carried by rain can enter and contaminate water supplies. Open dumping can also block waterways causing flooding **(W.6)** and creating unsanitary conditions that increase health risks, particularly for children. Wind can disperse waste across the landscape, polluting and threatening distant locations and people. Scavenging and contact with waste increases the risk of diseases such as dysentery, diarrhoea and cholera. Livestock consuming dumped waste may become ill or ingest harmful plastics.

Costs: Open dumping appears to be low cost with minimal implementation and operational expenses, but this perception is incorrect. The impact of this practice generates significant direct and indirect costs, including health-related expenses from pollution and disease outbreaks, environmental clean-up costs, flood mitigation due to blocked drains, economic losses from decreased property values, reduced tourism and the expense of climate change mitigation from increased emissions **(X.8)**. These hidden costs, called externalities, often exceed any perceived savings, making open dumping economically unsound when all factors are considered. The financial burden typically falls on local governments, communities and individuals.

Social Considerations: Open dumping creates unsightly and unpleasant conditions that diminish community well-being. The practice may result from a lack of waste collection services. This is more common in low-income and marginalised areas, intensifying the vulnerability and disadvantages of these social groups. Often people are unaware of the health and environmental risks of open dumping, underscoring the need for education and awareness.

Strengths and Weaknesses:
⊖ Severe environmental pollution (soil, water, air) often combined with harmful open burning **(U.11)**
⊖ Increased risk of drain clogging and floods
⊖ Attracts disease vectors and pests, creating public health risks
⊖ No waste recovery or resource management, leading to the loss of potentially valuable materials

→ **References and further reading material for this technology can be found on page 176**

Open Burning

Not recommended!

Response Phase	Application Level	Management Level	Key Objectives	Prerequisites
* Acute Response * Stabilisation Recovery Protracted Crisis Development	* Individual / Household * Community / Municipality Institution * Urban * Rural	* Household * Shared * Public	Undesirable way of getting rid of waste	
Space Required	**Technical Complexity**	**Link to other Actors**	**Input Products**	**Output Products**
* Low	* Low		Mixed Waste	

Open burning is the uncontrolled burning of waste in open areas. Open burning releases pollutants that are harmful to health and the environment. It is never an appropriate solution for waste management and should be rapidly discontinued.

Open burning is the intentional uncontrolled burning of waste in open areas such as backyards, vacant plots, roadsides, open dumping and disposal sites and fields or farmlands. It is also carried out in waste storage containers, pits, outdoor furnaces, woodstoves and fireplaces. Waste can start burning unintentionally from the spontaneous combustion of flammable materials or flammable gases (methane) typically found in larger accumulations of waste. Open burning refers to waste materials that burn in the presence of oxygen. The process results in incomplete waste combustion releasing a range of pollutants directly into the environment. The mix of pollutants depends on the waste composition. Possible emissions are particulate matter, dioxins, furans, black carbon and other toxic gaseous chemicals, some of which are also potent greenhouse gases. In addition to contributing to global warming, these emissions pollute the air and soil. They can create serious health issues for humans, such as respiratory problems, cancers and other chronic diseases. Despite its severe negative impacts, open burning is commonplace as it reduces the amount of accumulated waste, enables the recovery of valuable non-combustible materials from the ashes and is perceived as a cost-free, easy solution. However, the practice has severe impacts and indirect costs from the environmental degradation and health issues it causes.

Design Considerations: Open burning has no design. Its main pitfalls are its severe health hazards and environmental damage, hence open burning should be avoided. Nonetheless, the severity of its impact on human health varies depending on the location of the open burning. If residential areas are not downwind of open burning, it is sufficiently distant or there is very limited exposure of people to the smoke, then the health threat to people may be less direct or severe.

Materials: Open burning of waste is typically initiated by a person, a starter fire and dry combustible waste. Once the fire is started the waste itself is the fuel and burning can spread and continue until the material is consumed or extinguished by water/rain or a lack of oxygen. Spontaneous burning can also occur if several favourable conditions align including heat accumulation and the presence of easily combustible material and gas, especially in larger uncontrolled piles of waste such as in open dumping sites **(U.10)**.

Applicability: Open burning of waste is never an appropriate solution. Nonetheless, it might be used as a temporary measure in the early stages of an emergency response. However, humanitarian and development actors should always quickly plan for safer disposal options such as controlled waste pits **(U.8)** and controlled disposal sites/landfills **(U.9)**. If open burning takes place, it must be very short term and temporary and phased out as quickly as possible. Open burning is an indicator of poor and unsafe waste management.

Operation and Maintenance: There is no operation and maintenance for open burning.

Health and Safety: The open burning of waste has health implications, due to the release of toxic pollutants. These pollutants may include particulate matter which can penetrate deep into the lungs, causing respiratory problems such as aggravated asthma, bronchitis and reduced lung function. Polycyclic aromatic hydrocarbons, formed during the incomplete combustion of organic materials, are carcinogenic. Dioxins and furans can be released, especially when burning plastics; they pose a significant risk by causing reproductive and developmental problems, damaging the immune system and increasing cancer risk. These persistent chemicals can settle on the soil, contaminating fields and food sources. Burning materials that contain metals like copper, iron, chromium and aluminium can catalyse the formation of persistent organic pollutants, especially dioxins and furans. Uncontrolled burning of household waste causes an extra 270,000 premature deaths every year around the world. Even if the burning takes place away from the population, reducing the health hazards, there are climate impacts. The open burning of waste leads to emissions of black carbon, estimated to have a 20-year Global Warming Potential of 4,470 compared to one unit of CO_2. Globally, the release of methane and black carbon (in smoke) from uncontrolled dumpsites is accelerating climate change **(X.8)**.

Costs: Open burning is perceived as a simple, low-cost approach because it does not rely on equipment or infrastructure. However, costs can quickly escalate if fires spread. The cost is also high when indirect external costs are considered, such as the social impact, ill health, climate change, damage to livestock and wildlife and loss of business and tourism. The overall economic cost to society from improper waste management practices, such as open dumping **(U.10)**, open burning and inadequate resource recovery, is estimated to be five to ten times higher than the financial cost of proper waste management.

Social Considerations: Emissions from open burning significantly impact vulnerable populations, including children, the elderly and people with health problems. The intentional burning of waste to recover materials of value may be a livelihood strategy but its risks and health impacts outweigh the short-term economic benefits. Open burning is a common practice in low-income and marginalised communities due to poor waste management services and infrastructure, raising concerns about environmental justice. Although banned and illegal in many countries, it is often tolerated by service providers as it 'removes' waste; enforcing a waste-burning ban is therefore difficult. Sometimes waste is even burned as fuel in stoves which has a direct health impact, especially if plastics are included. Many are unaware of the associated severe health and environmental risks, highlighting the need for education and greater awareness. Open burning at disposal sites disproportionately affects vulnerable groups in the vicinity who may work with the waste, live close by or lack the means to oppose it. Addressing these issues requires better waste management and community education.

Strengths and Weaknesses:

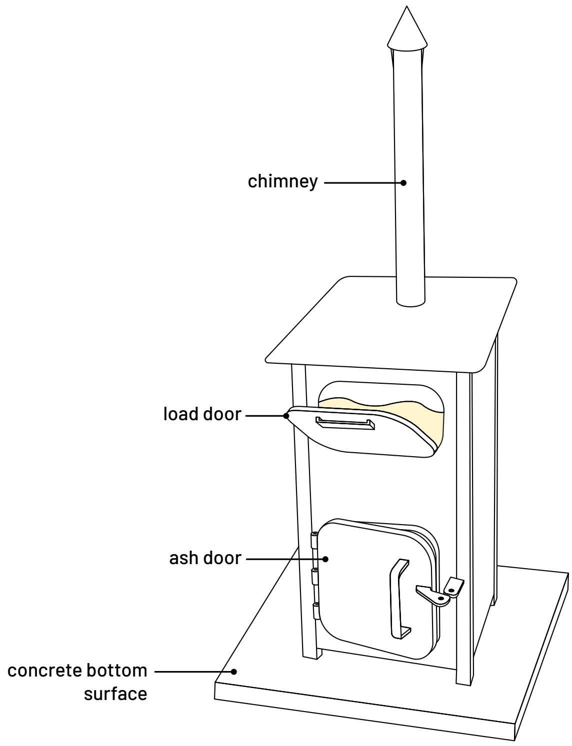
- (−) Contributes to air pollution and climate change, severely impacts the health of the affected population and leads to long-term environmental degradation
- (−) Can lead to the spread of fires, endangering lives and habitats
- (−) Has highest impact when near residential areas and indoors

→ **References and further reading material for this technology can be found on page 176**

Contained Burning

Not recommended!

Response Phase * Acute Response * Stabilisation Recovery Protracted Crisis Development	**Application Level** Individual / Household * Community / Municipality * Institution * Urban * Rural	**Management Level** Household * Shared * Public	**Key Objectives** Contained burning of specific waste fractions in the absence of other solutions	**Prerequisites** Waste segregation
Space Required * Low	**Technical Complexity** ** Medium	**Link to other Actors**	**Input Products** ● (Menstrual Waste), ● (Medical and Health Care Waste)	**Output Products**



Contained burning eliminates solid waste through the combustion of specific solid waste fractions under controlled conditions in a simple furnace. Contained burning is not recommended because of its high emission levels endangering health and the environment.

Contained burning is often assumed to be the same as incineration. It is not. In the absence of other solutions, specific waste fractions are burned in special infrastructure/equipment designed for the purpose. However, its simple design and limited control mechanisms make it a hazardous practice, potentially releasing contaminants and endangering human health and the environment. By contrast, incineration is a highly sophisticated, technical and complex waste-treatment approach that fully controls fly ash, gas and slag emissions using specific technical and monitoring measures to limit environmental and health impacts. However, incineration is expensive and highly skilled so it is not recommended for humanitarian response. Nonetheless, contained burning can reduce the volume of combustible waste. Harmful emissions can also be reduced if controlled conditions are maintained and the design and operation optimised for complete combustion. Controlled conditions include achieving and maintaining temperatures during burning and the residence time of the waste in the furnace. Contained burning is not recommended, as complete combustion of mixed domestic waste is difficult to achieve resulting in the emission of toxic and harmful fumes. Some waste is obviously non-combustible (such as stones and metals). Other waste is unsuitable such as organics (often wet and difficult to burn) and plastics release toxic pollutants.

Design Considerations: A simple contained burning furnace is constructed of one or two burning chambers with an exhaust chimney. Correct installation is essential to ensure optimal combustion conditions, including at least a one-second smoke residence time and high temperatures maintained (between 850 °C and 1000 °C in the primary and secondary combustion chambers) throughout the burning period, to foster complete combustion. The stack height of a furnace must exceed four meters to prevent emissions from directly affecting operators or others nearby. The furnace should be built at least 150 m away from households and 300 m from horticulture or leaf crops, further if nearby buildings are tall. It should be constructed of concrete, blocks or bricks; the floor should be solid concrete. Two furnace types are commonly used: auto-combustion furnaces for waste with a high enough heating value to support its own combustion; and fuel-assisted furnaces where fuel is added. The composition of the waste and its respective heating value is therefore a key consideration when selecting the furnace type. The furnace dimensions depend on the required capacity (volume and type of waste) and the burning capacity of the furnace model (dimensions, type, heat reached, quality of materials).

Materials: Because of the high temperatures, refractory bricks and mortar and stainless steel of sufficient thickness to reduce premature corrosion are recommended. These are generally available in most contexts. Alternatively, technical substitutes can be found (e.g. common mortar and cooked bricks) though they may affect the equipment's durability. Prefabricated or portable high-quality simple furnaces are available; they are more expensive and generally of low capacity..

Applicability: Contained burning may be applicable in the early phases of an emergency as a temporary measure to manage specific fractions of waste, such as menstrual waste **(W.3)** or medical waste **(W.1)**, reducing immediate public health risks. It should not be used long term due to its significant health and environmental impact. Complete combustion requires dry combustible refuse; when unavailable, additional, expensive fuels are required, making it even less appropriate for communities. As soon as possible, waste disposal should transition to more sustainable practices. Incineration can be suitable to thermally treat high-risk waste such as infectious and hazardous healthcare waste **(W.1)**.

Operation and Maintenance: Contained burning requires highly trained operators and an operating environment that limits the exposure of workers and communities to toxic combustion fumes and minimises potential environmental harm. An operation and maintenance plan is essential. As the temperature of a furnace is suboptimal at the beginning and end of the process, it is better to run it continuously. This requires specially designed working schedules. Maintenance includes checking the equipment and materials for cracks on internal and external bricks and corrosion in the chimney, hinges and other metallic parts; and cleaning the furnace interior, chimney, equipment, tools and surrounding area. Ashes should be regularly extracted from the furnaces and disposed of safely.

Health and Safety: Operators may be exposed to hazardous materials, medical waste, heat and ashes (which can contain toxic substances and heavy metals). They must be properly trained and equipped to handle them safely and understand the risks from toxic fumes (including furans and dioxins), high levels of particulates, acid gases, heavy metal vapours, carbon monoxide, nitrogen dioxide and sulphur dioxide – especially at temperatures below 600 °C if PVC and other plastics or chemicals are burnt. These fumes can be directly inhaled or deposited on the soil, water and crops, becoming part of the food chain, harming the environment and exposing operators and households to health risks. Personal protective equipment should be provided **(X.4)**, fire extinguishers and first aid kits available near the furnaces and, preferably, fencing around the equipment to prevent intrusion and injury.

Costs: If local materials are used, the cost of furnaces is low. Prefabricated, modular or portable high-end equipment is significantly more expensive. Budget for operation and maintenance (including equipment, training, and salaries), running costs (such as fuel oil, dry wood or charcoal) and the cost of segregation, collection and transportation of solid waste and the disposal of ashes if required.

Social Considerations: Due to its potentially high impact on local communities and because burning waste removes any incentive to sort and recycle, contained burning must be implemented with inclusive community consultation **(X.2)**. Local people's concerns should be addressed through awareness campaigns about air pollution, health effects and cultural sensitivities **(X.6)**.

Strengths and Weaknesses:

(+) A substantial reduction in the weight and volume of solid waste
(+) High temperatures deactivate pathogenic or infectious substances
(+) Low-technology solutions exist using local materials

(−) Generates emissions which endanger human health and the environment
(−) Does not contribute to recycling efforts
(−) Risk of malfunction if operators are not instructed correctly

→ **References and further reading material for this technology can be found on page 176**

PART 3 :

Cross-Cutting Issues

X.1 Institutional and Regulatory Environment
X.2 Inclusive Planning and Participation
X.3 Monitoring, Evaluation, Accountability and Learning (MEAL)
X.4 Occupational Health and Safety
X.5 Market-Based Programming
X.6 Hygiene Promotion and Behaviour Change
X.7 Links to Other Clusters and Topical Domains
X.8 SWM and Climate Change
X.9 Protection, Accessibility and Conflict Sensitivity
X.10 Advocacy

X

Cross-Cutting Issues

X.1 Institutional and Regulatory Environment

During humanitarian emergencies, states continue to be responsible for the safety and security of the affected population and those forcibly displaced on their territory. National laws, regulations, standards and codes provide the architecture for the emergency response, including the protection of public health and the prevention of environmental damage and pollution. In humanitarian settings, the overall responsibility for SWM remains with the local or national government authority. The detail in government SWM directives varies. Regulations may define which materials are considered as solid waste and categorise them according to their properties, origin or severity of the risk to public health or the environment. Regulations may also specify how SWM services are to be provided and by whom, the ownership of infrastructure and services and how operational models will be designed and implemented. In the absence of detailed SWM legislation, states may simply outline national objectives or action lines for the handling of solid waste. Such directives are, nonetheless, based on existing legal frameworks and can for instance be formulated as a national SWM strategy. Humanitarian actors must adhere to national regulatory frameworks or, in their absence, align with national objectives.

Formal Stakeholders

As sovereign states, government departments lead and implement emergency response and humanitarian assistance. Local government may play an important role and is usually responsible for all local public services, land issues and the sites of facilities. National policies and decisions and the leadership of government departments and local governments have a major influence on the relief approach.
Countries experiencing conflict, natural disasters or other public emergencies often face significant capacity and resource constraints and may be unable to fully assume their responsibility for the coordination and implementation of an effective response. In such cases, the government may reach out to the international community for support and assistance. Contributions can come from bilateral partners, multilateral organisations (such as the United Nations and its specialised agencies), local and international non-governmental organisations (NGOs), auxiliaries to the government such as the Red Cross and Red Crescent societies, or private-sector companies. At the community level, individuals and community-based or grassroots organisations often provide humanitarian assistance. All these actors (government, bilateral, multilateral, auxiliary, non-governmental and private sector) may be engaged in SWM at different levels. In emergencies in low and middle-income countries, the SWM expertise and capacity of government, utilities and national NGOs may be limited due to a lack of, or non-functional SWM in the country. Awareness raising and capacity strengthening might therefore be required, especially for government decision-makers and technical departments **(X.10)**.
For SWM humanitarian assistance, close collaboration with government entities and utilities is essential, providing opportunities for technical departments and utilities to strengthen their technical skills and expertise. In addition, it increases the sustainability of interventions and their longer-term impact. Furthermore, collaboration can facilitate the necessary clearances and permits from authorities, the use of existing utilities' resources and create opportunities for exit strategies. For instance, the site selection and design of SWM infrastructure (such as landfills **(U.9)**, transfer stations **(C.5)** or communal waste storages) may need approval from national authorities. The collaboration can ensure that expected standards and designs are considered from the outset. It can increase the pace of the implementation and both sides can learn from each other. Humanitarian actors may also benefit from utilities' often large workforces and vehicle fleets. Exit strategies can be pursued through a step-by-step handover of responsibilities, equipment and tasks to the local utilities. A welcome side effect of strengthening local capacity is that host or unaffected communities also benefit from enhanced services and expertise.

Coordination of Response Delivery

Humanitarian agencies must not frustrate or operate in isolation or in parallel to government efforts. Existing national capacities and local structures should always be the starting point when planning emergency response services and, if required, be assisted by targeted capacity-strengthening measures. The Cluster Approach was adopted in 2005 to enhance the effectiveness of humanitarian responses and ensure coordination between the government and different humanitarian actors. It consists of eleven thematic clusters each led by a designated international organisation. At a country level, clusters support national coordination platforms, are commonly co-chaired by governmental representatives and ensure that the humanitarian response of different agencies is coordinated and aligned with national response structures. At the global level, clusters can strengthen system-wide preparedness and provide leadership, accountability and technical capacity. Domestic SWM is assigned to the WASH cluster but is thematically linked to other clusters **(X.7)**. Intersectoral coordination is required as waste is generated by almost all sectors and should, ideally, be prevented in the first place **(PART 1)**. Specific materials recovered from waste, such as food waste, recyclables or non-recyclable composite plastics, can be used for livelihood opportunities and income generation. In addition to domestic solid waste, some cluster activities, such as in Health and Shelter, produce specific waste types such as medical waste or construction debris which require separate treatment and disposal. Some clusters directly manage their sector's specific waste types. Clusters with large workforces or expertise in fleet management may implement cleaning campaigns or waste collection and hauling **(X.7)**.

Legal and Regulatory Framework

When planning SWM interventions, the national regulatory framework must be understood. When SWM is legally defined, the law generally provides the overall framework and the regulations provide the details. A range of laws concern SWM, including environmental legislation, public health and planning laws. Within those, standards might have been developed; for instance, values defined to limit the contamination of accepted waste at landfills, waste material reuse and recycling, or energy recovery. Codes of conduct may state which systems are acceptable and how they should be designed and built. These frameworks can be limited to specific waste materials or cover a variety of waste categories.
In some countries, a detailed legal and regulatory framework might not be in place. Conversely, in the acute phase (depending on the humanitarian assistance required) it might not be possible to design SWM systems in line with national standards and regulations. In these cases, solutions should be discussed with the responsible authorities. A pilot status for a new intervention, or moratoria that temporarily suspend the legislation are ways to implement infrastructure outside existing codes of practice and standards; they may also lay the foundations for future reforms. Planning with a hand-over and exit strategy in mind typically increases the overall acceptability and potential sustainability of new systems. If national guidelines do not exist or are not specific, the Sphere minimum standards should be used for further guidance **(Introduction: Principles and Standards)**.
Relevant frameworks for SWM are not limited to national legislation or Sphere but also include international treaties. The Basel Convention controls and regulates the transboundary movement of hazardous wastes and their disposal. Various special waste types, or parts of them, are considered hazardous and fall under the Convention. They include Medical and Healthcare Waste **(W.1)**, e-waste **(W.7)** and other hazardous wastes such as waste oil and vehicles **(W.2)**.

Informal Sector

The informal sector is also usually involved in SWM. Actions of the informal sector include material collection at a household level, waste picking from communal or public storages or dumpsites, and the informal processing of waste. Activities of the informal sector are fuelled by the possibility of income generation through the recovery and sale of useable and valuable materials and components. This includes recycled materials within a country or region for which there is a price as secondary raw material. They include metals, glass, plastic, paper and cardboard. Precious metals, such as gold or copper, might be extracted through the uncontrolled melting and burning of specific waste materials such as e-waste **(W.7)**.
Informal waste handling practices typically adversely affect the informal workforce itself, public health and the environment and often include child labour. Waste picking from public storages or dumpsites exposes the informal workforce to disease vectors, injuries caused by sharp objects and unhealthy unhygienic conditions. Low air quality and exposure to toxic fumes can be caused by uncontrolled waste burning or the informal burning or melting of e-waste to extract precious metals. Environmental pollution can be caused by open dumping **(U.10)** or burning of waste **(U.11)**.
The informal sector can play a significant role within SWM; however, this role is usually limited to the recovery of materials that are easily removed from waste, recyclables which are not soiled by other waste, or high-value materials. Low-value, bulky or soiled materials, even if they have a trade value, are rarely recovered from waste by informal workers. Instead, they are dumped. Informal waste handling therefore does not contribute to solutions for public health or environmental issues caused by waste.
Humanitarian SWM interventions must avoid competing with the informal sector as it can undermine a last-resort livelihood opportunity. Instead, when possible, include the informal workforce in projects and formalise the sector, for instance through employment or the creation of associations. Associations can empower waste handlers and scrap dealers through an extended range of recoverable materials, defined prices, trading of larger amounts at higher prices and access to bulk traders. At the same time, adequate working conditions, the use of personal protective equipment and the prevention of child labour can be facilitated.

Certification of Private-Sector Partners

Humanitarian SWM service providers may procure specialised private-sector services, for instance for the disposal of special wastes **(PART 4)** which must be separately disposed of from other domestic solid waste. These service procurements must be conducted in accordance with national legislation or, in its absence, according to predefined quality standards. To simplify this due diligence, it is advisable to collaborate with certified companies; this can help to prevent illegal and unsafe waste dumping or violations of occupational safety standards **(X.4)**.
The International Organization for Standardization (ISO) provides a general framework for environmentally sound processes and procedures, such as ISO 14001 on environmental management systems. In addition, specific certification for the handling of e-waste **(W.7)** exists, such as Responsible Recycling (R2), Recycling Industry Operating Standard (RIOS) and e-Stewards.

→ **References and further reading material can be found on page 176**

X.2 Inclusive Planning and Participation

Inclusive planning and participation aim to actively engage diverse stakeholders in the process of developing SWM programmes and plans. The objective is to be accountable for ensuring that the perspectives of all stakeholders, particularly marginalised groups, are considered and addressed in SWM activities and services **(X.9 and X.3)**.

Inclusive planning and participation are key to achieving the objectives of short-term impact and longer-term sustainability of humanitarian interventions. The approach actively involves and empowers affected stakeholders to contribute to and inform the plans and activities. It also respects the role of local authorities, the entities usually in charge of, for example, approving the allocation of land for collection points or landfills and managing existing SWM systems and plans. It promotes adequate consideration of diverse stakeholders' needs, barriers, preferences, resources and opportunities to increase the efficiency, effectiveness and impact of services along the entire SWM service chain. Actively involving representative stakeholders in designs and plans also helps humanitarian actors anticipate and mitigate the risk of discrimination and harm – critical in all interventions.

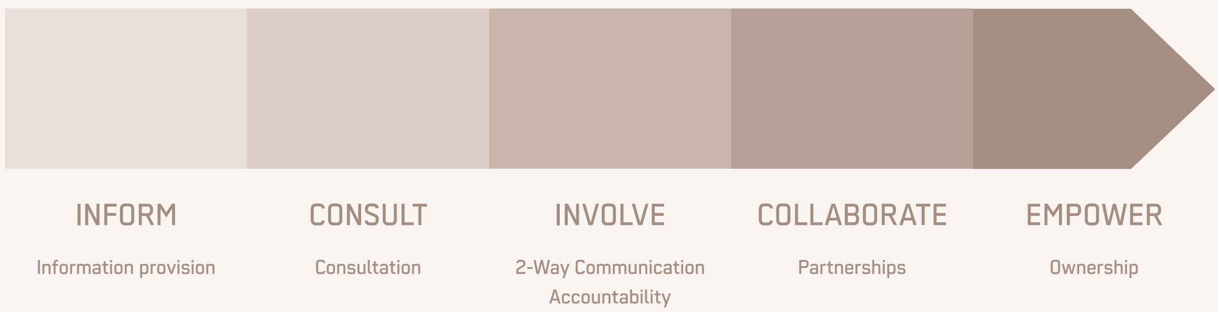
Inclusive planning in SWM generally starts with a (rapid) assessment **(PART 1: SWM Assessment)**. The assessment should be as participatory as possible, involving stakeholders in the process and gathering insights about their needs, capacities, and experiences. It enhances the relevance and accuracy of assessments by integrating the perspectives of those directly affected. The assessment can also help gauge stakeholders' attitudes and the willingness of community members (including those from marginalised groups) to engage in different forms of SWM, thereby fostering a sense of ownership and empowerment.

Once the information has been analysed, different SWM options should be jointly identified and their viability and implications discussed with the affected stakeholders. Options should consider social, economic and technical perspectives. Meaningful participation is dynamic; the co-creation of SWM response plans can only be achieved when both actors and communities are involved in the decision-making and planning process. The figure below describes what is often referred to as the five 'levels of participation': inform, consult, involve, collaborate and empower.

At the beginning of an emergency, people need vital information about how to protect themselves and where to get help (inform). However, there is always time to ask people about what they need. Over time, this consultation should broaden and deepen to shape and give feedback on SWM programme activities (consult). Even at the start of an emergency, there are opportunities to involve people in making decisions about, for example, the frequency of waste collection services or waste segregation options (involve). As stakeholders begin to self-organise, they can choose to partner with humanitarian actors, taking the initiative and proposing improvements (collaborate). Empowerment is usually seen as the highest level and involves stakeholders increasing their agency and activity to initiate, adapt and further engage in leading SWM decisions and coordination.

In keeping with the concept of empowerment, the process may also contribute to longer-term SWM capacity for relevant stakeholders. This process includes requirements and modalities for the continuous operation and maintenance of systems and structures established during the humanitarian response and jointly developed handover and/or exit and decommissioning strategies. Inclusive handover plans should also consider how to manage a (gradual) withdrawal of external donor funding for SWM activities, the capacities of stakeholders such as the local private sector and authorities and cost-recovery options.

Figure 8:
Levels of Community Engagement (adapted from WHO 2020 and ALNAP 2014)



Various participatory methods and tools, such as focus group discussions, transect walks or community mapping, can be used to facilitate this process and actively engage the different stakeholders. It is essential that the process is accessible to diverse groups, including children, women, men, older people, host communities, displaced people and different ethnic groups **(X.9)**. A comprehensive overview of existing tools and methods can be found in the Compendium of Hygiene Promotion in Emergencies.

People's level of engagement depends on their motivation and capacity to engage as well as the barriers, opportunities and incentives to participate. The crisis-affected population will not all be the same; it is vital to understand existing differences as well as the factors that separate and unite people. Working with existing local entities can increase their engagement; key individuals from known groups or organisations can act as representatives for others, broadening the scope of inclusion. Strengthened community organisation or bonds (or elected representatives from different stakeholder groups) can enable the affected population to collaborate with or lead the emergency response in partnership with response teams.

A truly inclusive planning process should follow the planning phases outlined below:

1. Understand the various dynamics and structures associated with SWM within the community and other stakeholders (stakeholder mapping, KAP surveys) while identifying accessibility and inclusion factors (barrier analysis, gender equity and social inclusion analysis).
2. Initiate the project design: who needs to be involved, who will manage the process and who has decision-making powers? Discuss the selection criteria and details of who will benefit from the programme.
3. Create an inclusive task force that represents all members of a target community and the relevant authorities, organisations and other key actors.
4. Discuss and prioritise possible solutions and ensure that the solutions are specific and implementable.
5. Consult host communities on the above and aim to develop SWM services that also benefit them. Where possible, joint activities based on shared goals and interests can help foster peaceful coexistence.
6. Produce an action plan that includes activities, resources and responsibilities.
7. Mobilise participation following the project's action plan and implement activities, including the setting up, operation and maintenance of SWM systems. Ensure follow-up on operation and maintenance for at least 6–12 months.
8. Evaluate the SWM plans in a participatory way and document and share the results.

The local authorities should also be involved at each stage; authorities play a crucial role in SWM during the planning and response and in taking over responsibilities at the end of the projects.

Participation is an iterative process and incorporates regular feedback loops ('consult, modify, consult'). SWM interventions need to be carefully monitored and reviewed **(X.3)**, especially in humanitarian settings. In addition to establishing feedback and complaint mechanisms and monitoring results, it is important to maintain a dialogue with communities and address potential issues as they arise. Workers should be encouraged to share the feedback they receive from community members and vice-versa. Regular meetings with an SWM task force are recommended to discuss progress and challenges. It can also be beneficial to run small pilots to see what works best. Fully sensitised and participating residents may act as ambassadors and local champions and use successful pilots to promote the system to other community members.

→ **References and further reading material can be found on page 176**

X.3 Monitoring, Evaluation, Accountability and Learning

Monitoring, Evaluation, Accountability and Learning (MEAL) are essential components of all WASH programmes, including SWM. One of the key objectives of MEAL is to guide the programme so that it continues to be appropriate and responsive to the needs and vulnerabilities of the affected population. MEAL helps to ensure that an SWM programme is going according to plan, achieving its stated goal, meaningfully involving all key stakeholders and acting on lessons learned so that the programme remains relevant and its quality improved. All SWM team members must ensure that MEAL is incorporated into the response and implemented in coordination with others working in the WASH and associated sectors. MEAL should be as participatory as possible, focusing on 'Do No Harm' and 'leaving no one behind' so that everyone affected can voice their opinions and input to SWM project design and processes **(X.2 and X.9)**.

Monitoring

Monitoring is the systematic and continuous checking of an SWM intervention. It ensures that SWM is achieving its aims (without doing unintended harm), allocated funds are being used effectively, feedback is heard and acted upon and strengths, weaknesses and gaps are identified and changes made accordingly. In an acute emergency, the monitoring system must be simple, fast and flexible.

Examples of key SWM elements to monitor regularly may include (but are not limited to):

- Types and amount of waste generated
- Geographic areas covered by the intervention
- Presence of solid waste accumulating around designated neighbourhoods or communal public collection points
- Appropriate and adequate waste storage at the household level
- Segregation practices and efficiency
- Access to designated solid waste collection points at an acceptable distance from dwellings
- Collection and transportation methods and frequency
- Appropriate and adequate waste processing, treatment, use and disposal options
- Availability and usage of personal protective equipment and documentation of health issues **(X.4)**
- Community awareness and public complaints mechanisms
- Operational (e.g. equipment shortages, staff issues, logistics) and environmental (e.g. water contamination, air quality) challenges

Existing national standards and indicators should be used to develop key actions and indicators. If national standards do not exist or are too broad, refer to the Sphere Handbook for guidance. Sphere's WASH technical chapter includes three dedicated standards for SWM with corresponding indicators. The selection of key actions and indicators depends on the context and response phase; it may need further adaption. Indicators measuring the programme objectives should be developed as early as possible.

Assessment **(PART 1: SWM Assessment)** findings inform the design of the objectives and indicators for the SWM intervention. This initial information helps to establish a baseline for each indicator so that monitoring can track any changes by the end ('endline') of an intervention. Additional specific information may be needed to fill gaps in the baseline. In an emergency, the context can constantly change and monitoring is essential to adapt the programme in response and measure progress.

Monitoring should also track the effective and efficient use of funds and whether the programme is having its intended impact. It is vital to monitor community engagement and participation, ensuring that all community members, including vulnerable groups, are consulted and represented in all programme aspects. Data should be disaggregated by age, gender and disability, at a minimum.

Different methods and tools can be used to collect monitoring data. They include regular inspections (of, for example, waste collection points, transportation routes, and disposal sites), observations, focus group discussions, community meetings, transect walks, community mapping, checklists and surveys and GPS tracking for waste collection vehicles. Channels (such as mobile apps for real-time reporting) can be provided for the community to report on issues, provide feedback and suggest improvements. Using different methods helps to capture different perspectives; collecting qualitative and quantitative data from various sources is recommended to triangulate and cross-check information.

A specific monitoring plan should be developed at the beginning of the programme with a timeframe, budget and a clear indication of staffing and responsibilities. The plan should clarify the purpose of collecting the information – who will use it, how, when and why. The community should participate in the monitoring process instead of being treated solely as monitoring subjects. Ideally, share the monitoring plan with different stakeholders, such as the community, partners, donors and other organisations. Advocate to the coordination platform or WASH cluster to establish an SWM monitoring system (as it may otherwise be overlooked). Establish a systematic and accessible feedback and complaints mechanism to encourage regular feedback from the community on what works and what doesn't, and to ensure no harm is done in the process.

Evaluation

Evaluation is a systematic and objective examination of the effectiveness, efficiency, relevance, coherence, sustainability and impact of the SWM response. It draws lessons to improve policy and future practice and to provide accountability. It can be carried out at various points in the project cycle.

Evaluations are carried out for several reasons, including to gather evidence, learn from successes or challenges, assess value for money and be accountable to key stakeholders such as donors and, especially, to the affected population.

Programme plans should develop a logframe with indicators to enable an evaluation of the inputs (resources used), activities (what was done), outputs (what was delivered), outcomes (what was achieved) and impact (long-term changes). Key SWM performance indicators should be defined such as collection coverage, response time, waste processing rates and reduction in health hazards. An evaluation may assess the impact of waste management activities on public health, environmental quality and community well-being or use a comparative analysis (comparing current performance with baseline data and historical data) to identify areas of improvement.

Accountability

Accountability enhances the quality of the response, verifies that resources are used appropriately and transparently and requires responders to meet certain standards. It is an obligation to demonstrate that the work complies with agreed rules and standards. SWM responders take responsibility for their work and for engaging with communities, authorities and other stakeholders to ensure that they are informed and benefit from efficient and effective programming.
The roles and responsibilities of all parties involved in waste management, including government agencies, contractors, and community groups, must be clearly defined and communicated. Reporting protocols should regularly detail activities, achievements, challenges and financial expenditures. Affected people have the right to be included in SWM response planning, implementation, monitoring and feedback **(X.2 and X.9)**. Information about, for example, waste management plans, activities and outcomes must be shared with all members of the community through locally relevant channels such as community meetings, newsletters and social media. An inclusive, accessible, open and transparent system for gathering and addressing SWM-related feedback and complaints from the community and workers should be in place to enable timely and fair resolution. Participatory MEAL engages men, women and children affected by a humanitarian crisis, ensuring that they are kept informed in a timely way and able to make decisions about the SWM programme.

Learning

Learning draws lessons from previous or ongoing interventions to adapt and improve waste management activities, future plans and approaches. Learning processes can be difficult to establish in humanitarian contexts. However, even in the acute response phase of a complex humanitarian response, some exchange of information, knowledge and views is possible. Learning captures and documents best SWM practices, identifies new challenges, disseminates information about innovative approaches and uses the findings to learn lessons and improve future responses. Focused, additional analyses can further develop the learning from monitoring and evaluation, for example undertaking specific SWM research to complement its findings. The main goal is to learn what works or does not work and why. Acknowledging mistakes and failures can contribute significantly to learning and building trust. For example, identifying why the affected population has not successfully adopted the desired SWM practices (such as waste segregation or safe disposal waste practices) is essential learning with which to adapt the overall SWM programme.

Knowledge Management is a crucial element of learning; it includes the documentation, centralisation, comparison, synthesis and sharing of information and guidance. Knowledge and experience can be disseminated in numerous ways, ranging from global knowledge management initiatives like the WASH Hub to organisation-specific knowledge management units and databases. Knowledge can be shared through the written word – and interactions such as personal communication, meetings, videos or workshops.
The creation of a dedicated SWM technical working group and/or community of practice is an opportunity to collaborate and coordinate with other SWM actors and exchange technical and contextual knowledge. Lessons learned contribute to real-time knowledge exchange to improve programme quality.

→ **References and further reading material can be found on page 176**

X.4 Occupational Health and Safety

Throughout the SWM service chain, workers are in contact with waste materials that could be hazardous to their health. The public and private individuals can also be exposed to risk from the collection and transport of waste and unauthorised entry to SWM facilities. Effective operating procedures, robust controls and appropriate occupational safety training help to protect workers and communities from risks to their health and safety. High safety standards protect workers and minimise the risk of accidents and health hazards. This can reduce absenteeism which in turn fosters stability and the quality of the service provided. As hazards are present throughout the SWM chain, risk assessments should be conducted for each specific activity and facility **(PART 1: SWM Assessment)**.
Waste handlers are likely to be in close or direct contact with waste materials. Although hazardous wastes **(W.2)**, including e-waste **(W.7)**, waste from medical facilities **(W.1)** or chemical substances must not be deposited with ordinary domestic waste, their presence should be assumed. Similarly, it should be assumed that waste may be contaminated by human excreta or body fluids, both of which carry pathogens. Even without pathogens or corrosive, flammable, reactive or toxic substances, waste materials can still pose a significant health risk as sharp and pointed items may be hidden in the waste matrix. In summary, for workers' safety, precautions should be taken for the following hazards: chemical (corrosive, flammable, reactive and toxic substances), biological (infectious materials), sharps and puncture risks (needles, blades, broken glass), radioactive materials and e-waste.

Hierarchy of Control

There are several ways to control risks associated with waste materials and waste management. The 'hierarchy of control' is a method of identifying and prioritising safety measures; it can be applied to SWM. The hierarchy lists the following steps in order of priority, from most to least effective:

1. **Elimination:** the first and most effective step to protect workers and the community is to physically remove the hazards. Incorrectly deposited hazardous materials are removed from domestic solid waste and separately handled and disposed of according to their characteristics **(PART 1: Waste Prevention)**. If possible, sharp or pointed items should be safely encapsulated (for example in sturdy plastic containers).
2. **Substitution:** refers to making changes to equipment or processes to reduce hazards. For example, preventing the reversing of vehicles, or selecting safer waste processing equipment.
3. **Engineering Controls:** engineering controls include making physical changes in the workplace, such as modifying equipment and barriers to reduce the risk of exposure. Examples include reducing the loading height in vehicles, using automatic loading vehicles to avoid strenuous lifting of heavy containers, or adding safety shields to machinery such as shredders.
4. **Administrative Controls:** these are procedures and policies to ensure that operations are carried out safely, facilities are designed to be safe and equipped with warning mechanisms and signs and staff receive relevant training. Safety controls include equipment checks and maintenance and clear work specifications and instructions. Examples of warning mechanisms are signs, horns or safety boundaries around machinery. Staff training should cover the safe use of equipment and execution of work procedures as well as occupational safety measures such as hygiene (for instance, not touching the face with dirty hands or clothes), and personal hygiene measures before breaks and at the end of shifts. Protection from sun and heat, rest periods and the importance of hydration should also be addressed. Workplaces must have facilities for personal cleaning and changing into work clothes and provide first aid kits. Staff should be offered regular health check-ups and relevant immunisation (such as hepatitis A and B, polio, tetanus, diphtheria and typhoid fever) based on recommendations from health professionals.
5. **Personal Protective Equipment (PPE):** is the 'last line of defence' and should be used along with stringent work procedures and controls to limit exposure to waste materials. PPE is equipment or gear designed to be worn or used to protect the body from severe injuries and illnesses. All workers should be provided with PPE and use this equipment systematically. The appropriate type of PPE depends on the tasks and responsibilities of workers – the drivers, waste collectors, or waste handlers at disposal or treatment facilities. In general, the following PPE is advised but should be adjusted on a case-by-case basis:

- Thick, hazard-resistant long clothing or overalls
- Reflective vest
- Impermeable and hazard-resistant working gloves
- Steel-toed and/or steel mid-sole impermeable boots
- Protective goggles
- Respiratory protection equipment
- Hard hats and/or caps
- Hearing protection
- Raincoat

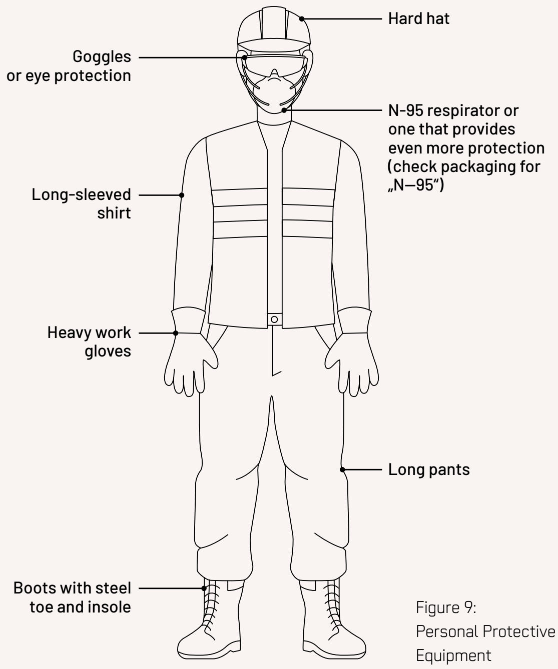


Figure 9:
Personal Protective
Equipment

6. **Hygiene Facilities:** as workers will be in close contact with waste, it is important to establish a clear barrier between the work and non-work environment. Specific clothes should be used at work; workers should shower before changing into non-working clothes. Workwear should remain at the work site and be regularly cleaned. Workers should have access to appropriate hygiene facilities. The following hygiene facilities should be available whenever possible:

- Changing rooms with washing spaces or showers
- PPE washing and drying facilities
- Toilets
- Handwashing stations that always have soap available
- Clean spaces away from waste for breaks and lunch

→ **References and further reading material can be found on page 177**

X.5 Market-Based Programming

Market-Based Programming (MBP) refers to a range of programme modalities to understand and support local market systems. Traditional waste management approaches, often reliant on linear models of disposal and limited resource recovery, frequently struggle to keep pace with the increasing volumes and complexity of waste generated. This challenge is exacerbated in crisis settings where a lack of government subsidies reduces the economic viability of waste recovery. This results in a cascade of negative consequences, including environmental degradation, public health risks and the squandering of potential economic opportunities. In this context, MBP is a promising strategy to address these multifaceted challenges. By harnessing the power of market actors and economic incentives, MBP can catalyse a shift towards more sustainable waste management practices, fostering a circular economy where waste is viewed not as a burden but as a valuable resource.
MBP in SWM recognises the inherent value embedded within waste materials. It seeks to unlock this value by creating economic opportunities in waste recovery, recycling and reuse. By incentivising the collection, sorting and processing of waste, MBP diverts valuable materials from landfills and dumpsites, transforming them into commodities that can be reintroduced into the production cycle. This approach reduces the environmental impact of waste and also stimulates economic development and creates livelihood opportunities, particularly in marginalised communities. The integration of MBP into SWM programmes goes beyond simply establishing new markets; it also seeks to optimise and strengthen existing local market structures to enhance the effectiveness and sustainability of interventions.

Key MBP Principles

The successful implementation of MBP in humanitarian and development contexts requires a multifaceted approach that engages various stakeholders and adheres to key principles:

Value Creation from Waste: the cornerstone of MBP lies in identifying and unlocking the economic potential of waste materials. This involves establishing mechanisms to facilitate the collection, sorting and processing of recyclable and reusable materials, transforming them into valuable commodities that can be traded in local, regional or even international markets. In humanitarian contexts, this may involve identifying immediate needs for waste-derived products (e.g. using rubble for temporary shelter construction) or establishing cash-for-work programmes where people are paid for collecting and sorting specific waste materials.

Private Sector Engagement: the private sector plays a pivotal role in MBP, bringing expertise, resources and market access to the table. Collaboration with private companies can lead to the development and implementation of innovative and sustainable waste management solutions, stimulating economic growth and creating job opportunities. This engagement can range from partnerships with established recycling companies to supporting the growth of small-scale waste collection and processing enterprises. In humanitarian settings, this could involve partnering with local businesses to provide waste management services in camps or supporting the creation of micro-enterprises focused on waste recovery and recycling.

Community Empowerment: MBP recognises that sustainable waste management requires the active participation and ownership of communities **(X.2)**. By providing training, support, and market linkages, MBP empowers communities to take an active role in managing their waste, generating income and improving their livelihoods. This can involve establishing community-based waste management systems, promoting waste segregation at the source **(PART 1: Waste Separation)** and facilitating access to markets for recyclable materials. In humanitarian contexts, community empowerment may entail working with displaced populations to establish waste management committees, providing training on safe waste handling and disposal practices or supporting the development of community-led waste recycling initiatives.

Environmental Sustainability: MBP in SWM prioritises environmentally sound waste management practices. It promotes recycling, organic waste treatment and other sustainable solutions that minimise pollution, reduce greenhouse gas emissions and contribute to climate change mitigation and ecosystem protection **(X.8)**. By incentivising the recovery and reuse of materials, MBP reduces the need for raw material extraction and manufacturing, thereby conserving natural resources and reducing the overall environmental footprint of waste. This extends to the incorporation of sustainability criteria into the procurement of humanitarian Non-Food Items, ensuring they can be managed safely at their end-of-life. Examples include prioritising repairability, low toxicity, recyclability and local production **(PART 1: Waste Prevention)**. In humanitarian settings, environmental sustainability may also involve promoting the use of biodegradable waste for composting **(T.1)**, implementing waste-to-energy projects **(U.6, U.7)** to reduce reliance on fossil fuels or establishing systems for the safe disposal of hazardous waste **(W.2)**.

Integration with Existing Markets: a successful MBP approach recognises and integrates with existing market structures and dynamics as well as government policies. By understanding the local context and optimising existing value chains, MBP interventions can enhance efficiency, reduce costs, and ensure long-term sustainability. This may involve collaborating with informal waste collectors, strengthening existing recycling networks or adapting MBP initiatives to fit within the prevailing market conditions. Examples in humanitarian settings could be integrating waste management programmes with existing market systems for food distribution, shelter materials or other essential goods and services.

MBP Interventions

MBP interventions in SWM can take various forms, each tailored to the specific context and needs of the community. Some examples include:

Cash for Work Programmes in SWM: in humanitarian settings, Cash for Work programmes can be a valuable tool for engaging communities in waste management activities. These programmes provide temporary employment opportunities for individuals to participate in waste collection, sorting, and recycling activities in exchange for cash. This helps to improve the immediate environment and also provides much-needed income to vulnerable households. For instance, in a post-disaster setting, a Cash for Work programme could pay residents to clear debris, segregate waste and construct temporary waste disposal facilities.

Cash and Voucher Assistance (CVA) in SWM: CVA programmes can also support SWM activities. They can be given to households in exchange for proper waste disposal or participation in community-based waste management initiatives. For example, households could receive vouchers for bringing their waste to designated collection points or for participating in waste segregation and composting programmes. This approach can incentivise responsible waste management behaviour and promote community ownership of waste management systems.

Grants or Temporary Support to Local Waste Management Businesses: in humanitarian contexts, local waste management businesses may be disrupted or overwhelmed by the increased waste generated by displaced populations or disaster events. Providing grants or temporary support to these businesses can help them maintain or expand their operations, ensuring the continuity of essential waste management services. This support could include financial assistance, technical training or access to equipment and resources. For example, a local waste collection company could receive a grant to purchase additional trucks or to establish a temporary waste transfer station in a displacement camp.

Capacity-Strengthening Initiatives for Market Actors in the Waste Management Sector in Humanitarian Settings: capacity-strengthening initiatives strengthen the skills and knowledge of individuals and organisations involved in waste management in humanitarian settings. Initiatives include providing training on safe waste handling and disposal practices, waste segregation and composting techniques or business management skills for waste entrepreneurs. By investing in capacity strengthening, humanitarian organisations can help to develop a skilled workforce capable of managing waste effectively and sustainably. For example, training could be provided to community members on how to construct and operate low-cost composting facilities or on how to establish small-scale waste recycling businesses.

Micro-Enterprises for Waste Collection and Recycling: humanitarian MBP could support the establishment of small businesses that collect and process recyclable materials, create income opportunities for marginalised groups and improve waste management services in underserved areas. Support can involve training, micro-finance and market linkages to enable these enterprises to thrive. In humanitarian contexts, it may involve providing grants or micro-loans for the creation of waste management businesses in displacement camps or conflict-affected communities. For instance, in a refugee camp, an MBP programme might provide seed funding and business training to a group of refugees to establish a small-scale recycling enterprise, collecting plastic waste and transforming it into reusable bags **(T.7)** or building materials **(T.8)**.

Pay-As-You-Throw (PAYT) Systems: PAYT systems charge households and businesses based on the amount of waste they generate, thus incentivising waste reduction and recycling at the source. This approach encourages individuals and businesses to adopt more sustainable waste management practices by directly linking their waste disposal costs to their waste generation behaviour. Although PAYT systems may be less applicable in acute humanitarian emergencies, they can be valuable tools for promoting sustainable waste management in protracted crises or during the recovery phase. For example, in a temporary settlement for internally displaced people, a PAYT system could be introduced where residents receive vouchers for proper waste disposal, encouraging waste reduction and community cleanliness.

Waste-to-Energy Projects: waste-to-energy facilities convert organic waste into biogas **(T.3)** or electricity, providing clean energy sources and reducing reliance on fossil fuels **(T.5)**, thereby contributing to climate change mitigation efforts. While these projects can potentially offset some operational costs through the sale of energy, they typically require significant investment and may not generate revenue. In humanitarian settings, waste-to-energy projects can provide a sustainable source of energy for camps or communities, reducing the need for firewood or other fuel sources that may contribute to environmental degradation. For instance, in a post-disaster setting, a mobile waste-to-energy unit could be deployed to process organic waste from temporary shelters, generating biogas for cooking and heating.

Extended Producer Responsibility (EPR) Schemes: producers are held accountable for the end-of-life management of their products, encouraging them to design products that are easier to recycle and reuse, promoting a circular economy and reducing waste generation. EPR schemes can create financial incentives for producers to minimise waste and invest in recycling infrastructure. While EPR schemes may be challenging to implement in humanitarian emergencies, they can be integrated into longer-term recovery and development efforts. For example, in a post-conflict area, an EPR programme could be established for construction materials, encouraging the use of recycled and reusable materials in rebuilding efforts.

Market Assessments: it is crucial to conduct comprehensive market assessments before designing and implementing MBP interventions **(see also PART 1: SWM Assessment)**. These assessments provide a nuanced understanding of the local market dynamics, including supply and demand patterns, existing market actors and their capacities, infrastructure and logistical considerations and the regulatory environment. By identifying key opportunities and constraints, market assessments inform the design of effective and sustainable MBP initiatives that build on existing market strengths and address potential challenges. In humanitarian contexts, market assessments should consider the specific needs and vulnerabilities of crisis-affected populations, as well as the impact of the crisis on local market systems. For instance, a market assessment in a drought-affected area might reveal a need for composting initiatives to improve soil fertility and support local livelihoods.

Challenges

While MBP offers a promising pathway to sustainable waste management, it is important to acknowledge and address potential challenges. Limited market access, lack of infrastructure and regulatory barriers can pose obstacles to the success of MBP initiatives. Integrating the informal sector, which often plays a significant role in waste management in developing countries, is crucial to ensure that MBP does not negatively impact their livelihoods. Robust monitoring, evaluation, and learning (MEAL) systems **(X.3)** are also vital to track progress, measure impact and ensure accountability in MBP projects. Key indicators, such as the quantity of waste diverted from landfills, income generated from recycling and community participation, can help assess the effectiveness and sustainability of MBP interventions. In humanitarian settings, additional challenges may include insecurity, displacement, and the disruption of existing market systems.

→ **References and further reading material can be found on page 177**

X.6 Hygiene Promotion and Behaviour Change

Hygiene Promotion (HP) is a planned, systematic approach that enables people to take action and encourages behaviours or conditions that prevent or mitigate WASH-related diseases. It aims to support the dignity and well-being of emergency-affected populations. No WASH intervention, including SWM, should be undertaken without it.

Hygiene Promotion's emphasis on the importance of listening to affected communities and its use of dialogue and discussion provide a practical way of facilitating participation and accountability. It gives people a voice and involves them in making decisions about how the SWM programme is delivered (e.g. clarity about responsibilities, collection schedules, operation and management issues or the siting of disposal facilities). It is critical to the success of SWM – both to enable the positive participation of affected populations and to adapt SWM to the local context.

Hygiene Promotion should be evidence based. Project teams should understand the enablers and barriers to behaviour change so that programmes focus on the provision of information and increasing knowledge and on working supportively with communities to understand how change can best be achieved. Hygiene Promotion therefore considers a broad range of determinants, including socio-economic, environmental and psychological barriers and enablers.

SWM-related behaviours that are commonly targeted include (1) reduction/avoidance of public littering, (2) carrying out (regular) clean-up campaigns, (3) reducing/avoiding waste, (4) waste segregation practices and (5) increasing recycling and reuse.

Assessment and Analysis

Before any intervention, the local context and the affected community's different perspectives on SWM must be understood. This includes their current needs, vulnerabilities and capacities, perceptions and existing norms as well as leadership structures and priorities around SWM. The coping strategies of the communities and their capacities should be mapped out so that interventions address gaps in SWM facilities, services and behaviours. To prioritise and respond to diverse and changing needs it is vital to learn about current SWM-related practices and norms. To what extent and how is solid waste currently managed? Is there a history of segregating waste? What is happening now and what has changed as a result of the emergency? What do different people need and want (e.g. discrete disposal options for menstrual pads)? What are the priority risks? What are the skills and capacities of the affected community, local agencies or government departments?
Not everyone is the same. It is recommended to identify different groups to work with in each context (e.g. youth, mothers and fathers of young children, women and girls, religious leaders, school children, canteen workers or market vendors). Tools and methods to gather assessment information include active listening, direct observations, Knowledge, Attitude and Practice (KAP) surveys, focus group discussions, transect walks and key informant interviews. The assessment results also provide a baseline for measuring progress at the end of an intervention or project (see also Monitoring below). Further information can be found in the 'Compendium of Hygiene Promotion in Emergencies', a comprehensive compilation of relevant, sector-reviewed hygiene promotion tools, methods and underlying theories.

Preconditions and Enabling Factors

Preconditions and enabling factors are the resources, processes, services and infrastructural prerequisites that enable the SWM service and the associated practices and behaviours of an affected population. For an SWM hygiene promotion intervention to be effective, the affected population needs access to physical infrastructure (e.g. colour-coded waste bins for different types of waste to make segregation easier and waste collection points or recycling centres), access to products (e.g. soap, household bins, reusable menstrual pads, buckets or bags) and services (e.g. reliable waste collection with clearly communicated collection schedules). Enablers must be equitable, affordable and culturally acceptable. The infrastructure must be located close to where the target behaviours should take place (e.g. washing facilities and waste bins for menstrual waste placed inside the toilet stall). Ensuring that the infrastructure is accessible and well-maintained can significantly influence positive behaviour change; it is more attainable if a participatory assessment **(X.2)** is completed before implementation. Preconditions and enabling factors need to be well understood. Not all factors will be present or feasible and humanitarian actors should be realistic about what is possible in their absence.

Community Engagement and Participation

Actively involving communities promotes shared ownership of good waste management practices and facilitates communities to participate in making decisions that affect their lives **(X.2)**. Depending on the community, this may require awareness-raising about the risks of improper waste disposal and the benefits of context-appropriate waste management practices. It may involve the strengthening of social norms for proper SWM, social support interventions and community capacity-strengthening to enable sufficient levels of participation, engagement and skills.
A variety of interventions can mitigate the immediate risks. It is part of the user engagement process for different groups to jointly identify what they can immediately do to improve SWM practices. This may include community meetings, initial or regular clean-up campaigns, measures to facilitate direct action (such as the provision of tools for digging waste pits **(U.8)** and providing equipment such as personal protective equipment for waste handlers **(X.4)**, handwashing facilities with soap, and household and community waste bins, ideally with (colour-coded) segregation options.
Operation and maintenance requirements should be considered from the beginning with community involvement through, for example, the formation of committees or user groups. For SWM at a household, community or institutional level, a feeling of ownership and management responsibility is critical for the continued functionality of the services. However, communities can become easily overwhelmed and overloaded by committees and user groups, so the setting up of committees must be well coordinated within the WASH sector and adjacent sectors. A recommended solution is to set up cluster-based committees rather than one for every single intervention.
A variety of methods and tools can be used to motivate different groups to take action to improve, use and maintain facilities and services effectively for women and men, people from different age groups and those with different abilities. Further guidance on appropriate tools can be found in the 'Compendium of Hygiene Promotion in Emergencies'.
It is essential to work closely with others involved in the response, especially the government, international, national and local WASH actors and other relevant sectors. Collaboration facilitates the timely delivery of services, enables participation, reduces duplication and helps prioritise interventions.

Joint clean-up campaigns are common in SWM programmes. In consultation with the population and responsible local authorities, periodic cleaning of streets, public spaces and common areas may be necessary to ensure a hygienic environment. Such clean-up events also encourage collective action; they reactivate and remind the public to participate in neighbourhood cleanliness as a civic duty and citizen responsibility.

Social and Behaviour Change

Social and behaviour change aims to understand the barriers and motivators for change and to enable individuals and communities to practise consistently healthy behaviours. Strategies to trigger and motivate change draw on a variety of factors and focus on the individual as well as the preconditions and enabling factors. It is important to find out what is potentially stopping individuals and community groups from acting (the barriers and obstacles to improved SWM) and to find out what help they need, if any. By conducting surveys and differentiating between doers and non-doers and users and non-users of facilities, the drivers that motivate action can be identified.

Behaviour change campaigns can help to highlight desirable norms, create peer pressure, ignite motivation and encourage individuals and communities to adopt behaviours such as regular waste segregation, proper disposal and recycling. Examples include recycling centres in the community where members can see the recycling process and understand its importance; model neighbourhoods where best practices for waste management are demonstrated and can be replicated in other areas; specific planning interventions that enable participants to incorporate intended practices into their daily routines and overcome barriers; or waste management education incorporated into school curricula to instil good practices in children from a young age. These campaigns focus on changing attitudes, social norms, efficacy beliefs and self-regulation processes related to waste management. They support community initiatives and help people to be motivated and motivate each other to adopt sustainable waste management practices.

Communication

Communication facilitates hygiene promotion through active listening, information exchange and guidance and advice to target audiences, enabling them to develop positive hygiene behaviours and practices. Active listening is a vital component of communication; listening, rather than simply providing information, should be the starting point. Key messages can be communicated in different ways and are broadly divided into participatory and mass communication:

Participatory communication is based on dialogue, involvement and interaction; it aims to understand the perspectives of the affected community and tailor interventions to their specific situation. It can also encourage communities to play an active and influential role in decisions that affect their lives. Conducting community meetings or focus group discussions are good examples of engaging with community members. Training community leaders, health workers, and volunteers in best practices for waste management and hygiene can amplify the impact of these efforts. Equipped with knowledge and skills, these individuals can lead by example and disseminate information effectively. Organising street dramas or role-playing exercises is another engaging way to interact with the community and portray the consequences of poor waste management and the benefits of proper practices. Social media platforms can also be used to share success stories, tips and reminders about proper waste management.

Mass communication disseminates information and key messages to large numbers of people rapidly and cost-effectively but it is mainly one-way communication with limited feedback options. Commonly used mass communication tools include Information, Education and Communication materials such as posters, billboards, flyers, radio, television or text messages. Posters and flyers can be used to provide clear, visual instructions on how to segregate waste, the importance of recycling, the dangers of improper waste disposal or as visual reminders at spots where the intended behaviour should take place. Public announcements may also be useful using local radio stations, megaphones or loudspeakers to share important messages about waste management.

Where possible, social media and messaging apps can be used as online communication platforms to reinforce SWM-related hygiene messages and behaviours and provide critical information to the target audience. They can help combine the benefits of participatory and mass communication.

No single method is guaranteed to be effective; a mix of different methods and communication channels tailored to different target groups is advisable.

Waste management messaging can also be linked to broader health initiatives to enhance understanding and compliance – for example by integrating messages about waste management with those about handwashing and safe water use. Messages should always be aligned with information from the Ministry of Health, Water, and/or Environment, including specific messages in HP campaigns about the risks, opportunities and best practices in the different waste streams. Hygiene Promotion interventions should be implemented along with practical activities in communities and schools.

Monitoring and Feedback

Regular monitoring of waste management practices and providing feedback to the community helps sustain behaviour change **(X.3)**. Recognising and rewarding good practices can motivate continued adherence to proper waste management. Competitions between neighbourhoods can be organised for those who can achieve the highest levels of cleanliness and waste segregation, with rewards or certificates for the winners.
It is also important to establish channels for community members to report issues with waste management services and to suggest improvements through mechanisms such as complaint boxes, hotlines or apps **(X.3)**. Humanitarian actors should also keep track of rumours that might be detrimental and respond to these as soon as possible by, for example, incorporating them into discussions with community groups or providing information.

→ **References and further reading material can be found on page 177**

X.7 Links to Humanitarian Clusters and Other Thematic Domains

In the humanitarian cluster system, domestic SWM falls under the Water, Sanitation and Hygiene (WASH) cluster, but has numerous links and overlaps with other clusters. Almost all cluster activities produce waste as well as benefitting from its products. The direct or indirect production of waste comes with the responsibility and need to prevent waste **(PART 1: Waste Prevention)**, plan for reuse and recycling and ensure that waste production connects with the SWM system, feeding waste materials into the relevant waste streams. Equally, different humanitarian clusters may benefit from waste processing and its corresponding production of fertilisers, soil conditioners, animal feed, energy and commercial goods. These inexpensive secondary products can be particularly valuable in humanitarian settings where financial resources or access to markets are often limited.
Humanitarian activities that generate special, often hazardous waste **(PART 4)** must ensure it is not mixed with regular domestic solid waste but handled separately and disposed of safely. Establishing waste management systems at each organisation's facilities, as well as schools, health and nutrition centres, warehouses, distribution centres, fleet workshops and offices enables organisations to efficiently segregate, handle and direct waste to the appropriate waste management streams. Some interventions linked to SWM, such as managing waste in drainage systems **(W.6)**, might intersect with several clusters. Although SWM is in the WASH cluster, other clusters can support its activities using their capacities, such as large cash-for-work workforces or vehicle fleets.

These interlinkages, overlaps and interdependence require inter-sectoral coordination and collaboration with different agencies and organisations. Coordination is in the interest of all humanitarian clusters as effective SWM helps to protect the environment and public health and contributes to broader protection outcomes.

Food Assistance and Provision of Non-Food Items

The in-kind distribution of food or Non-Food Items (NFI) in humanitarian settings can produce significant amounts of solid waste **(W.5)**. Influencing factors are the type and frequency of distributed goods, the size of the target population and the type and volume of packaging materials. Clusters distributing food and NFI include Food Security, Nutrition, Logistics and Shelter. Whenever possible, projects should minimise or retrieve packaging materials, use goods made from durable or recyclable materials and engage in green procurement **(W.5)**. Special attention should be paid to the distribution of goods which contain hazardous materials, such as electrical or electronic devices **(W.7)** and pharmaceuticals **(W.1)**. 'Take-back' schemes and designated collection points facilitate waste collection, for example, collecting packaging materials, end-of-life NFI such as solar lanterns, or hazardous wastes **(W.2)**. These separate collections help to direct items into the appropriate waste management streams and reduce the burden on existing SWM services. Depending on its material characteristics, waste collected through take-back schemes can be handed to the SWM service, specialised recyclers or waste processing projects within humanitarian responses T.

Food Production and Livelihoods

Secondary products made from organic waste can boost agricultural activities and food production, enhancing self-reliance and livelihoods. Secondary products, such as compost, frass from black solder flies or biogas digestate **(T.1–T.4)**, help to improve soil fertility. They can be sold to the local agricultural sector or used directly in humanitarian agricultural projects at a household and community level. Black solder fly larvae also serve as an alternative animal feed for chickens and fish farms **(T.4)**. Clusters engaged in such activities include the Food Security or Nutrition clusters.
Recyclable materials recovered from solid waste can be sold to the private recycling sector or repurposed for humanitarian recycling projects **(T.6)**. The latter can produce commercial goods or items deployed in humanitarian assistance. Inorganic materials which cannot be recycled or handed over to recyclers might be used for upcycling **(T.7)** or downcycling **(T.8)** activities, generating income or providing inexpensive essential goods. The main actors with an interest in recycling are agencies focusing on livelihoods and self-reliance or clusters distributing food and NFI.

Energy Provision

Organic waste secondary products, such as biogas **(T.3)** and solid biomass fuels **(T.5)**, can be used as energy sources. They can replace traditional cooking, heating or lighting fuels in households, or generate power and income for householders or communities. Productive use of energy may include the powering of restaurant equipment, processing and preserving agricultural goods, providing heat for livestock farming or lighting for small-scale workshops. The Shelter cluster may focus on household energy supply; livelihood organisations may instead use the energy for powering facilities and processes and engage in the productive use of energy.

Planning of SWM Infrastructure and Services

The planning and implementation of SWM services and infrastructure requires adequate physical space for waste storage **(S.2)**, accessible waste collection and transport C and suitable locations for safe waste disposal **(U.9)**. Collaboration with the Camp Coordination and Camp Management Cluster and organisations involved in site planning is required to ensure the space is available and appropriate.

Shelter

Shelter construction can use materials recovered from waste **(U.4)**. Conversely, the destruction, demolition or disintegration of shelters can generate considerable quantities of rubble and construction waste **(W.3)**. Due to their material properties and volumes, rubble and construction waste should be disposed of separately from domestic solid waste, reducing the risk that valuable SWM resources are overutilised and landfill space filled by construction waste. Debris from disintegrating shelters, such as wood pieces or chunks of concrete, can block drainage channels, and further mix with domestic solid waste **(W.6)**. The use of waste materials for construction and the management of construction waste must be coordinated with the Shelter Cluster and its organisations.

Health

Waste from hospitals, healthcare facilities, medical laboratories, diagnostic centres and other medical institutions potentially contains hazardous materials, especially if medical waste is not strictly segregated at source **(W.1)**. However, the largest waste fractions from medical institutions originate from administrative activities, regular housekeeping and meals for staff, patients and visitors. This 'general waste' or 'non-hazardous waste' can be handled and disposed of in the same way as domestic solid waste and even handed over to regular SWM services. To ensure the safe management of medical waste, it is essential to coordinate with the Health cluster.

Effective SWM interventions significantly contribute to the protection of public health and can therefore be seen as a preventive health measure. SWM and health objectives overlap. Collaboration with health-related organisations to immunise waste workers can support occupational health and safety **(X.4)**.

Workforce and Fleet Management

The available funding and resources for SWM in overstretched WASH budgets may be limited. Other clusters, such as Logistics, may support SWM interventions by providing additional capacity such as larger cash-for-work workforces or vehicle fleets.

WASH-Internal Coordination

SWM has strong links and overlaps with the WASH cluster. Without solid waste collection, waste materials may be disposed of in latrine pits or drainage channels **(W.6)**. In both cases, the infrastructure is compromised: pit emptying becomes more difficult and deposited waste fills the latrines instead of human excreta. Waste can block drainage channels leading to overflows, flooding of residential areas and stagnant water, creating breeding grounds for disease vectors. SWM must also respond to the need of women and girls to manage their menstrual periods confidently, in privacy and with dignity **(W.4)**.

→ **References and further reading material can be found on page 177**

X.8 Solid Waste Management and Climate Change

The Climate Action Accelerator estimates the Greenhouse Gas (GHG) emissions of the humanitarian sector globally in 2022 to be approximately 35.3 megatonnes of carbon dioxide. This compares to the emissions of a European city with approximately 4.6 million inhabitants. The sector's contribution to climate change cannot be neglected. To fulfil and acknowledge this responsibility, the humanitarian sector has launched various initiatives to reduce its carbon footprint. By early 2025, 471 humanitarian organisations had signed the Climate and Environment Charter for Humanitarian Organizations, stating their willingness to rapidly reduce GHG emissions. While the largest emissions in the humanitarian sector are linked to purchased goods (32 %), cash-based interventions (29 %) and purchased services (14 %), the contribution from waste is not known or quantified. Nevertheless, waste does generate GHGs and in line with the Climate and Environment Charter and the Do No Harm principle **(PART 1: Waste Prevention)**, GHG emissions from SWM in humanitarian response must be addressed and minimised.

Impact of SWM on Climate Change

The transport, treatment and disposal of solid waste generates greenhouse gases and airborne pollutants, contributing to climate change. Emissions come mainly from burning or decomposing waste and, to a lesser degree, the handling (transport) of the waste because of its use of fossil fuels. The largest source of GHG waste emissions is landfill methane (CH_4), which is generated from the anaerobic decomposition of organic materials. Uncontrolled burning of waste emits black carbon, nitrous oxide (N_2O), and carbon dioxide (CO_2) Other greenhouse gas emissions are halogenated compounds found in e-waste, such as refrigerants and insulating foam in fridges and freezers, which can be released when e-waste is inadequately disposed of or dismantled.

Global Warming Potential measures the potency of greenhouse gases. It is referenced to the potency of CO_2 and measures are expressed as a CO_2 equivalent. All waste emissions mentioned above – methane, nitrous oxide, black carbon and halogen-containing compounds – are much more potent than CO_2. Both methane and black carbon are Short-Lived Climate Pollutants (SLCPs), meaning they have a relatively short atmospheric lifetime. Reducing SLCPs is important as they have a significant impact on near-term global warming and cause other negative effects. For instance, black carbon is a component of fine particulate matter (PM2.5) and can cause respiratory health issues; methane contributes to ground-level ozone formation which adversely affects public health and ecosystems.

Methane emissions from uncontrolled disposal or open dumping **(U.10)** and landfills **(U.9)** have received the most attention in waste and climate discourse. Methane is generated during the anaerobic degradation of organic matter and is most prominent in disposal sites. Engineered, sanitary landfills are designed and constructed to capture and use methane. However, such landfills are rare in low and middle-income countries and humanitarian settings. In unmanaged disposal sites, methane instead flows by the path of least resistance and escapes directly into the atmosphere.

Black carbon is less well documented and its impacts are not well understood. Open burning (i.e. incomplete combustion) **(U.11)** is the main source of black carbon in waste management. Black carbon is also emitted from waste transportation, particularly when older vehicles and lower-quality fuels are used. Black carbon emitted into the atmosphere can travel long distances across the planet and settle on the surface of sea ice and snow. There, it accelerates melting by absorbing, rather than reflecting, sunlight, further contributing to global warming. Black carbon emissions from biomass burning are much lower than the methane emissions generated from waste. However, the significantly higher global warming potential of black carbon (its CO_2 equivalent) makes it a significant short-lived climate pollutant.

Mitigation of GHG Emissions from Solid Waste in Humanitarian Settings

Phasing out open burning **(U.11)** and diverting biodegradable wastes from disposal reduce GHG emissions from waste in humanitarian settings. Transitioning from end-of-pipe waste management towards resource management and a circular economy and enhancing waste prevention **(PART I: Waste Prevention)**, recycling and recovery could further reduce GHG emissions.

The most straightforward way of reducing black carbon emissions in humanitarian settings is to stop open burning **(U.11)** in all its forms and locations. This requires an understanding of the reasons for open burning followed by training, awareness and appropriate alternatives to prevent the practice. Waste emissions are also reduced by diverting the organic biodegradable fraction of waste from disposal into organic waste treatment and reuse **(T.1 to T.5)**, significantly reducing GHG emissions and eliminating methane emissions at the disposal site. Additionally, the recycled organic fraction can substitute for other products (such as fertilisers) avoiding emissions generated by their production. For example, diverted biodegradable waste generates compost **(T.1)** which can partially substitute chemical fertilisers, reducing GHG emissions from fertiliser production and increasing carbon sequestration and storage in soils. Similarly, anaerobic digestion **(T.3)** of waste generates biogas and digestate. Biogas is a carbon-neutral substitute for fossil fuels. Digestate can substitute chemical fertilisers and contribute to carbon storage. Black soldier fly treatment **(T.4)** produces insect protein for use as animal feed and frass, replacing fish meal and/or soya bean, preventing their GHG emissions. Frass can substitute fertilisers and contribute to soil carbon sequestration.

Making secondary materials out of recycled paper, glass, metals, plastics **(T.7)**, textiles and waste electrical and electronic equipment avoids emissions that would have been generated by primary extraction and production. For glass, plastics, ferrous metal, textiles and aluminium, studies show that recycling yields overall net greenhouse gas flux savings of between about 30 kg CO_2e (for glass) and 95 kg CO_2e (for aluminium) per tonne of municipal waste, compared with the disposal of untreated waste.

Overall, reductions in emissions of greenhouse gases associated with the transportation of waste, residues and recovered materials are minor compared to the much bigger greenhouse gas fluxes in the system, such as those resulting from preventing production and landfill gas emissions. Nevertheless, they can still be reduced by, for example, minimising travel distances, prioritising clean fuels and vehicles with efficient combustion and practising fuel-efficient driving.

Impact of Climate Change on SWM Systems and Strategies for Adaptation and Resilience

In some regions, climate change is expected to cause more frequent extreme or slow-onset events such as increased rainfall and wind speed or droughts. The infrastructure of solid waste is vulnerable to new climate patterns; it is rarely designed to be resilient to climate change phenomena and its lifespan can be shortened by these stresses. Excessive moisture and rainfall combined with improper design and poor maintenance may lead to severe landslides at disposal sites, more frequent flooding and disruption of roads. More wind and dry weather facilitate waste fires which emit hazardous gases, particulates and embers, further spreading fire during drought. Pests and pathogens can proliferate with increased temperatures and rainfall, potentially threatening the health of waste workers and residents. A better understanding of climate change effects and site-specific risk assessments are needed to reduce risk, better respond and improve the resilience of systems and their operation and maintenance.

→ **References and further reading material can be found on page 177**

X.9 Protection, Accessibility and Conflict Sensitivity in SWM Interventions

People affected by humanitarian crises can have vastly different experiences of SWM depending on their sex, gender identity, age, physical capacity, race, socio-economic status and other factors. These factors affect their vulnerability and response to crises and shape their ability to recover, access and engage with humanitarian programming. Emergencies often exacerbate existing inequalities, so humanitarian actors must observe the 'Do No Harm' principle throughout the SWM cycle, from assessment **(PART 1: SWM Assessment)** to monitoring **(X.3)** and handover. Applying conflict sensitivity in SWM interventions helps to minimise the risk of aggravating conflict dynamics and jeopardising outcomes. A conflict-sensitive approach considers both internal and external programme operations as well as their impact at the local, national or international level.

Protection and Ensuring Access to Vulnerable Populations

In keeping with 'Do No Harm', humanitarian actors are accountable for protecting and empowering affected communities, ensuring services reach those in need (particularly the most vulnerable) without negatively affecting them. Protection and access require humanitarian actors to involve local stakeholders and affected communities in decision-making and ensure transparency in plans and activities. For further guidance, see Inclusive Planning and Participation **(X.2)** and Monitoring Evaluation Accountability and Learning **(X.3)**.
According to UNHCR's Protection and Accountability Briefing Paper, SWM protection and accessibility challenges often exist (but are not limited to) for the following groups and contexts:

Girls and boys are vulnerable to Gender-Based Violence (GBV); they may be engaged to transport or dispose of solid waste outside the safety of their homes and might also engage in informal and unsafe SWM activities.
Adolescent girls are more vulnerable to sexual abuse and exploitation. They may be required to dispose of solid waste outside the safety of their homes or to engage in informal and unsafe SWM activities.
People with disabilities can be less able to express their needs and are particularly vulnerable to GBV and exploitation. They may be unable to access SWM services due to physical and design barriers.
Older people are also at risk of GBV and exploitation. They may be unable to access SWM services due to physical and design barriers.
Women often have less decision-making power and can be particularly vulnerable to GBV. They are less likely to be paid for SWM work yet are often responsible for SWM tasks at a household level. Women are frequently housebound and responsible for cooking, cleaning and domestic waste management. If waste collection requires them to leave the house, they are more likely to continue with open burning **(U.11)** in their backyards. Hence, they must be prioritised as service users.
Men are most likely to be engaged in formal or informal SWM works and decisions. As a result, they may face risks to their health and stigmatisation.
Lesbian, gay, bisexual, transgender, intersex or queer (LGBTIQ+) persons are likely to experience discrimination, harassment, violence and risks to their lives because of their sexual orientation or gender identity. They may be unable to access SWM services or benefit from paid SWM work.
Urban areas with higher population densities and enhanced access to markets commonly increase the quantity and types of waste but not necessarily with an accompanying increase in safe waste management services.

UNHCR's Briefing Paper also describes five principles that define how protection should be integrated into WASH, including SWM, in humanitarian settings and displacement contexts.

Principle 1 – Consultation, Participation, Information and Feedback (X.2): a diverse range of communities and people participate in and are consulted and informed about SWM interventions (including in initial assessments and monitoring). Feedback and complaint mechanisms are available and responsive.

Principle 2 – Equitable Access: access to SWM infrastructure, information and services is equitable and considers the requirements of people with specific needs and vulnerabilities.

Principle 3 – Protection, Safety and Privacy: are integrated into the design and delivery of SWM services.

Principle 4 – Menstrual Hygiene: the needs of women and girls to manage their menstrual periods confidently, in privacy and with dignity are integrated into SWM interventions **(W.4)**.

Principle 5 – Cross-Sector Collaboration, Coordination and Capacity (X.7): capacity strengthening, inter-agency coordination and collaboration with other sectors integrate accountability and strengthen protection and the quality of SWM interventions.

Dignity, Access, Participation and Safety (DAPS)

The DAPS approach is a practical method of integrating protection, gender, accountability and inclusion principles into SWM, enhancing inclusivity, equitable access, quality services and representation for all stakeholders while minimising protection risks throughout the response. This includes the critical role of informal sector workers who sort and facilitate waste management efforts in many contexts. They are often among the most vulnerable people in society. Every effort should be made to engage them in the design of an SWM programme, ensuring that their livelihoods are not displaced **(X.2 and X.6)**.

Dignity: Ensuring Respect and Inclusion

Dignity means systems that address the needs of all individuals, particularly those who are vulnerable or marginalised. Dignity emphasises equitable access to SWM facilities and services while fostering respect and reducing stigma.

Examples of challenges and suggested solutions include:

- Disposal of menstrual hygiene and incontinence products: the lack of appropriate disposal options for menstrual and incontinence products can lead to embarrassment, stigma and health risks, especially for women and girls and elderly or disabled individuals **(W.4)**. Without a convenient disposal option that people feel comfortable with, menstrual hygiene and incontinence items will often be disposed of in latrine pits. This can cause significant challenges for sludge removal and the management of solid waste from pits **(W.6)** and, in turn, increases the risk of women, girls and people with incontinence facing verbal abuse and violence. User feedback must inform the design of services and facilities which should be discrete and provide safe, dignified and convenient ways to dispose of waste.
- Stigma towards solid waste workers: waste workers are often marginalised and face discrimination due to societal perceptions of their work, impacting their dignity and inclusion. Women, children, elderly individuals, disabled persons and ethnic minorities are often over-represented in informal, unsafe or underpaid waste management work due to their low social status. Sensitisation about the importance of their role in the SWM cycle is critical for effective waste management. Workers should be respected and protected while performing these roles **(X.4)**.
- Cultural Sensitivity: services and facilities should be designed to respect local cultural norms (such as not burning materials with blood) and avoid stigmatising behaviours (such as handling certain types of waste).

Access: Removing Barriers to Facilities and Information

Women, children, elderly individuals, disabled persons and ethnic minorities often face systemic barriers to using waste management systems. Access involves designing SWM services and facilities that everyone can use. It also means ensuring that relevant information reaches all community members. Additionally, access means ensuring that new SWM services do not reduce access to resources for those already engaged in SWM practices.

Suggested solutions are:

- **Disability Accessibility:** waste disposal facilities should include ramps, low bins and handrails to accommodate individuals with mobility challenges.
- **Age-Friendly Services:** waste collection points should be in areas that are easy for older adults and children to access safely, minimising risks and encouraging active participation.
- **Inclusive Communication:** Training sessions and information campaigns should be delivered in all local languages, using visuals and simple messaging for individuals with limited literacy.

- **Inclusion of Informal Waste Workers:** the design of SWM facilities and services should be in partnership with informal waste workers to promote better livelihood opportunities **(X.2)**.

Participation: Amplifying Voices in Decision Making (X.2)

Inclusive SWM programmes actively involve all community members in planning, implementing and monitoring services, fostering ownership and ensuring more equitable and relevant solutions. Participation means exploring and addressing barriers that prevent marginalised groups from having a voice in decision-making.

Examples of challenges in participation:

- **Women and Girls** are often excluded from decision-making processes, leading to inappropriate services. Women are often deprioritised in employment and livelihood opportunities and should be equally considered and accommodated.
- **People with Disabilities** are rarely consulted during the planning of solid waste systems, resulting in facilities and services that are inaccessible or unusable.
- **Informal Waste Pickers** are frequently overlooked in policy discussions, despite playing a key role in recycling.
- **Knowledge Barriers** prevent people from participating if they do not understand the topic, teaching style or language. There may be practical barriers to their participation, for example, meeting times that clash with childcare responsibilities and inaccessible locations for persons with disabilities.
- **Children and Youth** are rarely involved in SWM design discussions despite being significant waste service users and critical disseminators of information.

Examples of strategies to increase participation:

- **Inclusive Decision-Making Committees:** form community committees with the balanced representation of different genders, age groups and people with disabilities.
- **Assessments with Disaggregated Data:** collect and analyse Sex, Age and Disability Disaggregated data to understand the specific needs and challenges of different groups within the community.
- **Focus Group Discussions (FGDs):** conduct FGDs with diverse community members, including groups often denied a voice in decision making, to gather insights, identify barriers and ensure their concerns are incorporated into the SWM services.
- **Barrier Analysis:** identify and address cultural, structural, environmental, knowledge/awareness and social obstacles that hinder participation. Collaborate with local counterparts to develop solutions tailored to the local context.

Safety: Protecting Vulnerable Populations and Safeguarding

Safety and safeguarding all individuals is critical to reducing harm and supporting community well-being. This involves designing facilities and services that minimise risks of violence, harassment, and harm while fostering a sense of security for all. It includes safeguarding against exploitation, abuse and neglect, particularly for vulnerable groups such as women, children, the elderly and individuals with disabilities.

Examples of challenges in safeguarding:

- **Exploitation of Informal Waste Pickers** who are vulnerable to exploitation due to their precarious employment conditions and lack of formal protection.
- **Risks for Women and Girls** when collecting or disposing of waste GBV at waste collection points or along unsafe pathways.
- **Children in Waste Management** are vulnerable to abuse, neglect and hazardous working conditions, particularly when waste collection is incentivised on the volume collected. They should not be employed formally or informally as waste pickers.
- **Barriers to Reporting** for marginalised groups who may lack access to safe and trusted mechanisms to report safeguarding violations in SWM systems **(X.3)**.

Examples of safety measures:

- **Safeguarding Policies** should be enforced for all stakeholders involved in SWM **(X.1)**.
- **Reporting Pathways** must be clear and confidential and provide accessible reporting pathways for community members to report concerns related to abuse or safety in SWM systems **(X.3)**.
- **Safe, hygienic and user-friendly Disposal Systems (section U)** should be provided, especially for hazardous waste **(W.2)**, ensuring they are accessible to all.
- **Lighting and Security Measures** should be installed at waste collection points to prevent harassment, violence, or exploitation, especially of women and girls.
- **SWM Emergency Preparedness** should be incorporated into community emergency response plans.
- **Awareness Campaigns** should be conducted with communities on safeguarding, rights, and protection mechanisms linked to SWM services **(X.6)**.
- **Disaster Risk Reduction** needs to be considered in the planning and implementation of SWM to minimise the impact of disasters and increase the resilience of services and infrastructure.

Conflict Sensitivity

Conflict sensitivity in humanitarian assistance is an essential contribution to building and sustaining peace. Aligned with 'Do No Harm', an awareness of conflict dynamics minimises the risk that programme activities aggravate conflict and jeopardise broad protection outcomes.
Conflict sensitivity is relevant for humanitarian organisations internally (such as in project administration) and externally during project implementation, as well as at local, national and international levels, affecting individuals, communities or cross-border relations.
According to the UN's good practice note on conflict sensitivity, peacebuilding and sustainable peace, there are four steps to a conflict-sensitive approach for humanitarian programmes:

- Understand the peace and conflict context (through a conflict sensitivity and peacebuilding analysis)
- Analyse how activities interact with peace and conflict
- Adapt activities and manage interactions
- Leverage opportunities for building and sustaining peace

→ **References and further reading material can be found on page 177**

X.10 Advocacy

Advocacy is the act of supporting, promoting or arguing in favour of a cause, policy or idea to influence public opinion, decision making or policy changes. It involves activities such as raising awareness, lobbying, building alliances and engaging with stakeholders to achieve a specific goal. The goals are often related to social, environmental, political or economic issues. Advocacy can be carried out by individuals, groups, organisations or coalitions; it often aims to bring about positive change or protect certain rights or interests.
Advocacy plays a critical role in transforming SWM practices and fostering community engagement **(X.2)**. This section explores the significance of advocacy in waste management, highlights successful advocacy strategies and outlines key principles for designing and implementing effective advocacy campaigns.
Advocacy is unlikely to be a priority in the acute phase of the response but becomes more significant over time when engaging with affected (and host) communities and local SWM actors.

The Role of Advocacy in SWM

SWM advocacy raises awareness, influences policy and mobilises communities to improve waste-handling practices. It has several crucial functions:

Raising Awareness: advocacy helps educate the public about the importance of waste management and the impact of waste on the environment and public health. With increased awareness, communities are more likely to engage in sustainable waste practices and support necessary policy changes.

Influencing Policy: effective advocacy with policymakers and stakeholders can lead to the development and implementation of robust waste management policies, regulations and strategies aligned with environmental goals and community needs.

Mobilising Action: advocacy campaigns inspire and mobilise individuals and communities for long-term waste management goals and to take action such as adopting better waste disposal practices and participating in local waste management initiatives.

Successful Advocacy Strategies

Successful SWM advocacy often includes the following:

Community Engagement: engaging community members in waste management initiatives fosters a sense of ownership and responsibility. Strategies may include workshops, community meetings and events to educate residents about waste management practices and encourage participation **(X.6)**.

Public Campaigns: information about waste management issues and solutions can be disseminated effectively through public campaigns using various media channels—such as social networks, radio, television, and print media. Campaigns should be tailored to the target audience and focus on key messages that resonate with the community **(X.6)**.

Partnership Building: collaboration with local organisations, businesses and government agencies enhances the effectiveness of advocacy efforts. Partnerships help leverage existing resources, expertise and networks to support waste management initiatives and amplify their impact.

Educational Programmes: educational programmes in schools, community centres and workplaces raise awareness about waste management and encourage behavioural changes. Programmes should cover topics such as waste reduction, recycling and the environmental benefits of proper waste handling.

Policy Advocacy: advocating with policymakers to develop effective waste management policies and regulations is essential. This includes providing evidence-based recommendations, participating in policy discussions and lobbying for changes that promote sustainable waste management practices.

Key Principles for Effective Advocacy

To increase the impact of advocacy campaigns, the following principles should be considered:

Consultations: before launching an advocacy effort, engage with the target audience to understand their perspectives and refine the advocacy strategy.

Clarity of Message: clearly articulate the goals and benefits of the advocacy campaign. Use simple, actionable messages that are easy for the public to understand and act upon.

Targeted Communication: tailor communication strategies to different audiences, such as community members, policymakers and other stakeholders. Customise messages to address the specific concerns and interests of each group.

Evidence-Based Approach: use data and evidence that demonstrate the need for improved waste management practices. Use statistics, case studies and success stories to build a compelling case for change.

Inclusivity: ensure that advocacy efforts are inclusive and address the needs of diverse community groups. Engage marginalised and underserved populations to ensure that all voices are heard and represented.

Sustainability: focus on creating long-term, sustainable change rather than short-term results. Develop strategies that build lasting partnerships, promote ongoing education and embed waste management practices into community norms.

Practical Advocacy Advice

Advocacy is a powerful tool for advancing sustainable waste management practices. However, people’s motivation to engage varies – either positively or negatively. For example, improved public health and a healthier environment are not necessarily the primary drivers for change. Therefore, it is crucial to analyse and understand the interests of each key actor before developing a targeted advocacy plan that captures their attention and interest. In all geographic locations, the following stakeholders are critical for SWM:

National Authorities have a mandate at the national level to establish laws, legislation and standards. They are (or should be) committed to ensuring sustainable waste management practices that protect public health, mitigate environmental harm and align with environmental, sanitation and health policies.

Local government officials, such as **municipal mayors**, are (or should be) committed to improving SWM in their municipalities because effective waste management can enhance residents' quality of life, attract investment and promote economic growth. Mayors should recognise that robust waste management practices lead to cleaner, safer environments and make their communities more attractive (for example for tourism and local business development). Successfully establishing SWM can also boost their reputation, build community trust and, potentially, support their re-election or career advancement – motivating factors that can be consciously used for SWM advocacy.

Municipal Technical Units or Utilities responsible for SWM should be motivated by the need to enhance operational efficiency and service delivery. Their engagement in advocacy can help secure better resource allocation, improve waste collection services and increase overall customer satisfaction.

Private SWM Service Providers are often motivated by profitability and market expansion. The reuse and recycling of waste resources can provide viable business opportunities. By collaborating with municipal authorities, NGOs, the informal sector and community organisations, private companies can explore new market opportunities in waste management and boost their business prospects.

Lawmakers or Politicians are motivated by the interests of their constituents and their own political reputation. Their support for sustainable waste management policies can resonate with voters, highlighting their commitment to environmental sustainability and public health.

This mix of motivations highlights the importance of tailored advocacy strategies that work with each actor's unique drivers, ensuring a collective push towards sustainable solid waste management practices. By understanding people’s motivations, advocates can better align their strategies, foster collaboration between stakeholders and drive the policy changes necessary to improve solid waste management.

→ **References and further reading material can be found on page 178**

PART 4 :

Management of Special Waste Types

W.1 Medical and Health Care Waste Management
W.2 Hazardous Waste Management
W.3 Disaster Waste Management
W.4 Menstrual and Incontinence Waste Management
W.5 Relief Waste Management
W.6 Management of Solid Waste from Sanitation Facilities and Drains
W.7 Management of Waste from Electrical and Electronic Equipment (WEEE)

W

Management of
Special Waste Types

W.1 Medical and Health Care Waste Management

Medical and health care waste is generated by activities and procedures conducted in hospitals, healthcare facilities, emergency field hospitals, medical laboratories, diagnostic centres and other medical institutions. According to the World Health Organization (WHO), 75 %–90 % of this waste includes materials similar to domestic solid waste. These wastes are mainly generated by administrative activities, regular housekeeping and food provision for staff, patients and visitors. Categorised as 'general waste' or 'non-hazardous waste', this waste can be handled and disposed of in the same way as domestic solid waste **(see PART 2)**. The remaining much smaller fraction of medical waste originates from medical procedures. Classified as hazardous waste **(W.2)** it poses significant health risks, especially for care staff, staff involved in medical waste handling as well as patients and their families. Hazardous medical waste can be further classified into sub-categories characterised by the nature of different hazards – such as cut and puncture injuries, the spreading of infectious diseases or other properties which can cause health problems or even death. The types, amounts and items included in these sub-categories vary between medical institutions and depend on the size and sophistication of a facility and the procedures it provides.

WHO classifies hazardous medical waste into the following subcategories:

- **Sharps Waste:** such as used or unused needles, syringes, scalpels, blades, broken glass.
- **Infectious Waste:** potentially pathogen-containing and disease-transmitting items such as waste contaminated with blood or other body fluids, laboratory cultures, microbiological stocks, human excreta and materials from isolation wards.
- **Pathological Waste:** human tissues, organs, body parts, foetuses.
- **Pharmaceutical Waste and Cytotoxic Waste:** pharmaceutical waste includes pharmaceuticals that have expired, or no longer needed, and materials which contain or are contaminated by pharmaceuticals. Cytotoxic waste includes substances with genotoxic properties, used, for instance, in cancer therapy.
- **Chemical Waste:** chemical substances including laboratory reagents, disinfectants, materials and substances containing heavy metals, solvents.
- **Radioactive Waste:** including liquids from radiotherapy, urine and excreta from patients undergoing unsealed radiation therapy, radioactively contaminated materials.

Some medical institutions classify pressurised canisters as an additional hazardous waste category. The canisters contain different types of gases, some highly flammable; they may explode or release their contents if punctured.

The Need for Strict Source-Segregation of Medical Waste

Because of the severe risk to health from hazardous medical waste, its segregation at source and safe containment is essential in Medical Waste Management (MWM). Without strict segregation, a relatively small amount of hazardous waste can contaminate the general waste and enter the waste management stream for regular domestic solid waste, threatening public health and the environment. If strictly segregated at source and safely contained, hazardous medical waste can be transferred to a safe treatment and disposal site where its hazards are eliminated. Strict source segregation also keeps the amount of hazardous medical waste small, minimising the effort and high costs of its safe containment and disposal.
Source segregation of hazardous medical waste must be systematic and the waste contained in appropriate colour-coded vessels marked with labels and hazard pictograms.

In the absence of national guidance on medical waste segregation, the following WHO-recommended segregation scheme is recommended:

- **Highly Infectious Waste:** strong, leak-proof and autoclavable plastic bags or containers in yellow, labelled with 'Highly Infectious'
- **Other Infectious Waste, Pathological and Anatomical Waste:** leak-proof plastic bag or container in yellow, marked with a biohazard symbol
- **Sharps Waste:** yellow puncture-proof containers labelled with 'Sharps'
- **Chemical and Pharmaceutical Waste:** brown plastic bags or rigid containers labelled with the appropriate hazard symbol
- **Radioactive Waste:** lead box marked with the radiation symbol
- **General (Non-Hazardous) Medical Waste:** black plastic bag

To limit the volume of hazardous waste, medical facilities should reduce their waste generation in the first place and reuse equipment (after adequate cleaning and sterilisation).
Training of all health staff is required to ensure that hazardous medical waste is completely and correctly segregated and disposed of. The entire MWM system in a facility can be compromised by incomplete or faulty segregation or later remixing of general waste with hazardous waste.
The safe containment of source-segregated and safely

stored hazardous waste must be maintained until the final disposal. This includes during internal transport for each facility, subsequent storage on the premises of medical institutions, external transport and handling and disposal at disposal sites.

Treatment and Safe Disposal of Hazardous Medical Waste

General and non-hazardous waste from medical institutions can be disposed of along with domestic solid waste. It is, however, essential that no hazardous waste materials are deliberately or unintentionally disposed of with it.
The treatment and disposal of hazardous medical waste must address its specific hazardous characteristics to ensure the complete elimination of public health and environmental risks. Disposal procedures therefore differentiate between the different hazardous waste subcategories and use specialised equipment and personnel. The procedures also vary according to the sophistication of the disposal infrastructure and the availability of specialised personnel. Humanitarian crises may reduce the availability and quality of the infrastructure and capacity of actors. A risk analysis should determine whether the existing infrastructure and specialist capacity of external waste facilities can still manage the treatment and disposal of medical waste, or whether treatment and disposal must be undertaken on the medical facility's premises. A hybrid approach may also be viable, where the medical facility carries out some pre-treatment (such as sterilisation of waste) to facilitate external transport for off-site processing. Medical waste (such as pharmaceutical or radioactive waste) may be returned to suppliers for safe disposal.

Hazardous medical waste treatment and disposal includes:

- Thermal low-heat processes, such as autoclaving, eliminate microorganisms and sterilise waste at temperatures of between 100 °C and 180 °C. Low-heat treatment can be done with wet or dry heat but as it does not lead to thermal degradation, the pathogen-free waste still requires safe disposal.
- Thermal high-heat processes, such as incineration or pyrolysis, completely disintegrate organic and combustible materials, reducing them to ash which contains inorganic and incombustible matter. High-heat processes produce combustion by-products which may require flue gas cleaning and the safe disposal of ash.
- Chemical treatment can be used to disinfect and destroy microorganisms.
- Landfilling untreated medical waste in sanitary landfills is not advised by WHO. If it is the only option, waste must be at least robustly encapsulated.
- Radioactive waste storage depends on its radiation level and decay rate. Radioactive waste is usually under the authority of the national nuclear regulatory agency. The handling and disposal of radioactive waste must adhere to its guidance.

In all cases, the handling, treatment and disposal of medical waste requires adequately trained staff and the use of special personal protective equipment **(X.4)**. WHO provides detailed guidance on safe management.

MWM in Upper-Middle and High-Income Countries

Upper-middle and high-income countries usually establish specialised infrastructure and personnel for the treatment and disposal of medical waste. Some fractions of hazardous medical waste may be incinerated in municipal waste incineration (MWI) plants, depending on their availability, functionality and official authorisation. If MWIs are used, hazardous medical waste is transported by specialist organisations and fed directly into the combustion system. Unlike regular domestic waste, it is not deposited in the waste storage pit of the MWI plant. In the absence of MWI, selected fractions of hazardous medical waste may be incinerated in specific hazardous waste incineration plants. Pathological waste can also be incinerated in crematoria but typically requires sterilisation or disinfection before transportation.

MWM in Middle and Low-Income Countries

Specialised infrastructure and actors with the capacity to safely treat and dispose of medical waste may not exist in middle and low-income countries (or in high-income countries affected by conflict and disaster). In these cases, the responsibility for treatment and disposal rests with the medical facility, usually on its premises.
If space is available and a safe distance from the population, medical waste might be disposed of in separate lined waste burial pits (e.g. sharp pits, anatomical waste pits or burial pits). However, this approach has significant disadvantages, including that the waste remains hazardous. If space permits, small-scale and low-tech incinerators made from locally available materials, such as the De Montfort incinerator, can combust high-risk fractions of medical waste. Such incinerators have very low combustion capacities and lack flue gas cleaning but still enable combustion at high temperatures of ca. 800 °C. Small-scale incinerators can also be imported and assembled on the premises of medical facilities.

Regulatory Frameworks and Guiding Principles

The implementation of MWM in humanitarian settings must adhere to the relevant national regulatory framework and international conventions **(X.1)**. National regulatory frameworks may define how hazardous medical waste must be segregated, stored, treated and disposed of. International conventions relevant to hazardous medical waste include:

- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal regulates the transboundary movement of hazardous wastes, including hazardous medical wastes.
- The Bamako Convention prohibits the importation of hazardous wastes into Africa. The Bamako Convention was established due to the failure of the Basel Convention to prevent the export of hazardous wastes from developed to less-developed countries.
- The Stockholm Convention on Persistent Organic Pollutants (POP). POPs can be produced during the incineration of hazardous medical waste.

Social, Ethical and Cultural Implications

MWM must respect social, ethical and cultural norms and traditions. These considerations particularly apply to the management of pathological waste, including body parts, foetuses and placentas.

→ **References and further reading material can be found on page 178**

W.2 Hazardous Waste Management

Hazardous waste refers to waste materials that pose a heightened risk to human health and the environment and require special handling and disposal. Hazardous waste can originate from various sources, such as manufacturing and industrial sites, agriculture, medical institutions **(W.1)** or discarded household products. It commonly displays one, or several, of the following hazardous properties:

Toxicity: harmful or fatal when ingested or absorbed.
Corrosiveness: strong acids and bases.
Reactivity: unstable substances under standard conditions, may react with water, release toxic fumes or cause explosions.
Flammability: materials that can catch fire easily, such as solvents and fuels.

Hazardous Waste in Humanitarian Settings

The following are the most frequently encountered hazardous wastes in humanitarian settings:

Pharmaceutical and Biomedical Waste includes infectious waste (such as contaminated sharps or body fluids), radioactive waste materials from medical procedures (such as imaging or cancer treatment), cytotoxic and genotoxic hazardous drug waste and expired or unused pharmaceuticals **(W.1)**.
Waste From Electrical and Electronic Equipment (WEEE) – or e-Waste – includes non-functional or obsolete equipment such as computers, mobile phones, electrical transformers, batteries and fluorescent lamps that contain harmful substances like heavy metals or acids **(W.7)**. E-waste also includes 'white goods' which refers to larger, commonly used household items such as fridges or freezers.
Household Hazardous Waste includes various hazardous materials found in households, such as fuel and chemical products (drain cleaning agents, oil-based paint, solvents, motor oil and fuel, poison, pesticides, herbicides and rodenticides), pharmaceuticals, batteries and electrical and electronic equipment (such as batteries, TVs, computers, mobile phones and other appliances like fridges and freezers).
Debris Containing Hazardous Compounds such as asbestos or hazardous organic compounds like polycyclic aromatic hydrocarbons (PAHs) or polychlorinated biphenyls (PCBs) from damaged or destroyed infrastructure and buildings.
Disaster Waste can contain the above-mentioned four hazardous waste types as well as chemicals, fuels or contaminated materials from commercial storage and industrial production sites.

Hazard, Quantity and Exposure

The potential impact of hazardous materials depends on their hazardous properties, the quantity released and the exposure of people and the environment. Levels of exposure relate to pathways (the dissemination of substances through air, soil and water bodies) and receptors (the receiving body, including humans, agricultural areas or natural environments). To reduce or prevent the impact of hazardous materials, one of the elements – hazard, quantity or exposure – must be removed.

Definition and Legal Framework

The classification of 'hazardous waste' and the materials included is based on relevant national frameworks **(X.1)** and the Basel Convention, an international treaty which controls the transboundary movements of hazardous wastes and their disposal. National and international legislation also define the safe and adequate handling and disposal of hazardous waste. Any divergence between the two legislations is usually related to the management responsibility of certain materials, not the degree of hazardousness. For instance, some national legislations consider radioactive substances hazardous, whereas the Basel Convention does not (they are controlled by the International Atomic Energy Agency). Similarly, conventional unexploded ordnance might be classified as hazardous material in national, but not international, legislation. Some legal frameworks also distinguish between 'hazardous materials' and 'dangerous goods'. Materials are hazardous if their handling or storage threatens human health and the environment. 'Dangerous goods' usually refers to substances which pose a threat during transport.

Identification of Hazardous Waste

The identification and management of hazardous waste in humanitarian settings are critical to protect public safety, the occupational safety of humanitarian workers and the environment. The presence or location of hazardous materials may be unknown, especially after disasters or during conflicts. Their identification and management should be done by Hazardous Material (HazMat) specialists. Due to their specialised, complex and potentially dangerous work, HazMat specialists are commonly affiliated with governmental organisations, including the armed forces, civil protection or professional emergency services including fire brigades. They are trained and equipped with field measurement and sampling equipment and corresponding Personal Protective Equipment (PPE). Initial assessments can also be done remotely using satellite imagery, historical site information, or by interviewing relevant stakeholders, such as staff from industrial or medical sites. The Flash Environmental Assessment Tool helps to identify hazardous substances, their potential impact and threat, and response priorities.

Suggested Key Actions

- **Assessing** the type of exposure anticipated (splash, spray, contact or touch) and the disease transmission category.
- **Provision** of PPE for waste handlers, such as gloves, masks, goggles and protective clothing to safeguard against exposure to hazardous substances **(X.4)**.
- **Training** all personnel engaged in hazardous waste management on safety standard operating procedures and the correct use of PPE when handling hazardous waste. Train community members and waste management personnel to identify, handle and dispose of hazardous waste safely.
- **Safe Collection Practices** and protocols developed and implemented for the safe collection of hazardous waste, ensuring minimal contact and exposure. This may require specialised tools and equipment.
- **Transportation** using dedicated vehicles for hazardous waste, ensuring they are secure and comply with safety regulations, including proper labelling and containment during transit. To transport segregated waste within a health facility, best practice is to use a cart or trolley.
- **Recycling** of some hazardous materials where appropriate and possible, and where local structures exist. For example, oil refining industries, if present in the area, could recycle used engine oil.
- **Treatment and Disposal** to ensure that hazardous waste is disposed of safely according to WHO recommendations. As required, ask the WASH and Health Clusters for support.
- **On-site Treatment** of hazardous waste, where feasible, using appropriate technologies such as autoclaving/microwaving/encapsulation of medical waste, neutralising chemical waste or incineration for certain hazardous materials. Only modern incinerators operating at 850 °C to 1,100 °C and fitted with special gas-cleaning equipment comply with international emission standards for dioxins and furans.
- **Off-site Disposal** to licensed off-site treatment and disposal facilities if on-site treatment is not feasible. Safe transport need to be ensured and check if the facilities can handle and treat hazardous waste according to regulatory standards.
- **Legal Frameworks** for hazardous waste management practices comply with local, national, and international regulations. This includes obtaining the necessary permits and adhering to hazardous waste handling, transportation and disposal guidelines **(X.1)**.
- **Coordination** and collaboration with local authorities, humanitarian organisations and environmental agencies in hazardous waste management efforts. Share resources and establish clear roles and responsibilities to ensure efficient and safe operations. Support from specialised organisations may be required to deal with hazardous materials.
- **Information Campaigns** should be conducted to raise awareness in affected communities about the risks and dangers of hazardous waste and the importance of proper disposal methods. Use various communication channels to reach diverse audiences **(X.6)**.
- **Regular Inspections** need to be carried out of hazardous waste storage and disposal sites to ensure compliance with safety standards and identify potential risks **(X.3)**.
- **Reporting Systems** are established for reporting incidents, spills, and non-compliance, taking corrective action as needed **(X.3)**.
- **Emergency Preparedness and Response** planning includes the design and implementation of a Waste Management Plan for hazardous and non-hazardous waste aligned with international guidelines.
- **Contingency Plans** are developed and implemented to prepare for hazardous waste spills, leaks or accidents. These plans should include emergency response procedures and contact information for relevant authorities and response teams.
- **Simulation Drills** are conducted to prepare waste management teams and community members for potential hazardous waste emergencies.

→ **References and further reading material can be found on page 178**

W.3 Disaster Waste Management

Disaster waste is all the solid and liquid waste generated during and after a natural disaster or conflict, including waste produced during the emergency response and recovery phases. It is characterised by large waste volumes, a mixture of waste types and a highly intertwined and complex 'waste matrix' (options for the handling and management of the multiple waste streams typical in and after a disaster). Waste produced by a disaster depends on the type of disaster but can include all kinds of mobile and immobile elements of destroyed residential, institutional, economic, transport and industrial infrastructure. The waste of destroyed infrastructure can further be contaminated by dead bodies, unattached body parts, unmanaged human excreta and released hazardous substances or ordnance. In addition to waste from humanity, this waste matrix might be mixed with elements of the natural environment such as vegetation, rock scree or soil sediment. In the aftermath of disasters, an increase in unsegregated waste due to interrupted SWM services and the influx of relief waste can exacerbate the complexity of waste management.

Disaster waste can be categorised as follows:

Debris from damaged buildings and infrastructure such as asphalt and concrete, metal, wood, clay, tar, insulation, shingles and other building materials (including asbestos roof sheets and pipes and insulation material), electrical poles, wire, electrical equipment or transformers.

Vehicles such as destroyed cars, trucks, buses or ships (cargo ships, boats, yachts). Vehicle batteries, oil and fuel are potential hazardous substances which can contaminate the area surrounding vehicle wrecks **(W.2)**.

Natural and vegetative debris such as trees, branches, bushes, rock scree, soil sediments, mud and ash.

Hazardous substances originating from storage, workshops or industrial sites (W.2), including fuel and oil, heavy metals, chemicals and chemical products (dyes, varnishes, solvents, pesticides, fertilisers etc.). Hazardous substances, such as asbestos, may be contained in construction materials; some can escape from contaminated sites and waste storage.

Waste from Electrical and Electronic Equipment (WEEE) (W.7) from households, institutions and industrial sites can contain toxic substances and must be considered hazardous waste. Depending on the community's lifestyle, a big fraction of WEEE may be 'white goods' – fridges, freezers and other household appliances. Their systems are often damaged, leaking refrigerants into the environment.

Medical waste (W.1) from medical facilities (clinics, hospitals, pharmacies, depots) or laboratories. Overloaded healthcare systems disrupted by disasters are more likely to mix healthcare waste with debris and non-hazardous general waste, endangering public health. Destroyed healthcare facilities can release medical waste, chemicals, medication and medical material into the environment.

Domestic solid waste is generated by the destruction of residential buildings and their furnishings and the accumulation of waste from interrupted SWM services. Domestic solid waste includes waste produced by relief efforts such as food assistance or temporary shelter materials like tarpaulins or tents **(W.5)**. Domestic solid waste may also be mixed with household chemicals (e.g. cleaning agents, solvents, pesticides etc.) which contaminate the waste and can leak into the environment.

If there is a potential presence of unexploded ordnance or human remains, relief workers need clearance from appropriate experts before handling any debris or waste. Neither subject is covered in the SWM Compendium due to their specialised nature; the Compendium's audience is also unlikely to be undertaking this work.

The characteristics and quantities of disaster waste vary substantially and depend on the type and scale of a disaster, the level of development, the composition of typical buildings and structures in the area and whether the disaster is in a rural or urban setting.

An efficient Disaster Waste Management (DWM) system will build on these characteristics along with information about the local context (including social and economic factors), the area of geographical damage and the political and waste management systems before the event. Ideally, a DWM system will include systematic waste segregation, planned and safe temporary storage or final disposal sites and the recovery of valuable and useful materials. Successful DWM has been linked directly to economic recovery where recycling initiatives feed directly into the communities' economy. Ad-hoc and unplanned dumping only relocates the debris or postpones its management, increasing the risks and costs; it should be prevented whenever possible. The highest priority for DWM is the identification and safe management of hazardous substances.

During the recovery and reconstruction phases or the planning of a new settlement, a Disaster Risk Reduction (DRR) approach should be taken, incorporating DWM planning for healthcare and waste management facilities, including domestic or municipal solid waste, hazardous waste and industrial waste.

Challenges in Disaster Waste Management

Disaster waste can be a significant risk to public health and the environment, directly and indirectly. The accumulation of open waste and the presence of hazardous materials risks exposure and direct contact; waste can contaminate soil, air and water bodies. Hazardous substances incorporated in building materials, such as asbestos or heavy metals, can be released into the environment. Unmanaged waste acts as a breeding ground for disease vectors such as rodents, blocks drains and reduces water flow, creating stagnant water with the corresponding risk of water-borne diseases.

Disaster waste debris can limit humanitarian access by blocking streets and access corridors, considerably impeding life-saving actions. Roads may be damaged and access corridors must first be created. The movement of large debris requires heavy-duty machinery and this is usually done by national armed forces, national civil protection or contracted local construction companies. The priority is immediate humanitarian assistance and ensuring access to hospitals. The first 24 to 48 hours are critical for this humanitarian assistance; waste and debris segregation are likely to be postponed to a later stage.

Existing SWM services may collapse or be overwhelmed by a disaster, leading to an accumulation of waste in disaster-affected zones. As well as clearing waste directly caused by the disaster, it is essential to revive SWM services and ensure that waste generated in the disaster's aftermath is also safely managed and disposed of. The sheer size and volume of disaster waste can impede longer-term rehabilitation activities. Emergency access roads are usually swiftly cleared for life-saving access but the remaining management and clearance of disaster waste may be slower and more time-consuming. Special care must be taken when searching for survivors and the deceased. The ownership of destroyed buildings, rubble and scattered properties must first be clarified and agreed upon with all involved stakeholders and requires relevant approval from the authorities and the consent of the affected population. Whenever possible, DWM should recover usable and valuable materials. This limits the required space for waste deposits and frees up resources. Common recyclables, such as metals or glass, can be fed into regular recycling streams. Building debris, if free from asbestos and other hazardous materials, can be reused for construction, for instance, to produce recycled concrete **(U.4)**. Recovering usable and valuable materials from disaster waste might be more complex due to the intertwined waste matrix and the potential presence of hazardous materials.

Short-Term Measures

Disaster Waste Management usually starts once life-saving interventions (such as search and rescue, the static inspection of damaged buildings or piled debris, or the identification and removal of unexploded ordnance) are completed. DWM's first and highest priority is the identification of potentially released or unsafely contained hazardous substances and their safe containment. Potential sources of hazardous materials are hospitals, fuel storages, industrial sites, harbours, contaminated construction materials and vehicle fleets and their cargo. Due to the complexity of this task, DWM teams typically include designated and qualified hazardous materials specialists. As well as preventing public health risks, a DWM priority is to ensure the occupational safety of its personnel **(X.4)**.

Work usually starts with an initial rapid assessment. The data gathered at this stage does not have to be precise but should be enough for initial decision making and to prioritise interventions. The data could include the geographic area, the types, quantities and composition of disaster waste streams and the classification of the waste according to its properties and risks, enabling the identification of appropriate handling and disposal methods. The initial assessment is usually done through available secondary data gathered from, for example, satellite imagery, local agencies or governmental sources. Common tools include a waste map of the affected area, hazard ranking, waste needs assessments or a waste handling matrix (see the Joint Environmental Unit publication in the further reading section). Some specialised organisations and agencies now support initial assessments with emerging technologies such as modelling and special drones; their results for the volume, type and distribution of waste are increasingly precise. The initial assessment should also gather information about the available equipment and transport, local capacities, the authority's ability to manage the situation or the potential need for further international assistance.

The main disaster waste management activities in the acute phase include the identification of accessible, environmentally compliant permanent disposal sites. Where no disposal sites exist, temporary disposal options should be identified and established; this requires authorisation from relevant authorities.

It is also essential in the short term to support the local economy and ensure communities can meet their basic needs. After a disaster, individuals might be traumatised and deeply affected psychologically. One option to help communities recover quickly and efficiently is through income generation or cash for work from sorting their waste. In recent years, several initiatives by local agencies and government have provided financial benefits, capacity building and food security.

In most disaster-affected contexts companies exist that have the equipment and skills to move and manage waste. It is important to identify and locate them and help them overcome any barriers to operations (e.g. rubble crushing machinery, or access to roads).

Medium and Longer-Term Measures

More detailed assessments can take place during the stabilisation and recovery phase. Depending on the context, this typically entails additional disaster waste information (locations, type of waste); a better understanding of the regulations; assessing locations for medium-term temporary disposal and waste separation sites for unsorted rubble; municipal waste and other potential waste management facilities in or near the disaster-affected area and assessing the potential for upgrades or improvements to current dumpsites into engineered landfills. It also includes assessing local capacities for addressing disaster waste and identifying gaps and needs for additional assistance.

Key activities at this stage include establishing temporary storage sites for debris and regular waste, initiating or expanding the collection and transportation of waste

and debris and preparing practical advice and guidance for local authorities on interim solutions to minimise the environmental and health impacts of disaster waste. All activities must be coordinated with the local authorities and relevant national or international coordination mechanisms. Disaster waste management must follow local/regional/national legal regulations **(X.1)**. If inexistent, local and international agencies can support their development, led by the national government.
The affected communities should be actively engaged at an early stage and consulted on public health, waste, livelihoods and environmental issues **(X.2)**. Exit strategies and hand-over options for disaster management (e.g. to local authorities or private sector partners) should be planned early on, in close collaboration with the local authorities and communities. Considerations include financial capacity (fees, public sector funds), technical capabilities, and the availability of experienced personnel and their corresponding capacity development needs. DWM runs in parallel with DRR – the aim of all planning and strategy is to reduce damage and casualties in the next disaster.
Disaster waste management must be continuously monitored and evaluated to ensure all disaster waste is addressed, either through appropriate disposal options, incineration where needed and reuse or recycling where possible.

→ **References and further reading material can be found on page 178**

W.4 Menstrual and Incontinence Waste Management

Menstrual and incontinence waste are the discarded items used to manage menstruation or incontinence. They include purpose-made products such as sanitary pads, tampons, panty liners, incontinence pants, adult (or infant) diapers and other materials used such as cloth or fabric. Despite obvious differences between menstrual and incontinence products, the management of both waste streams has much in common and is therefore combined in this section.
As discarded menstrual and incontinence products can constitute a significant waste flow in humanitarian contexts and pose an increased risk to health, menstrual and incontinence waste requires careful handling. Proper management is crucial to prevent contamination, control the spread of disease and protect public health and the environment. Despite the commonalities, incontinence waste is a higher health risk than menstrual waste due to its greater contamination with faecal pathogens and implications for subsequent waste management.
Menstrual hygiene concerns most women and girls of reproductive age for several days each month. Incontinence (the involuntary leakage of urine and faeces) can be considered a health condition. It particularly affects the elderly, women after giving birth, people with disabilities, traumatised individuals (including older children experiencing psychological distress) and people with certain chronic diseases. The type and severity vary by person and can be temporary or chronic. Many people (but not all) with an increased risk of incontinence are members of groups whom development and humanitarian actors often consider vulnerable or disadvantaged. They can also become marginalised due to their incontinence. For the sake of simplicity the management of infant diapers – often a considerable waste management challenge – is here incorporated into incontinence waste management due to their similar properties.
The management of menstrual and incontinence waste is challenging due to the nature of the materials involved and because of the prevalent negative cultural beliefs and stigma around the topic.
Sustainable waste management practices for menstrual and incontinence products include hygienic and convenient handling, reducing the amount of waste as far as possible, appropriate disposal methods, facilities that offer sufficient privacy, dedicated collection and transport systems and the identification of final disposal options. Public awareness and education about waste handling are essential components of responsible waste management.
Socio-cultural norms, along with the availability of waste management systems and waste classification practices, can vary significantly. These differences may result in diverse, localised approaches to managing menstrual and incontinence waste. For instance, countries may classify menstrual waste differently. They may categorise menstrual waste as either (1) a general solid waste product or (2) a medical waste product (despite 'medicalising' waste being seen as problematic as it can further marginalise people who menstruate). If the government or camp authorities have not determined the category, it is recommended that this waste should fall into the solid waste category.
The neglect of the management of menstrual and incontinence waste can also lead to protection issues **(X.9)**, for example, because women may go out at night to bury **(U.8)** or dump **(U.10)** or burn **(U.11)** their menstrual products.

Reducing Menstrual and Incontinence Waste

Disposable products, such as disposable menstrual pads or infant and adult diapers, are widely commercially available. They are easy to distribute in an early-onset emergency and to people in transit. However, they require constant repeat distributions and are disposed of after a single use, often leading to their uncontrolled disposal in the environment (or in toilets). Most disposable products contain superabsorbent polymer (SAP), typically made from sodium polyacrylate. SAP can absorb and retain large quantities of liquid relative to its own mass but creates persistent non-biodegradable waste and potential microplastic pollution.
A more environmentally and financially sustainable solution that can significantly reduce the volume of menstrual and incontinence waste is reusable products (e.g. reusable

menstrual pads, cloths, menstrual cups, period underwear, washable incontinence pants, diapers and pads). However, women may object to reusable products and using them calls for different behaviours (e.g. washing and drying instead of disposal). Additional infrastructure is required, such as dedicated places for discretely washing and drying materials and safe storage options. Reusable materials must be regularly cleaned with soap and water and fully dried to ensure hygienic and comfortable reuse. Shortages of water and soap make this challenging, as do humid conditions (e.g. during rainy seasons) which prevent materials from drying properly. Furthermore, drying reusable materials in public is viewed as undignified and unacceptable and beneficiaries do not want others in the family or community to see them. The secrecy often leads women to reuse damp materials that had insufficient time to dry or were dried under mattresses, under clothing or in other unsanitary locations. Being unable to wash, dry and store reusable materials properly can lead to health and hygiene problems, bad odours, discomfort and the premature disposal of the material by users.

The people who menstruate, people with incontinence and their carers must be actively engaged or, at minimum, consulted before distributing reusable items and products. Training, awareness-raising and discrete, culturally appropriate demonstrations may be needed to encourage acceptance and use, reducing the likelihood of the items being unused and going to waste. Inviting non-affected populations (those who do not menstruate or have incontinence) to similar sessions and other forms of hygiene promotion can improve community acceptance and understanding of these sensitive topics. Sessions should pay particular attention to taboos, myths and values about menstruation and incontinence.

Distributions of reusable items should include additional soap, water and disinfectant to enable proper reuse and avoid premature, unnecessary disposal. Reusable products will eventually have to be thrown away, so adequate disposal options are still required, though less frequently. A reusable menstrual cup can last up to ten years; reusable menstrual pads and pants, and incontinence pants can last between one and three years (depending on the quality, amount of exchange products and care).

If disposable products are the only feasible option, identify more environmentally friendly products such as biodegradable menstrual or incontinence products.

Supportive Water and Sanitation Facilities

Menstruation and incontinence remain highly sensitive topics deeply affected by cultural taboos, stigma and secrecy. Local mythology and taboos can influence how menstrual materials are disposed of; understanding these beliefs when designing appropriate waste management systems is crucial. Consultations with those concerned (including waste handlers who collect and transport the waste) are essential. People who menstruate and people with incontinence and their carers often avoid taking waste materials out of the toilet or being seen washing their materials.

Public and/or household sanitation facilities must therefore protect privacy, be accessible night and day and lockable from the inside. They should provide spaces for safely and discretely changing materials (ideally with a hook for hanging clothes) and discrete waste disposal options inside toilet stalls (such as disposal bins with lids or a chute system to an outside covered pit **(U.8)**) or discrete access to a contained burning option nearby **(U.12)**. Handwashing facilities with soap and water should be installed close to disposal areas.

People with incontinence need up to five times more soap and water than others. Women and girls also need more soap and water for personal hygiene during menstruation, to wash soiled underwear and bedsheets and, if used, to wash reusable items. Areas for discretely washing, drying and storing reusable materials are needed, including leakproof bags for incontinence materials and to store menstrual materials between monthly periods.

A mirror inside the facility is also recommended so that users can check their clothing for blood stains, urine or faecal residues, enhancing their confidence and dignity. Visible blood in bathing or laundry water can be embarrassing; covered drains reduce this exposure.

Discrete On-Site Collection and Disposal Options

The need for disposal systems is particularly urgent where single-use materials such as disposable pads are used. Reusable materials also require end-point disposal (although less frequently) but this option is frequently overlooked. Without a formal and discrete waste disposal system, used materials are often dropped into pit latrines, cesspits, septic tanks and open drains, or buried or indiscriminately disposed of in the environment (e.g. in forests or rivers). Direct disposal into toilets provides a particularly convenient, discrete and instantly available option. However, it leads to problems such as increased fill-up rates of pits or the need for laborious manual removal of solid waste prior to desludging, to prevent desludging equipment from getting clogged up **(W.6)**.

Menstrual and incontinence materials are often disposed of with general domestic waste **(see PART 2)**. Where there is a functioning SWM service chain, this works well, unless the waste is manually sorted for recycling and resale. The sanitary waste may be discarded in unsightly, publicly visible piles, disregarding local taboos or perceptions; this should be closely monitored. A potential solution is to conceal the waste in black or opaque bags or paper or tissue before collection.

Covered waste bins are recommended for all public, communal and household toilets and washroom cubicles. Ideally, waste bins should be waterproof and washable (e.g. plastic or metal) or lined with plastic bin liners. To reduce theft and other uses of the bins, holes can be punched in the containers, or the bins can be physically attached to the wall or floor. Alternatively, a chute disposal system can deposit the used products directly into a locked covered bin or deep covered pit outside the toilet. Behaviour-change campaigns about the proper disposal of menstrual waste are recommended as well as visual placing information signs inside the cubicle.

For incontinence waste, dedicated and clearly marked disposal bins in men's and women's toilets are recommended or leak-proof, sealed bags provided, to prevent odours and contamination. If people with incontinence use handheld urine containers, bed pans or commode chairs, safe disposal options for the urine or faeces must be identified (e.g. the importance of emptying into toilets). Otherwise, people may be unaware of the risks and empty the contents into open drains or open areas outside.

Menstrual and Incontinence Waste Collection and Transport

The waste in bins inside or outside the toilets, washrooms or households must be frequently emptied, collected and transported to a final disposal site. Menstrual waste is not usually kept separate but collected with other waste streams. To reduce the health risks for waste handlers, precautions may be needed for incontinence waste due to its higher pathogen load, which may also affect its subsequent treatment or disposal. Incontinence waste should be kept separate during transport using separate vehicles or designated collection devices to avoid cross-contamination with other waste types. If incontinence waste is combined with menstrual waste, the bins need to be bigger and emptied more frequently.

Toilet cleaners and waste handlers must be trained properly and equipped with Personal Protective Equipment (PPE) such as gloves, masks, overalls, waterproof footwear and containers for safe collection and transport **(X.4)**.

A schedule should be established for the regular collection and replacement of disposal bins. The system needs constant monitoring of, for example, waste accumulation rates, the use in practice of the disposal facilities, whether unwanted disposal options are still being used, or compliance with proper handling approaches during collection and transport.

Contained Burning

Menstrual and solid incontinence waste materials can be burned in a furnace **(U.12)** on-site or at a final disposal point. Although the practice is often recommended – particularly in various menstrual health and hygiene guidelines – caution is advised as the furnaces may not consistently reach the temperatures required and, when burning at lower temperatures, they can release toxic and harmful emissions. Disposable (and some reusable) menstrual and incontinence materials can contain polymer liners which, when burned at lower temperatures, typically release asphyxiant and irritant gases into the atmosphere. Further, the biodegradable components in disposable pads, such as cellulose, wood-pulp and cotton, often contain furans and dioxins. The World Health Organization recommends that all health-related waste should be burnt at temperatures over 800 °C to avoid the release of toxic and irritant chemicals. As contained burning **(U.12)** may not achieve this standard, it should be carefully evaluated before use.

Contained burning – often called incineration – requires electricity or fuel sources, trained operators and a regular burn schedule. If combined and burned with domestic solid waste, emissions are similar to other household waste streams. If contained burning cannot be avoided, the location's position relative to human populations need to be carefully assessed so that smoke and emissions do not become an immediate health hazard.

Strong taboos or myths may exist in communities about burning menstrual sanitary waste (or its handling by other people), which may limit the usefulness of contained burning (or collection systems). In some countries, people believe that anything a baby uses is connected to its soul, including diapers. The burning of diapers (or discarding them in the waste) is considered harmful to the baby's soul so diapers are often disposed of in rivers instead. Hence community consultation **(X.2)** and hygiene promotion interventions **(X.6)** are critical.

Final Disposal of Menstrual and Incontinence Waste

In the absence of existing waste disposal sites, dedicated facilities should be established for all solid waste (including menstrual waste), such as controlled pits **(U.8)** – either onsite or offsite – or controlled disposal sites/landfills **(U.9)**. If pits are close to, or within, settlements, people may dislike seeing used pads in pits and avoid using them for menstrual waste. Final disposal needs to be conducted in a manner and location that avoids creating health, safety or environmental problems for the host and affected populations.

For incontinence waste, coordination with available local waste management services is recommended to ensure compliance with public health regulations for sanitary landfills, incineration facilities or relevant parts of the sanitation and faecal sludge management system. If faecally-contaminated incontinence waste is disposed of in landfills it may pose significant health risks to local waste pickers. These risks must be adequately addressed through, for example, hygiene campaigns, handwashing facilities **(X.6)** and the provision of PPE **(X.4)**.

Operation and Maintenance

Effective menstrual and incontinence waste management requires regular operation and maintenance of all sanitation and washing facilities and the entire service chain. Cleaners and waste handlers need proper PPE and regular training on safety measures and protocols **(X.4)**. Operation and maintenance, including costs for personnel and training, must be included in project budgets. Responsibilities should be clearly assigned for all relevant tasks (such as regular cleaning, emptying of disposal bins, controlled waste burning or transport to a final disposal site) and scheduled (usually daily). Because of taboos, cleaners and waste handlers may need to be sensitised for their roles. Male cleaners may be unsuitable for facilities used by women and girls and more reluctant to handle menstrual waste. Women and girls may be reluctant to discard their waste if they know it will be handled by men.

Hygiene Promotion

Menstrual and incontinence waste management should always be accompanied by hygiene promotion and communication measures **(X.6)**. The public needs to understand how the system works and how the affected individuals (and care givers of people with incontinence) need clear and practical information about disposal methods and intended hygiene practices such as handwashing, washing reusable materials, collection times and cleaning schedules. Depending on the context, hygiene promotion includes changing norms and behaviours and awareness-raising measures on current unwanted behaviours (such as disposing of the waste in pits and its potentially negative impact). Signs and visuals inside the facilities are useful to inform people about proper disposal methods and hygiene practices. For people with incontinence, psychosocial support services may be helpful to share resources and information.

Monitoring and Refinement

Once the waste disposal system is up and running, consultation with the targeted population should continue **(X.3)**, using focus group discussions, key informant interviews, observations and transect walks. This helps to assess whether the system is meeting the needs of people who menstruate and people with incontinence. People's feedback can be used, as required, to adjust the design and operation of the waste management system. Hygiene promoters and leaders of the consultations should be aware that because of the taboos associated with menstruation and incontinence, challenges may not be openly disclosed.

→ **References and further reading material can be found on page 178**

W.5 Relief Waste Management

Relief waste is all the waste generated by humanitarian organisations and their relief operations. It includes packaging material, end-of-life household and distributed food and non-food items (e.g. tents, tarpaulins, lamps, or mattresses), materials used for humanitarian field activities and waste from facilities such as schools, nutrition centres, health centres, offices, guest houses, warehouses and vehicle workshops **(X.7)**. Relief waste here does not refer to waste, such as debris, generated by the disaster itself **(W.3)**.

Examples of the waste types produced by an organisation's relief activities include:

- **Construction Waste:** shelter materials for facilities and infrastructure, construction materials such as bamboo or wood, old or broken water pipes, scrap metals such as roof panels, broken or damaged water storage containers like bladders, collapsible or rigid tanks.
- **Chemicals:** water testing chemicals, broken sprayers and water treatment chemicals like chlorine and aluminum sulphate.
- **Office and Facilities Waste:** e-waste (laptops, radio, fridges, etc.), paper, cardboard, organic waste and old furniture.
- **Awareness-Raising Waste:** Information, Education and Communication materials such as posters, flyers or tarpaulins.
- **Cash for Work:** waste from livelihoods activities such as community clean-up campaigns or cleaning drainage canals.
- **Fleet Waste:** used oil, tyres, lubricants, filters, batteries and scrapped vehicles.
- **Lighting and Power Source Waste:** used oil from generators, scrapped generators, solar panels and batteries.
- **Packaging Materials for Relief Items:** cardboard boxes, plastic films, plastic bags, plastic strips etc.
- **Relief Stocks:** damaged, expired, surplus or unwanted donations.

Humanitarian agencies are responsible for minimising their relief waste as much as possible **(PART 1: Waste Prevention)**. Unavoidable waste generated by field activities, warehouses, offices and other facilities must be systematically segregated **(PART 1: Waste Separation)** and collected **(section C)**. This enables the proper handling of different waste streams or their safe disposal and avoids ad-hoc solutions such as open dumping **(U.10)** or open burning **(U.11)**.

Recommended steps for establishing waste management systems in relief programs, facilities and premises are:

1. Know your Waste: understand the type and quantity of waste generated at project locations such as facilities, offices, warehouses, distribution points and fleet workshops. Waste characterisation and estimation exercises **(PART 1: SWM Assessment)** relative to the project's size help identify the waste streams and quantities to be handled. This enables the planning and resource allocation to, for example, determine the space and volume storage requirements for bins/containers, design take-back and/or reverse logistic schemes or conduct a cost-benefit analysis based on potential revenues.

2. Explore Local Waste Solutions: use the waste management hierarchy **(PART 1: Waste Prevention)** to choose the best local solutions for each waste stream: reduce, reuse, repurpose, recycle, composting, energy recovery or safe disposal. Coordinate with the national WASH sector to assess local waste management services, recycling infrastructure and informal recycling options **(PART 1: SWM Assessment)**, ensuring compliance with local environmental regulations **(X.1)**. Check whether suppliers will take back old items, such as used batteries or tyres, when delivering new ones and identify local service providers who can process valuable waste, reducing the amount of waste for disposal. Research locally available treatment for specific waste types that need special management, such as hazardous **(W.2)** and electric and electronic waste (e-waste) **(W.7)**.

3. Describe Procedures and Raise Awareness: document the selected waste management options for each waste stream in simple Standard Operating Procedures (SOP). SOPs provide step-by-step instructions and define roles and responsibilities, ensuring a consistent and effective waste management system, including safety measures for handling hazardous waste. Share the SOPs with the team and seek feedback to enhance the system. Develop and update communications materials to support campaigns, procedures and information briefs **(X.6 and X.10)**.

4. Install Segregated Bins for Different Waste Types and Designate a Storage Area: including space for repairs or repurposing in facilities, office and premises or field areas. Tailor collection methods to serve different approaches such as take-back schemes **(PART 1: Waste Prevention)**, use colour coding or labelled bins to guide staff about where to dispose of each waste type and prevent contamination. Protect stored, segregated waste from the sun and rain and avoid bins spilling over. Ensure waste handlers wear personal protective equipment, particularly when handling hazardous waste. Provide regular training and raise awareness among colleagues when introducing new waste segregation and handling practices in the organisation **(X.4)**.

5. Monitor the System to Ensure Waste is Properly Managed: defining key performance indicators helps measure progress towards achieving specific objectives, monitor waste collection costs and revenue generated by the waste management system and identify issues where actions need to be taken. These indicators should be defined and customised based on the SWM goals.

Incorporating waste management systems into each sector/cluster-related activity increases the ownership and capacity of organisations to handle their waste effectively and reduce ad-hoc, harmful solutions that have a negative impact on the local environment and communities. Many organisations have signed the Climate and Environment Charter for humanitarian organisations. This global commitment contributes to the environmental sustainability of organisations' interventions and their reduction of waste and greenhouse gas emissions **(X.8)**.

→ **References and further reading material can be found on page 179**

W.6 Management of Solid Waste from Sanitation Facilities and Drains

Solid Waste from Sanitation Facilities

Solid waste is frequently found in pit latrines and other sanitation facilities. It creates significant challenges in pit emptying and subsequent waste handling and poses a risk to health due to the solid waste's contamination with faecal pathogens. The disposal of solid waste in sanitation facilities often results from a lack of awareness, the ease with which unwanted or problematic products can be disposed of in facilities that are close by and private, or simply from a lack of adequate waste management services. People may be further encouraged to drop solid waste into latrines in the absence of discreet on-site collection and disposal options in latrines, such as suitable waste bins.

The solid waste in pit latrines includes anal cleansing materials (e.g. toilet paper or stones), household solid waste and virtually everything else people want to get rid of (and do not want to be seen discarding) including hazardous waste such as oils and grease, chemicals, batteries, medical waste, clothing items, condoms, menstrual hygiene products, incontinence or baby diapers. Pit latrines offer a discreet place to discard items considered embarrassing or taboo, making them a 'catch-all' waste receptacle for logistically or socially awkward items.

Sanitation facilities rely on regular emptying and transport. This is severely constrained by the accumulation of solid waste in pits and tanks which can double the time and money required to empty them. The waste accumulating at the bottom of the pit reduces its functional volume, increasing the frequency of pit emptying. The presence of solid waste usually requires more manual handling by emptying operators, increasing the risk of contamination and exposure to human faeces. During pit emptying, solid waste can cause clogging, splashing and blocking; it may have to be removed manually (e.g. using rakes) before desludging. Some devices are available for pit emptying which immediately shred the solid waste during emptying. Others are designed to exclude rubbish and push the solid waste away from the sludge suction pipes, leaving the rubbish in the pits and sucking out the sludge into a transport container. However, waste gets stuck in emptying devices, especially sheet-like materials such as plastic or fabric; larger waste items (e.g. bottles or shoes) tend to remain in the pit. Extracting, unsticking and removing waste from emptying tools is a manual task, forcing pit emptiers into direct contact with faecal sludge and spillages.

Service providers face numerous physical, chemical and biological hazards, such as slips and falls, sharp objects contained in the sludge, heavy loads and exposure to pathogens. Health and safety protocols and Personal Protective Equipment (PPE) are therefore essential for emptying and transport workers. PPE should include gloves, overalls, rubber boots, safety glasses, masks and hard hats **(X.4)**. Hand washing facilities must also be provided. Due to its faecal contamination, solid waste collected from sanitation facilities is not suitable for reuse and recycling and should be handled with care. It should be transported directly to controlled waste pits **(U.8)** or controlled disposal sites or landfills **(U.9)** and disposed of.

Reliable and convenient alternative waste management systems prevent or discourage solid waste disposal in sanitation facilities. Additionally, design amendments can be made, such as decreasing the hole sizes to prevent larger items from entering the pit latrine (although mechanised emptying equipment often needs space and narrower pit holes can prevent them from operating).

Solid Waste in Drainage Systems

Solid waste accumulates in drainage systems due to indiscriminate rubbish dumping into open drains and water bodies, inadequate solid waste collection services or insufficient maintenance and cleaning of drainage networks. Uncollected solid waste spreads and, if left on the roadsides, ultimately finds its way into drainage systems where it accumulates. Most solid waste originates from households, street litter and construction debris.

Drainage systems are designed to quickly and effectively remove surface water from an area, preventing stagnant water and flooding. Accumulated waste reduces the profile of the drainage channel so it can no longer drain as much water as it was designed for. Drainage channels that are blocked, or have reduced capacity, increase the risk of flooding during heavy rainfall; they can cause backflows and overflows and potentially damage property. Stagnant water can become a breeding ground for vectors such as mosquitos, potentially spreading diseases like malaria and dengue. In addition, decomposing waste releases harmful greenhouse gases and the leachate from the waste can pollute soil, groundwater and surface water sources.

Accumulated waste in drainage systems has to be regularly removed. This can be done through community clean-up campaigns, cash for work activities or by directly engaging local service providers. Waste removers must be provided with proper PPE **(X.4)**. As drainage waste is soiled and potentially contaminated by pathogens it should not be reused or recycled but safely disposed of in controlled waste pits **(U.8)** or controlled disposal sites or landfills **(U.9)**.

Reducing and Improving Waste Disposal

Preventing waste from entering the latrine pits and drainage systems is critical. It starts with avoiding or reducing waste **(PART 1: Waste Prevention)** so that as little waste as possible is produced. Providing reliable and convenient alternative waste management systems also prevents or discourages solid waste disposal in sanitation facilities and drains. People need easy access to suitable storage facilities near where they produce the waste and live. Appropriate facilities include storage bins in households **(S.1)**, public litter bins **(S.3)** or shared communal storage facilities nearby **(S.2)**, ideally with separate collection options for hazardous waste that may otherwise end up in pits and drains. Waste bins placed inside the toilet allow for the discrete disposal of menstrual and incontinence waste. Collection services need to be reliable with regular collection and transport C, dedicated treatment and recycling sites T, and use and disposal facilities U.

Hygiene promotion, awareness-raising and information campaigns are essential to educate communities about proper waste disposal. Through community engagement and consultation, people's needs and preferences can be better understood and a more appropriate waste management system established. Information signs can be placed in latrines to discourage waste disposal in pits. Awareness can be raised about the negative impact of inappropriate solid waste disposal in drains. Community engagement methods include focus group discussions, key informant interviews, observations and transect walks **(X.6)**. Appropriate and accessible waste storage and improvements throughout the domestic waste management service chain all contribute to preventing solid waste from entering these essential facilities in the first place.

→ **References and further reading material can be found on page 179**

W.7 Management of Waste from Electrical and Electronic Equipment (WEEE)

Access to energy and the use of electrical and electronic devices is increasingly vital in humanitarian settings, especially in protracted contexts. Devices such as pumps, lights or fans convert electrical energy into motion or heat. Electronic appliances, such as mobile phones or laptops, control the flow of electrons to function. Electricity is essential for the protection of both the affected populations and host communities, for instance, lighting households, public spaces and sanitary infrastructure. Access to electricity enhances people's quality of life, prevents or reduces protection risks such as gender-based violence, facilitates education and creates economic opportunities. In protracted contexts, households often use appliances such as light bulbs, fans and mobile phones. Schools use electricity to light classrooms and provide computer courses. Medical facilities depend on electricity to store vaccines or laboratory samples in refrigerators and freezers. Drinking water extraction, treatment and distribution require electricity. Small and medium-sized enterprises often base their activities on electrical hand tools and electrical light for businesses such as handicrafts, hair salons, retail shops and market stalls.

In humanitarian settings (and many low and middle-income countries), using the national electricity grid is not an option. The grid either provides interrupted and unreliable access to electricity or is too far away to connect to remotely located settlements or camps. Historically, generators provided off-grid electricity, emitting significant greenhouse gases. Increasingly, renewable energy sources such as solar photovoltaic (PV) systems are used instead. The systems include solar mini-grids for the electrification of households and businesses, solar home systems linked to one household, solar streetlights and solar lanterns for public and individual lighting. Off-grid solar PV systems need batteries to store electricity and provide power outside daylight hours.

The increased use of solar PV systems and electrical and electronic appliances also increases the quantity of end-of-life broken and non-functional equipment. The collective and technical term for this waste category is 'Waste from Electrical and Electronic Equipment' (WEEE), as defined by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes. WEEE is often abbreviated as e-waste, and the term e-waste is used throughout this section.

Despite being a small fraction of the total waste, e-waste can pose significant risks to public health and the environment as it contains toxic and hazardous materials **(W.2)**. These toxic materials can be released in an uncontrolled and unsafe manner if e-waste is unmanaged, managed informally (and unsafely), or if valuable materials are informally (and unsafely) recovered from e-waste. Although an element of domestic solid waste, e-waste must be collected and processed separately from regular domestic waste due to its hazardous nature **(PART 1: Waste Separation)**.

Prevention of E-Waste

As with all waste, preventing waste generation is the best approach to reduce its potential adverse effects **(PART 1: Waste Prevention)**. It is consistent with the waste management hierarchy which prioritises prevention and reduction. Reducing e-waste generation can be addressed at various stages in their lifecycle, ideally in parallel.

If electrical or electronic equipment is procured by humanitarian or development actors, sale contracts can include the Extended Producer Responsibility (EPR), which has two distinct features. One is shifting responsibility for the end-of-life management of goods to the producer. This includes the physical responsibility to recycle and safely dispose of e-waste or the economic responsibility to fund safe end-of-life management. Both physical and economic responsibility can be partially or fully shifted to the producer and be directly linked to the specific traded goods or a defined quantity of existing e-waste. The second distinct EPR feature is enforcing or incentivising producers to include sustainability in the product design, such as its ability to be dismantled or repaired. Although the shift of responsibility for end-of-life management might rely on a producer's voluntary actions, EPR may also be included in national legislation **(X.1)**.

If electrical or electronic equipment is purchased by households and institutions, the potential for EPR is limited. Opportunities to reduce e-waste include repair or, for equipment that can no longer be repaired, take-back schemes and safe disposal.

Exercising rights to existing warranties on electrical and electronic equipment is challenging in humanitarian settings. Products may have been distributed by humanitarian actors or brought in by intermediary traders. Relevant producers or suppliers responsible for upholding the warranty might not have an on-site presence. Furthermore, the product must be linked to the procurement (e.g. by a receipt) which is often difficult in cases of informal sales or in-kind distributions.

If electrical and electronic equipment are distributed, it should happen as soon as possible after the procurement and delivery of goods. Extended storage can be unsuitable for some devices and may lead to complete discharge of batteries.

Local Repair of E-Waste

Opportunities for decreasing e-waste by repairing electrical and electronic equipment should be assessed; their viability depends on local repair capacity and the ability and willingness of end-users to pay for repairs. Informal repair shops often exist, especially in protracted humanitarian contexts. The quality and range of their work may need improving and extending to include the community's most relevant repair and maintenance issues. Capacity strengthening could include vocational and advanced training for existing repair shops or the provision of specific repair equipment and spare parts. Occupational safety is an important training topic as workers can be exposed to fumes (e.g. during soldering) or toxic materials contained in e-waste **(X.4)**. As well as repairing household appliances, trained local technicians may be able to maintain public infrastructure (e.g. solar streetlights or solar PV systems in institutions). Technicians should also be trained in e-waste handling, such as sorting and separation and final disposal.

Ideally, support for local repair should be done in collaboration or consultation with larger producers of electrical and electronic equipment and specialised organisations (e.g. Électriciens sans frontières). Producers may support local repair by offering repair tutorials and training, repair equipment or spare parts. They may be interested in setting up local repair points through corporate social responsibility programmes, in the same way that typical off-grid providers of energy products or services ensure after-sales services.

Collection of E-Waste

In humanitarian (and other) settings, households often keep broken and non-functional electrical and electronic equipment at home instead of disposing of them. This practice (sometimes called the 'hibernation of e-waste') can occur for different reasons, for example, households may still see value in the broken equipment or expect that it can be exchanged for new and functional ones.

Information campaigns and take-back schemes are needed to collect e-waste from households and overcome the hibernation of e-waste. Communities are often unaware of the public health and environmental risks related to e-waste. Sensitisation campaigns can explain take-back schemes or collection procedures. E-waste collection can be done through door-to-door collection or take-back collection points. If possible, collection points should offer repairs. Householders can establish whether their equipment can be fixed and only hand over items beyond repair.

Financial incentives might be required to facilitate e-waste collection but must align with existing take-back market rates to prevent competition with the informal waste sector. Appropriate pricing can be achieved by conducting local market surveys and understanding the local e-waste informal sector/processes. To ensure the financial sustainability of e-waste management, financial incentives should consider the estimated end-of-life value of e-waste as well as its disposal cost.

Safe Recycling and Disposal of E-Waste

Safe recycling and disposal of e-waste is unlikely to be viable for humanitarian actors and requires an assessment of national capacity. This may include public services provided by authorities and utilities or private-sector services from specialised companies. Although humanitarian interventions may include the repair and collection of e-waste, recycling and reuse are unlikely or limited to a few non-hazardous materials. Complete recycling and safe disposal are not feasible in humanitarian settings due to the technical complexity and hazardous nature of e-waste.

If e-waste is sold at cost to public or private-sector services, its valuable content (e.g. copper, gold and other metals) might partially offset disposal costs. The end-of-life value of e-waste should therefore be assessed before agreeing on disposal fees. In low and middle-income countries some components and materials found in e-waste cannot be safely recycled or disposed of in-country. The export of e-waste to other countries falls under the control and regulation of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes **(X.1)**. The Convention does not necessarily prevent export but does increase the complexity for private sector companies in charge of transport and can increase the cost of disposal.

The procurement of e-waste management services must consider relevant national regulatory frameworks and, ideally, verify the certification and quality standards of the private sector companies, even if not legally required **(X.1)**. Humanitarian organisations may have due diligence standards for such sensitive private-sector partnerships. Overall, companies should guarantee that e-waste is handled and disposed of safely concerning public health and environmental risks and that corresponding occupational safety standards for the company workforce are maintained. The International Organization for Standardization (ISO) provides a general framework for environmentally sound processes and procedures, such as ISO 14001 on environmental management systems. In addition, specific certifications for the handling of e-waste exist, such as Responsible Recycling (R2), Recycling Industry Operating Standard (RIOS) and e-Stewards.

Collaboration with the Informal Waste Sector

In humanitarian settings and many low and middle-income countries, the informal waste management sector may be involved in the collection and informal processing of e-waste. The incentive is the recovery of valuable materials from e-waste, such as copper, gold or other metals. Informal e-waste handling should be avoided at all costs; it can involve child labour, the unsafe burning of waste to extract the materials and the unsafe dumping of the residual waste.

Humanitarian organisations engaged in e-waste management must avoid competing with the informal sector. Instead, informal actors and activities can be included in e-waste interventions leading to formalisation and potential employment opportunities. People can be employed as regular staff or remunerated as paid volunteers or through cash for work programmes. Training and PPE must be provided to personnel **(X.4)**. If formal employment is not possible or desirable, the informal sector can still be formalised and strengthened by establishing associations. A waste worker's association, for example, can increase the leverage and economic opportunities for an individual informal worker or a small group of informal workers by defining agreed prices, listing all collectable materials and enforcing working standards (such as the prevention of child labour or use of PPE).

Safety Considerations for E-Waste Management

The management and handling of e-waste require thorough health, safety and environmental measures, starting with training for personnel and the provision of appropriate tools and PPE **(X.4)**. Certain e-waste components require particular attention during handling and transport, especially lead-acid batteries (risk of toxic and corrosive leachate) and lithium-based batteries (risk of self-ignition through thermal runaways).

Lead-acid batteries should be kept out of direct sunlight. Sealed lead-acid batteries must not be opened and have to be kept in collection trays able to retain and withstand leaked acid. The acid of wet batteries must be drained and stored in secured containers.

Lithium-based batteries should be fully discharged prior to storage. They should be stored inside their original product or in closed, sand-filled compartments capable of withstanding the heat from potential self-ignition. Before transportation, lithium-based batteries should be stored for longer to ensure that they are fully discharged.

→ **References and further reading material can be found on page 179**

Appendix

Glossary

A

Animal Feed: Raw or processed biodegradable waste used for animal nutrition. It can also refer to products derived from the treatment of biodegradable waste, for instance, Black Soldier Fly larvae grown on biodegradable waste **(T.4)**. Biodegradable solid waste includes food waste, crop residues, food processing waste or animal manure. The animal feed derived from it contains nutrients such as protein, carbohydrates, fats, vitamins, and minerals.

B

Biogas: Common name for the mixture of gases produced by the anaerobic digestion **(T.3)** of organic material. Biogas comprises methane (50 % to 75 %), carbon dioxide (25 % to 50 %) and varying quantities of nitrogen, hydrogen sulphide, water vapour and other components, depending on the material being digested. Biogas can be collected and combusted as fuel.

Black Soldier Fly (BSF) waste processing: Biological aerobic process where BSF larvae feed on organic matter. The grown larvae are harvested for animal feed for pigs, fish, poultry or pet food. The residue (frass) from the larval feeding process is a valuable soil conditioner and fertiliser **(T.4)**.

C

Camp Coordination and Camp Management (CCCM): Humanitarian coordination mechanism to ensure the rights, dignity and basic needs of displaced populations by managing and coordinating the delivery of essential services, such as shelter, water, sanitation, and safety across multiple displacement sites.

Carbonisation: Process of converting organic materials into char through heating in the absence or limited presence of oxygen **(T.5)**.

Char powder: Powderised charcoal **(T.5)**.

Collection (primary): Collection and transport of waste from the location of waste generation to a transfer station, often executed with manual or animal-powered vehicles or small to medium-sized motorised vehicles.

Collection (secondary): Collection and transport of waste from a transfer station to the site of disposal, treatment or use. This bulk transport is often executed with larger motorised vehicles.

Composite Waste: Combination of different materials that are bonded together and often challenging to separate into individual components for recycling or disposal. Composite waste can take various forms, such as composite packaging (e.g. a milk carton), composite building materials (e.g. reinforced concrete) or items made from a combination of different materials that are fused or bonded during manufacturing. Although recycling composite materials might be technically feasible, it may not be of economic interest; therefore composite materials are usually considered non-recyclable.

Compost: Decomposed biodegradable matter resulting from controlled aerobic degradation **(T.1)**. Microorganisms (mainly bacteria and fungi) decompose biodegradable waste components and produce an earth-like, odourless, brown/black material. Compost has excellent soil-improving properties and contains a variety of nutrients.

D

Debris: Waste from damaged buildings and infrastructure including a wide range of materials such as asphalt, concrete, metal, wood, clay, tar, insulation, shingles and other building materials as well as destroyed electricity infrastructure such as electrical poles, wire, electrical equipment or transformers.

Disaster Waste: All solid and liquid waste generated by a natural disaster or conflict both during the event itself and the subsequent emergency response and recovery phases. It is characterised by large volumes of waste, a mixture of waste types and a highly intertwined waste matrix, which further complicates its management **(W.3)**.

Downcycling: Process of transforming materials into products of lesser quality, value and functionality than the original **(T.8)**.

E

e-Waste: Waste from Electrical and Electronic Equipment (WEEE), or e-waste, is discarded or obsolete electrical or electronic devices and appliances that no longer function or have reached their end-of-life. It includes a wide range of items, such as computers, mobile phones, household appliances, lamps and photovoltaic panels. Due to the presence of toxic materials, like heavy metals, e-waste is hazardous and poses a risk to public health and the environment. Ensuring its safe recycling and disposal is critical **(W.7)**.

Extended Producer Responsibility (EPR): EPR is a policy approach that holds producers and manufacturers accountable for the entire lifecycle of their products, including end-of-life. It incentivises producers to consider environmental costs and design for better end-of-life product recovery.

F

Fertiliser: Plant nutrients applied to soil and plants to enhance crop yield and replenish soil nutrients depleted by farming practices. Fertilisers typically contain macronutrients (such as nitrogen, phosphorus and potassium) and secondary micronutrients (such as calcium, magnesium and sulphur). Fertiliser can be organic or synthetic; fertiliser derived from organic solid waste is organic.

Frass: Waste products and excrement produced by insects, particularly larvae, fed on organic waste. Frass is rich in nutrients and organic matter which are beneficial to plants. It is typically used as a fertiliser or soil amendment. It can improve soil health by adding organic content and beneficial microbes **(T.4)**.

G

Glass: Solid, brittle and often transparent material. Silica is commonly its main component and the main glass-forming constituent. Depending on its function and colour, glass can contain other constituents such as soda, lime, metals and fining agents to improve clarity. Glass waste includes used glass bottles, jars, containers and other glass consumer products. Intact and broken glass can be recycled. Used glass is separately collected and melted down to produce new glass products.

Greenhouse Gases (GHG): Gases in the atmosphere, such as carbon dioxide or methane, which absorb infrared radiation, trap heat and contribute to the greenhouse effect and raised surface temperature of the earth.

H

Hazardous Waste: Waste is hazardous if it contains materials posing a significant threat to human health or the environment. These materials often exhibit characteristics of toxicity, flammability, corrosiveness or reactivity. Examples of hazardous household waste include paint, solvents, pesticides, batteries, electrical and electronic devices and certain cleaning products. Proper disposal of hazardous domestic and municipal waste is essential to prevent contamination of the environment and protect the health and safety of waste handlers and the general public **(W.2)**.

I

Incineration: Highly sophisticated, technical and complex waste treatment approach that fully controls fly ash, gas and slag emissions using specific technical and monitoring measures to limit environmental and health impacts. Incineration has very high cost and skill requirements. It is not a feasible solution for humanitarian situations but is typically used in municipal waste incineration plants or hazardous waste incineration facilities.

Information, Education and Communication (IEC): Range of products supporting hygiene behavioural change such as infographics, flyers, leaflets, brochures, social media posts, television adverts, audio sessions for radio, posters and billboards or murals. IEC is used by hygiene promoters to inform and motivate people to prevent WASH-related diseases.

L

Landfill: Carefully engineered site designed for the controlled disposal of municipal solid waste. It isolates waste from the environment to prevent contamination, employing barriers like liners and leachate collection systems to manage harmful liquids. Waste is deposited in layers, compacted, and covered daily to minimise odours and pests, ensuring environmental protection throughout its lifecycle **(U.9)**.

Leachate: Liquid produced by water percolating through solid waste, extracting soluble or suspended materials in the process. This liquid often contains a variety of organic and inorganic contaminants, making it a significant environmental concern as it can pollute groundwater and surface water if not properly managed **(U.8 and U.9)**.

Litter: Small pieces of rubbish or discarded items improperly disposed of in public places. Litter typically includes food wrappers, cigarette butts, beverage containers and other small items left in outdoor areas, parks, streets or public spaces. It is prone to end up in drainage and stormwater systems and can lead to blockages or reduce drainage efficiency **(S.3 and W.6)**.

M

Material Recovery Facility (MRF): Combined waste sorting and waste transfer facilities that receive, separate and prepare recyclable materials for further use or processing.

Medical and Health Care Waste: Waste from the activities and procedures conducted in hospitals, healthcare facilities, medical laboratories, diagnostic centres and other medical institutions. The largest fraction of waste from these institutions (between 75 % and 90 %) includes materials similar to domestic solid waste. A much smaller fraction of medical waste originates from medical procedures and is considered hazardous waste. It can pose a significant risk to public health, especially for care staff, staff involved in medical waste handling as well as patients and their families **(W.1)**.

Medical Waste Management (MWM): Systematic process of handling, segregating, treating and disposing of waste generated by healthcare activities to ensure environmental safety, regulatory compliance and protection of healthcare workers and patients **(W.1)**.

Menstrual and Incontinence Waste: Discarded items used for managing menstruation or incontinence, including purpose-made products such as sanitary pads, tampons, panty liners, incontinence pants or adult (or infant) diapers and other materials used (e.g. cloth or fabric) **(W.4)**.

Metals: Range of materials made completely or mostly of metals such as copper, aluminium or iron. Metal waste includes aluminium cans, steel packaging and scrap metal from construction or manufacturing processes. Metals are valuable materials that can be recycled repeatedly without a significant loss of quality. The recycling of metal waste entails collecting, sorting and processing the materials for reuse in the manufacturing of new metal products.

Mixed Waste: Combination of various waste materials that are commingled and disposed of together and are difficult to separate. This waste stream typically includes a mixture of biodegradable, non-biodegradable, recyclable and non-recyclable materials. Mixed waste may contain a diverse range of items such as food scraps, paper, plastics, glass, metals and other miscellaneous items. Managing mixed waste can be challenging because the separate handling of different waste components is not possible without labour-intensive sorting. Litter is a specific form of mixed waste.

Mulching: Covering the soil with a layer of old leaves or small wood pieces (or compost). It is typically used to retain moisture and suppress weeds. Its slow incorporation into the soil eventually enriches the soil with nutrients.

Municipal Waste Incineration (MWI): Controlled combustion process that thermally treats mixed solid waste from households and businesses in specialised facilities (see Incineration), reducing waste volumes while potentially recovering energy as electricity and heat.

N

Non-Food Items (NFI): Any individual or household items other than food that are distributed to affected people in humanitarian settings. NFIs include buckets, jerrycans, soap or sanitary towels.

Non-Recyclable Waste (NFI): Materials that are not recycled for technical or financial reasons. The categorisation of 'recyclable' and 'non-recyclable' is context-specific and depends on the availability of suitable recycling infrastructure and whether the recycling of materials is of economic interest. Non-recyclable waste is often destined for disposal.

O

Organic Food/Kitchen Waste: Any fast-degrading organic matter that can be broken down by microorganisms into their constituent elements and compounds. It commonly consists of food scraps, trimmings, leftover and spoiled food and food market waste. It is rich in nutrients, particularly nitrogen, phosphorus and potassium. It can be decomposed during aerobic and anaerobic processes and transformed into valuable resources like biogas, compost, animal feed and frass. The agricultural use of processed organic food/kitchen waste recirculates the nutrients into the soil for plant growth. Separating and processing organic waste reduces the volume of waste sent to disposal sites, decreasing the emission of flammable and climate-relevant gases from deposited waste and contributing to more environmentally friendly waste management practices.

Organic Garden/Wood Waste: Slower-degrading fraction of organic waste that is generally more fibrous than food waste and has higher lignin content. It commonly consists of bamboo, nut shells, sawdust, agricultural residues, twigs, branches and (untreated) timber and construction wood. It has a high carbon content that makes it an important component in composting and vermicomposting for balancing the carbon-to-nitrogen (C:N) ratio and is a valuable source for producing solid biomass fuel.

P

Paper or Cardboard: Products from cellulose fibres such as cardboard or paper packaging, newspapers, magazines or office paper. Processed cellulose fibre originates from wood, grasses or other plant sources. However, as paper or cardboard also contain non-biodegradable auxiliary materials (such as colour pigments, glue or lamination), it is not usually listed as a biodegradable material. Paper or cardboard is considered recyclable waste that can be collected, processed and reused to create new products. The recycling of paper and cardboard is common practice and these materials are often collected separately from other waste to facilitate recycling.

Personal Protective Equipment (PPE): Equipment or gear designed to be worn or used to protect the body from severe injuries and illnesses. Depending on the workers' tasks and responsibilities, it may include masks, gloves, rubber boots, resistant clothes and overalls or reflective vests **(X.4)**.

Plastics: Synthetic or semi-synthetic material made from a wide range of organic polymers. Different plastic types are distinguished by their polymers, including Polyethylene (PE), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET) and various others. If a plastic item consists of only one plastic type, it is potentially recyclable. The feasibility, complexity and economic incentives to recycle depends on the plastic type and its cleanliness. If plastics are mixed with other materials, such as metal coatings or cardboard, they are considered composite materials. Plastic waste includes plastic packaging, bottles, containers and other products made from plastic materials. Plastic waste creates environmental challenges due to its persistence and potential for pollution. Recycling involves collecting, sorting and processing plastic waste to manufacture new plastic products **(T.6–T.8)**.

R

Recyclable Waste: Mainly non-biodegradable materials that can be collected, processed and reused to create new products. Recycling these materials entails sorting, cleaning and processing them so that they can be used as raw materials for new goods. The categorisation of 'recyclable' is context-specific and depends on the availability of suitable recycling infrastructure and whether the recycling of materials is of economic interest.

Recycling: Recycling indicates that the produced new goods have comparable material properties and functions as the original material. Recycling waste is a key component of sustainable waste management, helping to conserve natural resources, reduce energy consumption and decrease the environmental impact associated with the extraction and production of new materials.

Relief Waste: Waste generated by humanitarian relief operations, also referred to as humanitarian waste. It includes all waste generated by the response and services provided (e.g. food waste, packaging materials, shelter waste and other NFI). It also includes waste from the organisations' functional services in offices, guest houses, warehouses and vehicle workshops **(W.5)**.

Residual Waste: Waste that remains after materials that can be reused, recycled or composted have been separated and removed. It includes items typically disposed of in landfills or incinerated in municipal waste incineration plants. Residual waste encompasses a variety of materials, such as composite plastics, mixed waste and other items that are challenging to recycle or do not have established recycling markets. Reducing the generation of residual waste through waste minimisation and recycling efforts is a key goal in sustainable waste management practices.

Reverse Logistics: Process in which a product is returned from the point of sale to the manufacturer or distributor for recovery, repair, recycling or disposal.

S

Separation: Process of separating waste into different waste fractions (material types). Waste separation is an integral part of SWM, separating items and materials that can be repurposed, reused, recycled or treated from the main bulk of waste. Separation and subsequent recovery, treatment and recycling reduce the volume of waste for disposal. Waste separation describes waste segregation and waste sorting. Segregation separates waste that has never been mixed with other waste immediately after generation. Waste sorting extracts certain waste fractions from mixed waste later in the waste management process. Waste segregation is the priority as segregated waste is higher quality, facilitating recovery rates by lowering the complexity and cost of waste treatment and recycling **(PART 1: Waste Separation)**. It also provides safer and cleaner working conditions for SWM workers.

Segregation: Waste separation process immediately after generation when the segregated waste fractions have never been mixed with other waste.

Sorting: Waste separation process where certain waste fractions (usually recyclables and/or organics) are extracted from mixed waste. Waste sorting can take place at different stages of the SWM service chain.

Solid Biomass Fuel: Mainly derives from biodegradable garden and wood waste. Common sources such as wood, bamboo, nut shells, sawdust and agricultural residues have a high cellulose content. Larger pieces of wood or bamboo can be directly used as fuel. Smaller, more dense or powdery materials burn less efficiently, or not at all. These biomass wastes can be processed into pellets, carbonised or non-carbonised briquettes **(T.5)**.

Solid Waste from Sanitation Facilities and Drains: Waste directly discarded into sanitation systems (such as pits or septic tanks), or solid waste and litter discarded in public spaces or streets. It eventually accumulates in stormwater lines and drainage systems where it can lead to blockages, overflow, clogging of pipes and channels or stagnant water pools. It can be comprised of a wide range of materials including biodegradable matter (such as food waste), non-biodegradable materials (such as plastics, paper, glass and metals), sanitary products (menstrual products or diapers) or debris. It can be difficult and hazardous to remove. Solid waste in drains may contain additional biodegradable matter such as leaves and plant debris and non-biodegradable materials such as sediment, silt, sand and other debris. It may contain contaminants such as oils, grease, chemicals, pathogens and other pollutants. These, and other waste from sanitation facilities and drains pose risks to human health and the environment if not managed properly **(W.6)**.

Standard Operating Procedure (SOP): Step-by-step instructions for performing routine tasks consistently and efficiently.

T

Take-back: Schemes where end-of-life goods are collected and returned to the supplier. They are particularly relevant in humanitarian response for products which cannot be disposed of locally or which contain hazardous materials, such as e-waste from solar lanterns and other electrical and electronic devices. Take-back schemes for distributed items may offer financial or material incentives. Empty food and NFI packaging can be returned during new distributions.

Textile: Material made from natural or synthetic fabrics. Textile waste includes worn-out clothing, household textiles and scraps from manufacturing. Recycling initiatives often focus on collecting and processing textile waste for reuse by transforming textiles into new products or converting them into fibres for use in various applications.

Total Cost of Ownership (TCO): The total cost of a product during its lifecycle.

Transfer Station: Sites where waste is transferred from smaller to larger vehicles for transport to final use and disposal, increasing the efficiency and safety of transport logistics.

U

Upcycling: Artistic and creative reuse of waste materials while potentially increasing its financial value.

V

Vermicompost: Type of compost produced through the breakdown of organic waste by earthworms. Earthworms consume organic materials such as food scraps, agricultural residues and other biodegradable waste. As they digest this material, the worms produce castings or worm excrements which are rich in nutrients and beneficial microorganisms **(T.2)**.

W

Waste Audit/Characterisation: Evaluation of waste generation and composition used for planning, identifying opportunities for reducing waste and enhancing recycling efforts. Waste samples are collected and analysed to inform and design better waste management practices.

Waste Composition: The specific types and proportions of materials making up a waste stream, including categories such as organic waste, plastics, paper and metals. Understanding waste composition is essential for effective waste management as it informs strategies for recycling, disposal and resource recovery.

Waste Fractions: Waste types (also referred to as waste products) classified by their properties into a group (e.g. biodegradable, plastic or metal waste fractions).

Waste from Electrical and Electronic Equipment (WEEE), or e-waste: End-of-life waste from broken, obsolete and non-functioning electrical and electronic appliances and solar PV systems **(W.7)**. E-waste can pose significant risks to public health and the environment as it contains toxic and hazardous materials **(W.2)**.

Waste Generation: The amount and composition of waste produced by households and non-household generators of waste, critical for informing decisions about solid waste management systems. Accurate data on waste generation can be collected through waste audits which measure waste over a specified period, ideally accounting for seasonal variations. Waste generated is often expressed as kilograms per person per day (kg/person/day).

References

All listed references are available online and can be downloaded from the Emergency WASH Knowledge Hub online platform (emergency-wash.org).

Introduction

Why Solid Waste?

Global humanitarian and development guidance documents:

→ ICRC & IFRC (2021): Climate and Environment Charter for Humanitarian Organizations. Switzerland

→ Sphere Association (2018): The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response. Switzerland

→ UNHCR (2018): Global Compact on Refugees. Switzerland

→ United Nations (2015): Sustainable Development Goals (SDGs)

Implementing SWM in Humanitarian Contexts

SWM Strategy from Cox's Bazar, Bangladesh:

→ WASH Sector Cox's Bazar & ISCG (2021): SWM Strategy Cox's Bazar. Inter Sector Coordination Group. Bangladesh

Book on sanitation in emergencies including a comprehensive chapter on SWM in acute humanitarian settings :

→ Reed, R. (2024): Sanitation in Humanitarian Settings. Practical Action. United Kingdom

Principles and Standards

Sphere minimum standards in humanitarian response:

→ Sphere Association (2018): The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response, 4th Edition. Switzerland

ISO standards:

→ International Organization for Standardization (2015): ISO 14001:2015 Environmental Management Systems – Requirements with Guidance for Use

→ International Organization for Standardization (2018): ISO 45001:2018 Occupational Health and Safety Management Systems – Requirements with Guidance for Use

Collection of waste management standards, conventions and guidelines:

→ WREC/Logistics Cluster (2023): Global Digest of Waste Management. Standards, Conventions, Guidelines

PART 1: Preparing for SWM

Waste Prevention

Green procurement materials available in various languages:

→ WREC & Logistics Cluster (2024): Green Procurement Market Assessment Toolkit

→ WREC & Logistics Cluster (2023): Green Procurement Journey Poster

SWM Assessment

Comprehensive tool for assessing and improving SWM in humanitarian contexts:

→ Tosi Robinson, D., Mertenat, A., Ubbiali, S., Zurbrügg, C. (2025): Humanitarian Aid Solid Waste Assessment and Improvement Guidelines. Eawag. Switzerland

Resources and tools to support environmental screening for humanitarian operations:

→ Neat+ (undated): Nexus Environment Assessment Tool

→ UNEP/OCHA Joint Environment Unit (2024): EHA Global Training Template. Module 2 Environmental Screening in Humanitarian Action

Methodology to assess and improve municipal SWM through data-driven measurement of waste generation, collection and treatment

→ UN-HABITAT (2021): Waste Wise Cities Tool. United Nations Human Settlements Programme. Kenya

Free online SWM course, including guidance on waste audit (generation and characterisation study):

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 1.11a Planning a Waste Generation and Characterization Study. Switzerland

→ Eawag, Sandec (2018): Municipal SWM Online Course in Developing Countries. Module 1.11b Conducting a Waste Generation and Characterization Study. Switzerland

PART 2: SWM Service Chain – Technology Overview

S.1 Individual and Household Storage

Key design features of household storage:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

General overview of household storage:

→ Bjerregaard, M., Meekings, H. (2008): OXFAM Technical Briefing – Domestic and Refugee Camp Waste Management Collection and Disposal. OXFAM. United Kingdom

S.2 Community and Shared Storage

Key design features of community and shared storage:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

General information on community storage options:

→ Bjerregaard, M., Meekings, H. (2008): OXFAM Technical Briefing – Domestic and Refugee Camp Waste Management Collection and Disposal. OXFAM. United Kingdom

S.3 Public Litter Storage

Key design features of public litter storage:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

C.1 Manual Transport

Key design features of waste transport options:

→ Coffey, M., Coad, A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ Rouse, J., Ali, M. (2002): Vehicles for People or People for Vehicles? Issues in Waste Collection. Water, Engineering and Development Centre (WEDC), Loughborough University. United Kingdom

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

General overview of waste transport:

→ Bjerregaard, M., Meekings, H. (2008): OXFAM Technical Brief – Domestic and Refugee Camp Waste Management Collection and Disposal. OXFAM. United Kingdom

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit. How to Collect Waste Safely and Efficiently. A Step-by-Step Guide. WasteAid UK. United Kingdom

→ Rouse, J., Reed, B. (2013): Solid Waste Management in Emergencies. Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies. World Health Organization. Switzerland

C.2 Animal Transport

Guidance document to design solid waste collection systems:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme, Kenya

Technical design and manufacture guide for animal-drawn carts:

→ Barwell, I., Hathway G. (1986): The Design and Manufacture of Animal-Drawn Carts. IT Publications. London. ISBN: 978-0946688524

Small waste collection vehicles' social, technical and institutional considerations, including the user's perspective:

→ Rouse, J., Ali, M. (2002): Vehicles for People or People for Vehicles? Issues in Waste Collection. Water, Engineering and Development Centre (WEDC), Loughborough University. United Kingdom

C.3 Motorised Transport – Small Vehicles

Key design features of the selection of small- and medium-sized motorised vehicles:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ Rouse, J., Ali, M. (2002): Vehicles for People or People for Vehicles? Issues in Waste Collection. Water, Engineering and Development Centre (WEDC), Loughborough University. United Kingdom

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

C.4 Motorised Transport – Large Vehicles

Key design features of the selection of large motorised vehicles:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ Rouse, J., Ali, M. (2002): Vehicles for People or People for Vehicles? Issues in Waste Collection. Water, Engineering and Development Centre (WEDC), Loughborough University. United Kingdom

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

C.5 Transfer Station

Key design features of transfer stations:

→ Coffey, M., Coad A. (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme, Kenya

General overview of transfer stations:

→ Rouse, J., Ali, M. (2002): Vehicles for People or People for Vehicles? Issues in Waste Collection. Water, Engineering and Development Centre (WEDC), Loughborough University. United Kingdom

T.1 Composting

User manual on how to do composting:

→ Rothenberger, S., Zurbrügg, C. (2006): Decentralised Composting for Cities of Low-and Middle Income Countries. A Users' Manual. Waste Concern. Bangladesh

Overview of organic treatment technologies with technical information on composting:

→ Zabaleta, I., Mertenat, A., Scholten, L., Zurbrügg, C. (2020): Selecting Organic Waste Treatment Technologies - SOWATT. Eawag. Switzerland

Guidance for schools with detailed information on composting and vermicomposting of waste:

→ ISWA (2017): A Handbook for Schools on Organic Waste Management. International Solid Waste Association

Free online SWM course with modules on composting:

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.2 Science of Composting. Switzerland

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.4. Operating the Composting Process. Switzerland

T.2 Vermicomposting

User manual on how to do vermicomposting:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit – How to Turn Organic Waste into Compost Using Worms. A Step-by-Step Guide. Wasteaid. United Kingdom

Overview of organic treatment technologies with technical information on vermicomposting:

→ Zabaleta, I., Mertenat, A., Scholten, L., Zurbrügg, C. (2020): Selecting Organic Waste Treatment Technologies - SOWATT. Eawag. Switzerland

Free online SWM course with module on vermicomposting:

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.10 Vermicomposting of Biowaste. Switzerland

T.3 Anaerobic Digestion

Package of a guide and Excel-based tool to evaluate the feasibility of biogas production in humanitarian contexts.:

→ Zurbrügg, C., Tosi Robinson, D., Ubbiali, S. (2024): Is Biogas a Feasible Option? Assessing Anaerobic Digestion for Humanitarian Contexts. Eawag. UNHCR, Geneva Technical Hub. Switzerland

User manual for anaerobic digestion:

→ Vögeli, Y., Riu Lohrli, C., Gallardo, A., Diener, S., Zurbrügg, C. (2014): Anaerobic Digestion of Biowaste in Developing Countries. Practical Information and Case Studies. Eawag. Switzerland

Free online SWM course with modules on anaerobic digestion:

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.7 The Basics of Anaerobic Digestion of Biowaste. Switzerland

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.8 Anaerobic Digestion Technologies and Operation. Switzerland

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.9 Using the Products of Anaerobic Digestion. Switzerland

T.4 Black Soldier Fly (BSF) Waste Processing

Key guidance documents on BSF:

→ Dortmans B.M.A., Egger J., Diener S., Zurbrügg C. (2021): Black Soldier Fly Biowaste Processing - A Step-by-Step Guide - 2nd Edition. Eawag. Switzerland

→ Climate and Clean Air Coalition (CCAC) (2023): Scaling up Underfinanced SLCP Mitigation Solutions: Driving Innovation and Technology in the Waste Sector

→ Diener, S., Gold, M. (2022): Global Study on Black Soldier Fly Sector. Subnational Climate Fund (SCF)

→ Eawag (undated): Practical BSF Knowledge Hub. Switzerland

Free e-learning on BSF:

→ Eawag, Sandec (2018): Municipal SWM in Developing Countries Online Course. Module 3.11 Biowaste Processing with Black Soldier Fly Larvae. Switzerland

→ Eawag, Sandec (2021): Black Soldier Fly (BSF) e-Learning Series. Switzerland

T.5 Making Fuel from Biomass

Guideline on household fuel combustion:

→ WHO (2014): WHO Guidelines for Indoor Air Quality: Household Fuel Combustion. World Health Organization (WHO). Switzerland

Clean cooking in displacement settings:

→ UNHCR (2021): Compendium: Protection-Sensitive Access to Clean Cooking. UNHCR, the Refugee Agency. Switzerland

Pyrolysis of Biowaste in low- and middle-income Settings:

→ Zabaleta, I., Bulant N., Pfyffer, B., Rohr, M., Ivumbi, E., Mwamlima, P., Rajabu H.M., Zurbrügg, C. (2018): Pyrolysis of Biowaste in Low and Middle Income Settings. A Step-by-Step Manual. Eawag. Switzerland

Char fuel production in developing countries:

→ Lohri, C., Rajabu H.M., Sweeney D.H., Zurbrügg, C. (2016): Char Fuel Production in Developing Countries – A Review of Urban Biowaste Carbonization. Eawag. Switzerland

Instruction on production of carbonised briquettes:

→ Somorin, A., Gitau, J., Agbefu, D.J., Gebrezgabher, S. (2023): Biomass Briquetting: A Training Module for Trainers and Practitioner. International Water Management Institute (IWMI) and Consultative Group on International Agricultural Research (CGIAR). Sri Lanka

Charcoal briquetting in displacement settings in Uganda:

→ UNHCR (2022): Access to Clean Energy for Refugees, Uganda Case Studies. UNHCR, the Refugee Agency. Switzerland

Instructions on how to transform woody waste into fuel briquettes:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit. How to Transform Woody Waste into Fuel Briquettes. A Step-by-Step Guide. WasteAid UK. United Kingdom

T.6 Plastic Recycling

General overview of plastic recycling and downcycling:

→ Bill, A., Haarman, A., Böni, H., Gasser, M. (2019): Processing of WEEE Plastics. A Practical Handbook. EMPA and WRF. Switzerland

Overview of different recycling processes:

→ Mertenat A., Zurbrügg C. (2023): Planning for Zero-Waste at Schools – A Toolkit. Part 5 – Factsheets. Eawag. Switzerland

Open-source guidance on low-tech plastic recycling:

→ Precious Plastic Foundation (2024): Precious Plastic Academy. Stichting Precious Plastic Foundation. The Netherlands

T.7 Plastic Upcycling

General overview of plastic processing:

→ Bill, A., Haarman, A., Böni, H., Gasser, M. (2019): Processing of WEEE Plastics. A Practical Handbook. EMPA and WRF. Switzerland

Example of plastic waste upcycling in refugee camps in Cox's Bazar:

→ WFP (2021): It's a Wrap: Rohingya Refugees Upcycle Hopes and Dreams in Bangladesh. World Food Programme, Bangladesh

→ USAID (2023): Options for Humanitarian Packaging Reuse, Repurposing and Recycling. Joint Initiative on Sustainable Humanitarian Assistance Packaging Waste Management

T.8 Plastic Downcycling

General overview of plastic recycling and downcycling:

→ Bill, A., Haarman, A., Böni, H., Gasser, M. (2019): Processing of WEEE Plastics. A Practical Handbook. EMPA and WRF. Switzerland

Overview of different downcycling processes and products:

→ Mertenat A., Zurbrügg C. (2023): Planning for Zero-Waste at Schools – A Toolkit. Part 5 – Factsheets. Eawag. Switzerland

Instructions on the production of pavement tiles and eco-bricks from downcycled plastics:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit. How-to Guides 1–12: How to Turn Waste Materials into Useful Products. WasteAid. United Kingdom

U.1 Sale of Recyclable Materials

Guidance on how to prepare plastic for selling:

→ Lenkiewicz Z., Webster M. (2017): Making Waste Work: A Toolkit. How to Prepare Plastic Waste to Sell to Market a Step-by-Step Guide. Wasteaid. United Kingdom

Recycling value chain analysis in a displacement context in Bangladesh:

→ UNDP (2019): Recycling Value Chain Analysis (RVCA) in Teknaf and Ukhia, Bangladesh. United Nations Development Programme. Bangladesh

→ WREC (2023): A WREC Case Study. The Role of Scrap Dealers in Cox's Bazar to Support Humanitarian Response and Reduce Environmental Impact. Bangladesh

U.2 Reuse of Waste Materials

General overview of reuse of waste materials:

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

U.4 Construction with Waste Materials

A report on SWM in cities, including examples of reusing construction and demolition waste:

→ UN-Habitat (2010): Solid Waste Management in the World's Cities. Water and Sanitation in the World's Cities. Earthscan. United Kingdom

Information on different recycled materials and their use in construction:

→ Bolden, J., Abu-Lebdeh, T., Fini, E. (2013): Utilization of Recycled and Waste Materials in Various Construction Applications. North Carolina A and T University. USA

Step-by-step guide on how to turn plastic waste and bottles into Ecobricks:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit. How to Turn Mixed Plastic Waste and Bottles into Ecobricks. WasteAid. United Kingdom

A case study from Bangladesh on the use of plastic bricks for construction in Rohingya camps:

→ Haque, S., Islam, S. (2021): Effectiveness of Waste Plastic Bottles as Construction Material in Rohingya Displacement Camps. Elsevier. Bangladesh

U.5 Use in Agriculture

Guidance on composting including information on the use and marketing of compost products:

→ Van der Wurff, A.W.G., Fuchs, J.G., Raviv, M., Termorshuizen, A.J. (Editors) (2016): Handbook for Composting and Compost Use in Organic Horticulture. BioGreenhouse

→ Rouse, J., Rothenberger, S., Zurbrügg, C. (2008): Marketing Compost. A Guide for Compost Producers in Low and Middle-Income Countries. Eawag. Switzerland

U.6 Use of Biogas

Technical guidance on anaerobic digestion and use of biogas:

→ Deublein D., Steinhauser A. (2011): Biogas from Waste and Renewable Resources: An Introduction. Wiley-VCM. Germany

→ Kossmann, W., Poenitz, U., Habermehl, S., Hoerz, T., Kraemer, P., Klingler, B., Kellner, C., Wittur, T., Von Klopotek, F., Krieg, A., Euler, H. (1999): Biogas Digest Volume II. Biogas - Application and Product Development. GTZ. Germany

→ Vögeli Y., Lohri C. R., Gallardo A., Diener S., Zurbrügg C. (2014): Anaerobic Digestion of Biowaste in Developing Countries: Practical Information and Case Studies. Eawag. Switzerland

Assessment guide to check the suitability of anaerobic digestion:

→ Zurbrügg, C., Tosi Robinson, D., Ubbiali, S. (2024): Is Biogas a Feasible Option? Assessing Anaerobic Digestion in Humanitarian Contexts. Eawag

U.7 Use of Fuel from Biomass

Technical guidance on clean cooking and biomass stoves:

→ Yunusa, S.U., Mensah, E., Preko, K., Narra, S., Saleh, A., Sanfo, S., Isiaka, M., Dalha, I.B., Abdulsalam, M. (2023): Biomass Cookstoves: A Review of Technical Aspects and Recent Advances. Elsevier

→ Clean Cooking Alliance (2024): The Clean Cooking Catalogue

Guidance on clean cooking in refugee situations:

→ UNHCR (2021): Compendium: Protection-Sensitive Access to Clean Cooking. UNHCR, the Refugee Agency. Switzerland

→ Owen, M., Stone, D., Davey, C., Petersen, M. (2002): Cooking Options in Refugee Situations. A Handbook of Experiences in Energy Conservation and Alternative Fuels. UNHCR. Switzerland

Household cooking and indoor pollution:

→ WHO (2014): WHO Guidelines for Indoor Air Quality: Household Fuel Combustion. Word Health Organization (WHO). Switzerland

U.8 Controlled Waste Pit

Technical note on SWM in Emergencies:

→ Rouse, J., Reed, B. (2013): Solid Waste Management in Emergencies. Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies. WHO. Switzerland

Technical brief on SWM in the immediate period following an emergency:

→ Bjerregaard, M., Meekings, H. (2008): Domestic and Refugee Camp Waste Management Collection and Disposal. OXFAM. United Kingdom

U.9 Controlled Disposal Site / Landfill

Humanitarian-specific guideline document for safe disposal of solid waste in disposal sites:

→ Tosi Robinson, D., Ubbiali, S., Mertenat, A., Zurbrügg, C. (2024): Guidelines for the Safe Disposal of Solid Waste in Humanitarian Contexts. Eawag. Switzerland

Comprehensive guidelines for manually operated landfills: design, construction and operation:

→ Jaramillo, J. (2003): Guidelines for the Design, Construction and Operation of Manual Sanitary Landfills. A Solution for the Final Disposal of Municipal Solid Wastes in Communities. Pan American Center for Sanitary Engineering and Environmental Sciences. Peru

Short Technical Brief on SWM in emergency situations:

→ Bjerregaard, M., Meekings, H. (2008): Domestic and Refugee Camp Waste Management Collection and Disposal. OXFAM. United Kingdom

Short step-by-step guide to designing and operating a basic waste disposal site:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit - How to Design and Operate a Basic Waste Disposal Site. WasteAid. United Kingdom

U.10 Open Dumping

Guidance toolkit on community waste management solutions:

→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit. Community Waste Management in Low and Middle Income Countries. Wasteaid. United Kingdom

Health effects and environmental pollution of landfilling and open dumping:

→ Siddiqua, A., Hahladakis, J.N., Al-Attiya, W.A.K.A. (2022): An Overview of the Environmental Pollution and Health Effects Associated with Waste Landfilling and Open Dumping.

→ Williams, M., Gower, R., Green J, (2019): No Time to Waste - Tackling the Plastic Pollution Crisis Before It's Too Late. Tearfund. United Kingdom

U.11 Open Burning

Editorial article about SWM challenges in the 21st century:

→ Wilson, D. C., Velis, C.A. (2015): Waste Management – Still a Global Challenge in the 21st Century: An Evidence-Based Call for Action. ISWA.

Review article on Challenges and Environmental Risks of Improper Global SWM:

→ Cook, E., Velis, C.A. (2021): Global Review on Safer End of Engineered Life. Royal Academy of Engineering. United Kingdom

U.12 Controlled Burning

General information on contained burning:

→ Bjerregaard, M., Meekings, H. (2008): Domestic and Refugee Camp Waste Management Collection and Disposal. Oxfam. United Kingdom

→ Stauffer, B., Stuhler, D. (2020): Small Scale Incineration Factsheet. SSWM. Sustainable Sanitation and Water Management Toolbox's Chapter on Small Scale Incineration. Switzerland

→ JSI (2010): The Incinerator Guidebook. A Practical Guide for Selecting, Purchasing, Installing, Operating and Maintaining Small-Scale Incinerators in Low-Resource Settings. JSI

→ Picken, D.J. (2004): "De Montfort" Medical Waste Incinerator: Webpage Presenting De Monfort Incineration Technical Considerations and Designs.

PART 3: Cross-Cutting Issues

X.1 Institutional and Regulatory Environment

Overview of different SWM stakeholders and institutions:

→ UN-HABITAT (2010): Collection of Municipal Solid Waste in Developing Countries. United Nations Human Settlements Programme. Kenya

→ UNEP (2005): Solid Waste Management. United Nations Environment Programme. Kenya

SWM Regulation and Policy Concerns:

→ Pires, A., Martinho, G., Rodrigues, S., Gomes, M. (2019): Sustainable Solid Waste Collection and Management. Springer International Publishing. Switzerland

X.2 Inclusive Planning and Participation

A comprehensive collection of key HP components, tools and approaches incl. chapters on community engagement and participation:

→ Gensch, R., Ferron, S., Sandison, P., Bindel, A., Coerver, A., Cottafavi, L., Deniel, K., Ewers, L., Friedrich, M., Harter, M., Hoffmann, O., Machado, A., Shrinivasan, S., Vallis, S. (2022): Compendium of Hygiene Promotion in Emergencies. German Wash Network, IFRC, SuSanA, GWC

General guidance on community engagement and participation:

→ Oxfam (undated): Community Engagement in Humanitarian WASH Responses. United Kingdom

→ WHO (2021): Voice, Agency, Empowerment. Handbook on Social Participation for Universal Health Coverage. Switzerland

X.3 Monitoring, Evaluation, Accountability and Learning

Sphere minimum standards including SWM standards :

→ Sphere Association (2018): The Sphere Handbook: Humanitarian Charter and

Minimum Standards in Humanitarian Response, 4th Edition. Sphere Association. Switzerland

Hygiene Promotion Compendium including general information on MEAL in WASH:

→ Gensch, R., Ferron, S., Sandison, P., Bindel, A., Coerver, A., Cottafavi, L., Deniel, K., Ewers, L., Friedrich, M., Harter, M., Hoffmann, O., Machado, A., Shrinivasan, S., Vallis, S. (2022): Compendium of Hygiene Promotion in Emergencies. German Wash Network, IFRC, SuSanA, GWC

Monitoring checklist example:

→ IFRC (2019): Checklist: Minimum Standards for Inclusive, MHM-friendly SWM Facilities. Internation Federation of Red Cross and Red Crescent Societies. Switzerland

X.4 Occupational Health and Safety

Training module on occupational health and safety (general introduction and focus on hazardous healthcare waste):

→ UNDP, GEF, WHO, Health Care Without Harm, UIC (undated): Module 6: Occupational Health and Safety

X.5 Market-Based Programming

Information on WASH MBP in emergencies with an emphasis on market analysis:

→ Oxfam (undated): WASH Market Based Programming for WASH. United Kingdom

Review of MBP's effectiveness in WASH, with insights applicable to waste management:

→ Global WASH Cluster (2020): Evidence Building for Cash and Markets for WASH in Emergencies. Switzerland

Practical challenges and methods for final waste disposal in humanitarian settings:

→ Climate Action Accelerator (undated): Final Waste Disposal in Humanitarian Settings

UNHCR's strategic approach to managing diverse waste streams in humanitarian operations:

→ UNHCR (2023): UNHCR Waste Management – From Design, Procurement, Warehousing and Distribution to Post-Consumer Disposal. Switzerland

Practical guidance on designing and implementing MBP interventions in WASH, including waste management:

→ Global WASH Cluster (2021): Market-Based Programming in WASH - Technical Guidance for Humanitarian Practitioners. Switzerland

Case study of San Jose's zero-waste strategy, showcasing policies and programmes like Pay-As-You-Throw systems:

→ EPA (undated): Zero Waste Case Study: San Jose. USA

Case studies on waste-to-energy solutions in humanitarian contexts:

→ UNEP-CCC (undated): Piloting waste-to-energy solutions in humanitarian contexts. UNEP Copenhagen Climate Center. Denmark

Information on extended producer responsibility that holds producers accountable for end-of-life management of their products :

→ UNEP (undated): Extended Producer Responsibility. International Environmental Technology Centre

X.6 Hygiene Promotion and Behaviour Change

Compilation of the most relevant hygiene promotion components, tools, methods and approaches for humanitarian contexts:

→ Gensch, R., Ferron, S., Sandison, P., Bindel, A., Coerver, A., Cottafavi, L., Deniel, K., Ewers, L., Friedrich, M., Harter, M., Hoffmann, O., Machado, A., Shrinivasan, S., Vallis, S. (2022): Compendium of Hygiene Promotion in Emergencies. German Wash Network, IFRC, SuSanA, GWC

Compilation of case studies of SWM behaviour change interventions:

→ Ionkova, K.M.; Tomio, A.A.; Roy, E.D.; Yadav, S.; Kaza, S.; Karver, J.G.; Vakis, R. (2023): Behaviour Change in Solid Waste Management. A Compendium of Cases. World Bank Group. USA

Guideline with a focus on behaviour change for waste segregation:

→ NITI Aayog (2021): Promoting Behaviour Change for Strengthening Waste Segregation. Policy Guidelines. National Institution for Transforming India

Guidance for addressing SWM issues in schools:

→ Swiss Water & Sanitation Consortium (undated): Blue Schools. Switzerland

→ Climate and Clean Air Coalition (2016): A Handbook for Schools on Organic Waste Management

IFRC Guide on HP in Emergencies:

→ IFRC (2017): IFRC WASH Guidelines for Hygiene Promotion in Emergencies. International Federation of Red Cross and Red Crescent Societies. Switzerland

General Guidance on systematic behaviour change in WASH:

→ Mosler, H., Contzen, N. (2016): Systematic Behavior Change in Water, Sanitation and Hygiene. A Practical Guide Using the RANAS Approach Version 1.0. Switzerland

Environmental Education Tool on Plastic Prevention:

→ Waxin, L., Luud, E.M., Hausmann, J., Demmelbauer, V. (2025): Let's Stop the Plastic Flood: Join In! The WECF Plastic Tool – A Hands-On Tool for Environmental Education in Schools, Youth Work and More. Women Engage for a Common Future (WECF). Germany

X.7 Link to Humanitarian Clusters and Other Thematic Domains

General information on humanitarian coordination and the cluster approach:

→ IASC (2015): Cluster Coordination at Country level. Inter-Agency Standing Committee

→ Global Education Cluster, Translators without Borders, Save the Children (2020): Humanitarian Coordination and the Cluster Approach: A Quick Guide for Local and National Organizations

X.8 SWM and Climate Change

Climate commitments and climate action in the humanitarian sector:

→ Climate Charter (2025): The Climate and Environment Charter for Humanitarian Organizations.

→ Climate Action Accelerator (2024): Roadmap for Halving Emissions in the Humanitarian Sector by 2030 – A Path to Climate-Smart Humanitarian Action.

→ Global WASH Cluster Climate TWiG (2025): Humanitarian WASH and Climate Action Framework

→ Global WASH Cluster (2024): Climate Change and WASH Toolbox for Humanitarian Practitioners

Best practices for climate-responsive SWM:

→ EPA (2023): Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries. EPA. USA

→ Global WASH Cluster (2011): Disaster Risk Reduction and Water, Sanitation and Hygiene Comprehensive Guide. Switzerland

→ SWA (2024): Definition of Climate-Resilient Water Sanitation and Hygiene Services. Sanitation and Water for All

X.9 Protection, Accountability and Conflict Sensitivity

Age, gender and diversity in displacement settings:

→ WaterAid (2018): Accessibility and Safety Audits. United Kingdom

→ UNEP (undated): Gender and Waste Management. International Environmental Technology Centre

→ UNHCR (2018): UNHCR Policy on Age, Gender and Diversity. The UN Refugee Agency. Switzerland

→ CBM International, HelpAge International, Handicap International (2018): Humanitarian Inclusion Standards for Older People and People with Disabilities. ADCAP
→ Alliance for Child Protection in Humanitarian Action (2019): Minimum Standards for Child Protection in Humanitarian Action (CPMS)

Key resources on including protection, gender and accountability in WASH:

→ UNHCR (2017): WASH, Protection and Accountability Briefing Paper. The UN Refugee Agency. Switzerland
→ IFRC (2022): Protection, Gender and Inclusion in Water, Sanitation and Hygiene Promotion Guidance Note. Switzerland

Tools for safety and safeguarding:

→ Inter-Agency GBV Guidelines Reference Group (undated): Data Collection for GBV Risk Mitigation
→ Save the Children (2019): Safeguarding in Emergencies Toolkit

Conflict sensitivity and peacebuilding:

→ UNSDG (2022): Good Practice Note: Conflict Sensitivity, Peacebuilding and Sustainable Peace. United Nations. USA
→ UNICEF (2024): WASH for Peace – Conflict Sensitivity and Peacebuilding Guidance and Tools for the WASH Sector. USA
→ IFRC (2021): Better Programming Initiative – Do No Harm: How to Do Conflict-Sensitive Context Analysis. Switzerland

X.10 Advocacy

Guidelines and Toolkits including SWM messaging and advocacy for behaviour change to improve community waste management and resource recovery:

→ UN-Habitat (2019): Advocacy Toolkit and Guide "My Waste, Our Wealth". The United Nations Human Settlements Programme. Kenya
→ Lenkiewicz, Z., Webster, M. (2017): Making Waste Work: A Toolkit – Community Waste Management in Low and Middle Income Countries. WasteAid, United Kingdom
→ IFRC (2020): Managing Solid Waste: Sector-Specific Guidelines for the Red Cross Red Crescent. International Federation of Red Cross and Red Crescent Societies. Switzerland

Compendium of Hygiene Promotion in Emergencies with a specific chapter on WASH advocacy:

→ Gensch, R., Ferron, S., Sandison, P., Bindel, A., Coerver, A., Cottafavi, L., Deniel, K., Ewers, L., Friedrich, M., Harter, M., Hoffmann, O., Machado, A., Shrinivasan, S., Vallis, S. (2022): Compendium of Hygiene Promotion in Emergencies. Advocacy for WASH and Community Priorities. German Wash Network, IFRC, SuSanA, GWC

Case studies and best practices on SWM Advocacy from different countries:

→ Egan, A., Currea, A.M. (undated): Waste Not, Want Not. Women Leaders in Viet Nam Address Urban Waste Through Innovation & Advocacy. GEF Small Grants Programme. Vietnam
→ Stephen Wandefu, M. (2022): Advocacy for Waste Management: Realization by Churches in Kenya for Improved Environmental Sustainability. International Journal of Research and Innovation in Social Science. Kenya
→ EPA (2020): Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries. USA

PART 4: Management of Specific Waste Types

W.1 Medical and Health Care Waste Management

Overview of medical waste management in humanitarian settings:

→ ICRC (2011): Medical Waste Management. International Committee of the Red Cross. Switzerland

Overview of medical waste management:

→ Chartier, Y., Emmanuel, J., Pieper, Ute., Prüss, A., Rushbrook, P., Stringer, R., Townend, W., Wilbum, S., Zghondi, R. (2014): Safe Management of Wastes from Health-Care Activities. World Health Organization. Switzerland

Treatment technologies for infectious and sharp wastes:

→ WHO (2019): Overview of Technologies for the Treatment of Infectious and Sharp Waste from Health Care Facilities. World Health Organization. Switzerland

Minimum standards for emergency medical teams:

→ WHO (2021): Classification and Minimum Standards for Emergency Medical Teams. World Health Organization. Switzerland

Guidelines and best practices for the management of pharmaceutical waste:

→ WHO (2025): Safe Management of Pharmaceutical Waste from Health Care Facilities - Global Best Practices. World Health Organization. Switzerland

W.2 Hazardous Waste Management

Guidance on disaster waste management, including hazardous materials:

→ Joint UNEP/OCHA Environment Unit (2013): Disaster Waste Management Guidelines. Switzerland

Tool to identify acute environmental risks following disasters, including a list of potential hazardous materials for different processes and facilities, substances, and related hazards:

→ UN Environment/OCHA Joint Unit (2017): Flash Environmental Assessment Tool (FEAT). Switzerland

Practical guides on asbestos, its associated health risks and key recommendations for minimizing the risks of dealing with asbestos in post-disaster transitional settlement and reconstruction operations:

→ Shelter Center / ProAct (undated): A Brief Guide to Asbestos in Emergencies: Safer Handling and Breaking the Cycle. Switzerland
→ UNDP (2021): Asbestos Handling and Disposal Guidelines. International Best Practices. United Nations Development Programme. USA

W.3 Disaster Waste Management

Guidance note on debris management:

→ UNDP (2015): Guidance Note – Debris Management. United Nations Development Programme. USA

Disaster waste guidelines:

→ Joint UNEP/OCHA Environment Unit (2013): Disaster Waste Management Guidelines. Switzerland
→ Bjerregaard, M. (2010): Debris Management Guidelines. MSB/UNDP

General information on DWM:

→ UNEP (2024): Sustainable Debris Management. United Nations Environment Programme. Kenya

W.4 Menstrual and Incontinence Waste Management

Strategic Guidance on menstrual disposal and waste management in humanitarian settings:

→ USchmitt, M.L., Clatworthy, D., Gruer, C., Sommer, M. (2020): Menstrual Disposal, Waste Management & Laundering in Emergencies: A Compendium. Columbia University and International Rescue Committee. USA

Menstrual Hygiene Management (MHM) toolkit for humanitarian settings:

→ Columbia University, International Rescue Committee (2017): A Toolkit for Integrating Menstrual Hygiene Management (MHM) into Humanitarian Response. The Full Guide. USA
→ IFRC (2020): Menstrual Hygiene Management. Guidelines and Tools. Switzerland

Guidance on supporting people with incontinence:

- Rosato-Scott, C., Giles-Hansen, C., House, S., Wilbur, J., Macaulay, M., Barrington, D.J., Culmer, P., Bhakta, A.N., Burke, L. (2019): Guidance on Supporting People with Incontinence in Humanitarian and Low- and Middle-Income Contexts (LMICs)

Collection of case studies focusing on supporting people with incontinence:

- House, S., Chatterton, C. (2022): Mapping of Support for People Living with Incontinence in Humanitarian Contexts. Through the Lens of WASH, GBV and ASRH. Summary Report. Norwegian Church Aid. Norway

IFRC guidelines with specifications on supportive water and sanitation facilities for MHM and incontinence:

- IFRC (2019): Addressing Menstrual Hygiene Management (MHM) Needs. Guide and Tools for Red Cross and Crescent Societies. Switzerland

W.5 Relief Waste Management

Guidelines and handbook with a section on how to manage disaster waste in detail from the immediate response phase onwards:

- Joint UNEP/OCHA Environment Unit (2013): Disaster Waste Management Guidelines. Switzerland
- United Nations (2024): UNDAC Handbook. Switzerland

Minimum standards for waste management interventions for WASH, Shelter, Food Security, Nutrition, Health, and other sectors and recommendations for inter-cluster coordination in collaboration with local authorities and other stakeholders:

- Sphere Association (2018): The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response, 4th Edition. Sphere Association. Switzerland

Mapping of existing waste management and recycling infrastructure:

- Logistics Cluster (2025): Environmental Sustainability in Humanitarian Logistics. Enabling Humanitarian Logistics Partners to Reduce their Impact on the Environment. WREC Coalition

Red Cross Red Crescent Green Response Initiative with sector-specific guidelines for managing solid waste in emergency response operations:

- IFRC (2024): Managing Solid Waste: Sector-Specific Guidelines for the Red Cross Red Crescent. International Federation of Red Cross and Red Crescent Societies. Switzerland
- IFRC (2023): Green Logistics Guide. International Federation of Red Cross and Red Crescent Societies. Switzerland

Procurement decision tree to reduce the environmental impact of humanitarian packaging:

- Logistics Cluster (2024): Joint Initiative Procurement Decision Tree to Reduce the Environmental Impact of Humanitarian Packaging. Joint Initiative for Sustainable Humanitarian Assistance Packaging Waste Management

W.6 Management of Solid Waste from Sanitation Facilities and Drains

Publications on faecal sludge management including information on the management of solid waste from sanitation facilities:

- Strande, L., Ronteltap, M., Brdjanovic, D. (Editors) (2014): Faecal Sludge Management. Systems Approach for Implementation and Operation. IWA Publishing. United Kingdom
- Simwambi, A., Kapembwa, M. A., Kapanda, K. (2023): Effects of Poor Solid Waste Management on Faecal Sludge Emptying, Treatment and Disposal Services in Lusaka. European Journal of Applied Sciences. United Kingdom

Information on the management of solid waste found in drainage systems:

- WHO, UNEP (1991): Surface Water Drainage for Low-Income Communities.

W.7 Management of Waste from Electrical and Electronic Equipment (WEEE)

Lessons learnt across a range of e-waste management projects:

- IOM (2022): Toolkit for Creating a Circular Economy for e-Waste in Displacement Settings. International Organization for Migration. Switzerland

Study on e-waste management in displacement settings:

- Gibson, M., Demir, E. (2022): Electronic Waste (E-Waste) Management for Off-Grid Solar Solutions in Displacement Settings. Global Platform for Action (GPA)

Technical introduction to recycling off-grid solar products:

- GOGLA (2019): E-Waste Toolkit Module 1 Briefing Note. Global Association for the Off-Grid Solar Energy Industry. The Netherlands

E-waste management in Rhino Camp Refugee Settlement, Uganda:

- De Fautereau, B., Courtois, J., Clarke, A., Stillhart, R. (2022): Electronic Waste Management in Displacement Settings. Report from a Field Mission in Rhino Camp Refugee Settlement, Uganda. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Germany

Battery management in low-income countries:

- Manhart, A., Hilbert, I., Magalini, F. (2018): End-of-Life Management of Batteries in the Off-Grid Solar Sector. How to Deal with Hazardous Battery Waste from Solar Power Projects in Developing Countries? Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Germany

Management of e-waste from distributed solar lanterns in displacement settings:

- Schleicher, T., Manhart, A., Amera, T. (2022): E-Waste Management Action Plan for the Collection and Recycling of Solar Lanterns in UNHCR Displaced Persons Settlements. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Germany
- Spear, R., Cross, J. (2021): Towards a Circular Economy in UNHCR: A Focus on Core Relief Items (Solar Lamps). The University of Edinburgh. Scotland

Basel Convention:

- United Nations (1992): Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Switzerland

Bibliographic References

Ewers, L., Gensch, R., Hayman, S., Krähenbühl, M., Kucharski, M., Machado, A., Mertenat, A., Salem, F., Tosi Robinson, D., Ubbiali, S., Zurbrügg, C. (2025): Compendium of Solid Waste Management in Humanitarian Contexts. German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC), International Federation of the Red Cross and Red Crescent Societies (IFRC), Sustainable Sanitation Alliance (SuSanA). Berlin. Germany. ISBN: 978-3-906484-81-5

Chapter Lead Authors:
Pierre Burgos: U.12
Lorenz Ewers: Waste Prevention, U.3, U.4, X.5
Robert Gensch: Response Phases and SWM Implications, X.2, X.3, X.6, W.2, W.3, W.4, W.6
Manuel Krähenbühl: Roles and Responsibilities of SWM Actors, Principles and Standards Related to SWM, Waste Separation, S Intro, S.1, S.2, S.3, C Intro, C.1, C.3, C.4, C.5, T.5, T.6, T.7, T.8, U.2, X.1, X.7, W.1, W.7
Marta Kucharski: W.5
Adeline Mertenat: T.1, T.2, T.3, U.1
Dorian Tosi Robinson: SWM Assessment, C.2, U Intro, U.8, U.9, X.4
Farah Salem: X.9
Saloni Vijay: U.10, U.11
Rolando Saul Wallusche: X.10
Christian Zurbrügg: What is SWM?, Why SWM?, T Intro, T.4, U.5, U.6, U.7, X.8

Graphic Design and Layout:
Jan-Hendrik Schmidt, germantoilet.org (Layout)
Jana Evers, datamadevisual.de (Technical Drawings)
Text Editing:
Peta Sandison
First Edition:
2,000 Copies
Printed by:
Buch- und Offsetdruckerei H. Heenemann,
Berlin, Germany

This publication has been developed to support those working in humanitarian assistance where resources, including time, may be limited due to the urgency of their work. It is intended to support decision making and is a complement to, not a substitute for, sound professional judgement. The authors and publishers do not guarantee and accept no legal liability of whatever nature arising from or connected to the content of this publication.

The Compendium of Solid Waste Management in Humanitarian Contexts is also available as an interactive online version.

emergency-wash.org

German WASH Network
c/o German Toilet Organization
Paulsenstr. 23
12163 Berlin, Germany
info@washnet.de
www.washnet.de

The Compendium of Solid Waste Management in Humanitarian Contexts is the fourth in a series of WASH in Emergencies compendia. While the first three compendia focused on the widely known pillars of WASH – water supply, sanitation and hygiene promotion – this publication expands the series with a focus on another key area of WASH: Solid Waste Management (SWM).

Using a similar approach to its predecessors, this Compendium develops a sector-agreed categorisation and structure. It provides concise but comprehensive information on SWM technologies, planning aspects and cross-cutting issues while drawing on the latest initiatives, materials and evidence. It disaggregates SWM into its functional components, clarifies terminology and provides guidance for identifying the most appropriate solutions in all contexts.

The focus of this Compendium is the management of domestic and municipal solid waste in humanitarian contexts, including non-hazardous commercial and institutional waste. The management of other waste types typically found in humanitarian contexts – such as medical and health care waste, disaster waste or hazardous waste – is described more briefly in the final chapter.

The Compendium of Solid Waste Management in Humanitarian Contexts is primarily a capacity strengthening tool and a reference book. It also supports planning, implementation and decision making for designing context-specific SWM interventions. It is intended as a starting point for accessing relevant, up-to-date and summarised information about SWM, signposting users to additional guides and publications, where available.

emergency-wash.org

With support from:

german humanitarian assistance
DEUTSCHE HUMANITÄRE HILFE

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

ISBN: 978-3-906484-81-5