UNOPS

FROM RUBBLE TO RESOURCE

Guidance for people-centred circular rubble management and reconstruction

UN environment programme

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This report may be cited as follows: UNOPS, 2026. From rubble to resource: Guidance for people-centred circular rubble management and reconstruction. UNOPS, Copenhagen, Denmark.

For more information:
UNOPS website: www.unops.org

Acknowledgements

UNOPS would like to thank the following persons for their contributions:

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Vicky Leung, Francisco Santos-O'Connor, Elisa Selva and Tomoki Watanabe (International Labour Organization)

Expert reviewers and consultees

Rory Collins, Simon Conway, Amir Omeragic, Simon Darke, Paolo Zorzoli, Gordon Nuttall, Jean-Vincent Colin, Sylvia Aguilar Camacho, Marcus McKay, Rasmus Hansen, Kamma Blair, Malva Govori, Steven Crosskey, Daniela da Silva, Marija Bateman, Noriko Kominami, Nives Costa, Michela Martini, Stefan Kohler, Muna Al Banna, Chloe Decazes, Fitsumberhan Weldelibanos, Joseph Stables, Suranga Mallawa Arachchige, Marcello Fodde, and Beatriz Marins Corrêa de Sá (UNOPS)

Hae-Kyeung Chun, Christoph Ernst, Elisenda Estruch Puertas and Stefan Tromel (International Labour Organization)

Orkhan Aliyev and Jennifer Cinelli-Oomen (Habitat for Humanity)

Faisal Ridwan and Htet Mon Mon Aung (UN Development Programme)

Anita van Breda (World Wildlife Fund)

Mae Emerick (Emerick OPOV)

Giulio Ferrini (Institute for Human Rights and Business)

Publication support

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Foreword

Jorge Moreira da Silva
United Nations Under-Secretary-General
and UNOPS Executive Director

Across the world, conflicts and disasters are leaving behind destruction on an unprecedented scale. Beyond the tragic human toll, these crises generate millions of tonnes of rubble - shattered concrete, steel, brick. It delays reconstruction and recovery, overwhelms local systems, pollutes ecosystems and stands as a painful, constant reminder of loss.

Too often - this rubble is treated as mere waste. Yet within this challenge lies an opportunity. The materials left behind after disasters and conflicts can become part of the solution: supporting reconstruction, reducing environmental harm and creating economic opportunities for affected communities.

This publication calls for a people-centred circular approach to rubble management and reconstruction. It highlights practical solutions that can help governments, local authorities, financiers and others to use rubble as a key resource to support the sustainable recovery of disaster and conflict-affected communities.

The scale of this challenge cannot be overstated. Recent conflicts in Gaza and Lebanon and the Syria-

Türkiye earthquake - for example - have left hundreds of millions of tonnes of rubble behind. Such vast quantities can overwhelm solid waste management systems. At the same time, reconstruction efforts place increased strain on limited natural resources, while driving greenhouse gas emissions, environmental degradation and air pollution.

In many post-crisis contexts, massive demand combined with disrupted supply chains also drive up the price of common construction materials, which in turn stalls reconstruction efforts.

Circular rubble management offers a different path.

Using recycled rubble directly substitutes the need for expensive, hard-to-source raw materials. This approach offers substantial cost savings and helps build the foundation for a sustainable construction and demolition waste sector. Crucially, it can create immediate local jobs and speed up recovery.

At UNOPS, we have seen the value of this approach firsthand. Across humanitarian, peacebuilding and development contexts, we work with governments, communities and partners to rebuild infrastructure and restore essential services. We focus on implementation and on practical solutions. Based on this global experience, we recognize that significant operational challenges remain when trying to translate circular rubble management aspirations into reality on the ground.

This publication is centred on practical solutions to address those operational challenges and bridge implementation gaps. It offers actionable approaches to create demand for circular materials, mobilize local actors and navigate complex operating environments.

Communities who have survived the trauma of conflict and disasters deserve every opportunity to not only rebuild but build back better. By transforming rubble from waste into a resource, we can help communities recover faster while laying the foundations for a better and more sustainable future.

How to use this guidance

For a quick overview

1. Read the key terms for definitions of important concepts.
2. Read the executive summary for a short overview of the paper.

For a detailed review

1. Read the key terms for definitions of important concepts.
2. Read the introduction to understand the importance of people-centred circular rubble management and reconstruction, compared to a linear model.
3. Read about the barriers and operational challenges that limit the effectiveness of circular rubble management.
4. Explore the approaches to addressing implementation barriers based on your specific context and objectives.
5. Read the recommendations to prepare for the management of rubble in case of future disasters and conflicts.

For practical application

1. Use the roadmap to quickly find an approach to use in a rubble management or reconstruction project.
2. Go to the corresponding section of the report to find information such as:
   a. **When to use this approach:** which objectives, barriers, users and outcomes the approach can be relevant for.
   b. **Actions:** potential measures a reader can take to implement this approach.
   c. **Examples:** real-life examples of how a particular action has been implemented.
   d. **Resources:** links to guidance, tools and detailed information in the annex.

A roadmap to using people-centred circular approaches in rubble management and reconstruction

For funders and financiers

I am involved in	Suggested approaches
Assessment and planning stage	1.1 Review and share examples of successful circular rubble management initiatives (p. 38) 1.2 Calculate the costs and benefits of circular rubble management (p. 43)
Rubble management stage	1.3 Finance, incentivize and require circular rubble reuse (p. 47) 3.2 Support the development of a sustainable construction and demolition waste sector (p.108) 3.4 Enable safe and meaningful community participation in rubble management and reconstruction (p. 114)
Reconstruction stage	
Preparedness stage	

For government actors and local authorities

I am involved in	Suggested approaches
All stages	1.4 Create standards and certification mechanisms for circular construction materials (p. 50) 1.5 Create laws and regulations for sustainable rubble and C&DW management (p. 53) 2.4 Address housing, land and property issues related to rubble management and reconstruction (p. 85) 3.2 Support the development of a sustainable C&DW sector (p. 108) 3.4 Enable safe and meaningful community participation in rubble management and reconstruction (p. 114)
Assessment and planning stage	1.1 Review and share examples of successful circular rubble management initiatives (p. 38) 1.2 Calculate the costs and benefits of circular rubble management (p. 43) 2.1 Develop a people-centred circular rubble management strategy (p. 61) 2.2 Assess resource requirements for rubble management (p. 74) 2.3 Use damage and hazard assessments to prioritize works (p. 80) 3.1 Establish an information management system for coordinated rubble management (p. 106)
Rubble management stage	1.3 Finance, incentivize and require circular rubble reuse (p. 47) 1.6 Assess and demonstrate the quality of circular materials (p. 56) 3.1 Establish an information management system for coordinated rubble management (p. 106)
Reconstruction stage	2.8 Refuse, rethink and reduce reconstruction to minimize material consumption and rubble generation (p. 101)
Preparedness stage	2.1 Prepare for rubble management as part of disaster preparedness (p. 61)

For practitioners in rubble, debris or solid waste management

I am involved in	Suggested approaches
All stages	3.2 Support the development of a sustainable C&DW sector (p. 108) 3.3 Enforce occupational safety and health standards (p. 111) 3.5 Identify and strengthen skills and capacities to maximize job creation in circular rubble management (p. 118)
Assessment and planning stage	1.1 Review and share examples of successful circular rubble management initiatives (p. 38) 1.2 Plan for the costs of circular rubble management (p. 43) 2.1 Develop a people-centred circular rubble management strategy (p. 61) 2.2 Assess resource requirements for rubble management (p. 74) 2.3 Use damage and hazard assessments to prioritize works (p. 80) 2.4 Address housing, land and property issues related to rubble management (p. 85) 3.1 Establish an information management system for coordinated rubble management (p. 106)
Rubble management stage	2.4 Address housing, land and property issues related to rubble management (p. 85) 2.5 Manage hazards before removing rubble (p. 90) 2.6 Maximize circularity while removing rubble (p. 94) 2.7 Apply sustainable, safe and efficient methods of recycling rubble (p. 98) 3.1 Establish an information management system for coordinated rubble management (p. 106) 3.4 Enable safe and meaningful community participation in rubble management (p. 114)
Reconstruction stage	1.6 Assess and demonstrate the quality of circular materials (p. 56) 3.1 Establish an information management system for coordinated rubble management (p. 106)
Preparedness stage	2.1 Prepare for rubble management as part of disaster preparedness (p. 61)

For practitioners in design and construction

I am involved in	Suggested approaches
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Preparedness stage	

Key terms

Is the guidance about rubble or debris?

1. Concrete and masonry rubble

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- ✓ This guidance focuses on rubble, which is waste from damaged, destroyed and deconstructed buildings and infrastructure.
- ✓ Specifically, it concerns **concrete and masonry rubble**, including clay bricks, adobe, earth blocks and stone masonry. These make up the majority of rubble and debris.

2. Other debris

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- ✗ This guidance does not focus on general debris that includes rubble and other waste, such as clay, mud, trees, branches and bushes. [1]
- ✗ It does not cover metal, wood, glass, or building components, such as windows, doors, and mechanical equipment.

Rubble is found in two forms:

3. Available rubble

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Rubble that can be easily and safely accessed for removal, such as loose rubble on roads and in public spaces.

4. Unreleased rubble

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Rubble generated from the demolition or deconstruction of damaged structures and loose rubble inside them.

Circular rubble materials in this paper refers to construction materials derived from reusing, repurposing or recycling rubble.

Which scenarios does this guidance cover?

This guidance covers **disasters or conflicts that generate large amounts of concrete and masonry rubble,** impeding the recovery of affected communities. This includes **earthquakes, tsunamis, and armed conflicts** in which weapons damage infrastructure and buildings.

Hurricanes, typhoons, cyclones, wildfires and floods may generate large volumes of other types of debris[2] that are not covered by this guidance.

The guidance also uses the following terms:

- **Disaster:** A serious disruption of the functioning of a community or society due to hazardous events (such as earthquakes or tsunamis) interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.[3]
- **Conflict:** Armed conflict in which the use of armed force is directed not only against the enemy's armed forces but also "against the enemy's territory, its civilian population and/or civilian objects, including (but not limited to) infrastructure".[4]

For simplicity, the guidance uses the terms **'post-disaster**' and **'post-conflict'** to describe the period and operational environment **following a hazardous event** or **the cessation of hostilities and violence.**

Note: This guidance provides some relevant information for rubble management during active or protracted conflict, but it does not fully cover considerations to manage ongoing safety risks and instability.

What is the difference between deconstruction and demolition?

Deconstruction involves the selective dismantlement of building components (avoiding damage) in order to reuse, repurpose or recycle them in the future.

Demolition is often a more destructive process that focuses on quickly clearing a site, turning construction materials into waste.[5]

What is people-centred circular rubble management and reconstruction?

People-centred circular rubble management and reconstruction uses rubble as a key material for reconstruction in order to accelerate the recovery of disaster- and conflict-affected communities. It is composed of four aspects: rubble management, reconstruction, circularity and a people-centred approach.

1. **Rubble management** is a waste management process that starts from the generation of rubble until its reuse or disposal. This can include steps such as planning, assessment, demolition or deconstruction, removal, transport, sorting, cleaning, recycling, and disposal.
2. **Reconstruction** is the act of rebuilding or repairing damaged or destroyed infrastructure and buildings to restore shelter and essential services for affected communities.
3. **Circularity** in the built environment aims to maximize the lifespan of construction materials and components of buildings and infrastructure. In post-disaster and post-conflict contexts, this includes repairing damaged structures, finding ways to reuse rubble for reconstruction, and building forward better to give reconstructed structures a longer service life.
4. **A people-centred approach** empowers affected communities to quickly recover from disasters and conflicts by reaping the benefits of a more sustainable and resilient built environment. It creates decent jobs, provides skills development opportunities and supports the growth of enterprises within rubble and construction and demolition waste (C&DW) management, especially for informal workers. It prioritizes people's safety in all activities. It protects housing, land and property rights and respects the principles of Leave No One Behind and Do No Harm, recognizing that vulnerable and marginalized groups are often disproportionately impacted by disasters and conflicts.

This approach is a more sustainable alternative to **linear rubble management and reconstruction**, which treats rubble as a waste product that loses its value as a material at the end of a structure's lifespan. Large amounts of raw materials are then extracted for reconstruction, leading to resource depletion, pollution, greenhouse gas emissions and loss of biodiversity.

Executive Summary

Disasters and conflicts generate millions of metric tonnes of debris and rubble from the destruction of the built environment. Traditionally, rubble is landfilled to enable emergency response, recovery and reconstruction. Such large volumes of rubble – often adding up to more than 5 to 15 times the community's annual waste production[6] – strain landfills, create pollution, pose long-term health risks for affected communities, and serve as a reminder of devastation and loss.

Discarding rubble also means consuming more raw materials to replace damaged and destroyed structures, exacerbating the unsustainable 'take-make-waste' model of construction. The extraction and production of construction materials are responsible for more than 15 per cent of global greenhouse gas emissions,[7, 8] endangering over 1,000 species on the International Union for Conservation of Nature's Red List of Threatened Species[9] and creating air pollution linked to more than 36 million disability-adjusted life years lost every year.[10] Combined with post-disaster or post-conflict economic challenges, massive demand and limited supply can inflate the price of construction materials by 30 to 120 per cent,[11] delaying reconstruction and prolonging socioeconomic recovery for local communities.

People-centred circular rubble management and reconstruction uses rubble as a key resource to support the sustainable recovery of disaster- and conflict-affected communities.

This has the following benefits:

- **Environmental stewardship:** Returning rubble to the built environment reduces the need for finite raw material extraction, mitigates related emissions and prevents ecosystem degradation in extraction sites.
- **Socioeconomic recovery:** It supports affected communities to recover from disasters and conflicts by creating decent jobs, skills development opportunities and enterprises, preventing exposure to hazardous materials (such as asbestos and explosive remnants of war), providing locally available materials in resource-constrained contexts, and mitigating the long-term health impacts of landfilling and uncontrolled dumping of rubble.
- **Economic efficiency:** This guidance estimates that while the upfront operational costs of recycling rubble can be around 25 per cent higher than disposal, the value of the resulting materials makes the total cost of circular rubble management and reconstruction 29 to 49 per cent cheaper than a linear 'dispose and buy new' approach.

Despite these benefits, three major barriers limit the operationalization of circular rubble management in post-disaster and post-conflict settings:

1. **Limited capacities and systems for circularity,** including a lack of laws, policies, regulatory frameworks, standards, testing capacity, technical skills and knowledge, technology and equipment, and the awareness or capacity needed to mitigate environmental damage and social risks related to rubble management, as well as decent work deficits.
2. **Low demand for reused or recycled rubble** due to lack of awareness, social stigma, trauma, cultural resistance, unknown quality of reused or recycled materials, and availability and cost of materials.
3. **Complex operating environments** driven by disruptions, instability, informality, competing priorities, health and safety risks, hazardous substances and contaminants in rubble, lack of coordination and community engagement, housing, land, and property (HLP) issues, insufficient space, and limited capacity for rubble assessments.

This guidance offers a variety of practical approaches for implementers, governments, authorities, funders and financiers to overcome these barriers and increase rubble recycling, repurposing and reuse. The approaches are categorized under three main objectives:

1. **Create demand for circular materials:** Recycled materials need to be accepted as viable alternatives to raw materials for reconstruction in order for circular initiatives to be effective. This objective includes approaches to create an enabling environment for a circular construction materials sector as well as to change end-user perceptions about the value of circular materials.
2. **Optimize implementation in complex environments:** Rubble management in post-conflict and post-disaster settings will always be challenging. Building on lessons learned from real projects, this objective includes approaches that help plan and implement rubble management within constraints while achieving positive social and environmental outcomes.
3. **Mobilize local actors to allow them to benefit from circular initiatives:** Waste management actors, designers, construction firms, civil society organizations, academia, workers and communities make sustainable rubble management and reconstruction possible. This objective includes approaches to implement coordinated rubble management works that create decent, safe and equitable opportunities for work and skills development, and ensure equitable and safe access to reconstruction materials for all people.

Based on these approaches, this guidance offers the following recommendations for stakeholders to prepare for future disasters and conflicts:

- **Enable the market:** To facilitate circular rubble management despite operational challenges, governments should incentivize the development and use of circular materials and build the capacity of the C&DW management sector. This will allow them to sustainably manage rubble while enforcing decent work principles and environmental protections.
- **Bridge the financial gap:** To secure the long-term benefits of circular rubble management, financiers, funders, donors and governments should subsidize the high upfront costs.
- **Advocate for circularity:** To shift perceptions and influence policy, circular economy actors, civil society organizations and academics should advocate for and support countries in the transition to circular systems.
- **Plan early:** To improve implementation efficiency and enable circular reconstruction at later stages, implementers and decision makers should plan for circular rubble management during disaster preparedness and at the beginning of a crisis response.
- **Build better:** To mitigate the creation of rubble and ensure service continuity, built environment practitioners should design, build and maintain structures to be sustainable and resilient over the long term.
- **Ensure equity:** To support an equitable reconstruction process, governments and construction sector actors should help people access safe, affordable and sustainable reconstruction materials after conflicts or disasters. While rubble may be commonly used for informal reconstruction, guidance and technical standards can help ensure it is used safely and effectively.
- **Improve working conditions for waste workers:** To encourage equitable growth, governments should make sure waste management workers, especially informal workers, have decent working conditions and skills development opportunities, and support the formalization of informal C&DW enterprises.

Introduction

The challenge of linear construction and rubble management

Intensifying conflicts and disasters are generating millions of metric tonnes of debris and rubble. As of April 2026, conflict has destroyed or damaged over 80 per cent of structures in Gaza,[12] creating an estimated 68 million metric tonnes of debris.[13] In 2024, conflict in Lebanon generated 14.5 million metric tonnes,[14] while the 2023 Türkiye-Syria earthquake generated around 210 million metric tonnes of debris in Türkiye.[15] The debris produced from just these three crises is equivalent to the total municipal solid waste generated in Central and South Asia in a whole year.[16]

Large amounts of rubble impede recovery and prolong devastating impacts. Removal may take several months or even years, delaying reconstruction and keeping communities vulnerable to new shocks and stresses. Rubble may also be mixed with hazardous materials such as asbestos, explosive ordnance or toxic waste, which represent major occupational and public health risks and require specialized management.

Rubble is often seen as a waste product at the end of a structure's lifespan in a 'take-make-waste' model of construction. Rubble starts off in the form of raw materials extracted and transformed into construction materials for buildings and infrastructure. When these structures are damaged and destroyed, these materials are considered 'rubble'. In a linear approach to construction and rubble management, rubble is removed and disposed of, losing its value as a material. The process is then repeated with new materials during reconstruction.

Disposing of rubble as waste may seem like the fastest and simplest solution, but it can create long-term negative impacts. In most regions, between 70 to 90 per cent of municipal solid waste is landfilled, dumped or burned in an uncontrolled manner.[17] A disaster or conflict can overwhelm

> Rubble is often seen as a waste product at the end of a structure's lifespan in a 'take-make-waste' model of construction.

waste management systems with rubble equal to 5 to 15 times the community's annual solid waste production.[18] Uncontrolled dumping and landfilling of such a massive amount of rubble, especially when the disaster or conflict disrupts environmental regulatory procedures, can lead to long-term issues such as soil and water contamination, air pollution, habitat destruction, and health risks for waste management workers and nearby communities. As urbanization and construction increase over the next decades,[19] future conflicts and disasters will generate even larger amounts of debris and rubble, making landfilling unsustainable over the long term.

Extracting massive amounts of new materials for reconstruction worsens the negative effects of the already unsustainable construction sector. The built environment accounts for approximately 31 per cent of global material consumption.[20] Each year, it consumes approximately 4.2 billion tonnes of concrete,[21] 2.2 billion tonnes of fired clay bricks[22] and 1.7 billion tonnes of steel.[23] The production of these materials accounts for roughly 15 per cent of global greenhouse gas emissions,[24,25] not including emissions from transport and construction activities. The overextraction of construction minerals destroys ecosystems and impacts at least 1,047 species on the International Union for Conservation of Nature's Red List of Threatened Species.[26] Industrial processes including metal processing and cement-making cause outdoor air pollution due to fine particulate matter, accounting for more than 36 million disability-adjusted life years lost every year.[27] In addition, the buildings and construction sector is estimated to be responsible for 15 per cent of freshwater use,[28] contributing to a global state of water bankruptcy.[29] Reconstructing entire villages, towns and cities with new materials can only multiply these negative effects, especially if environmental safeguards and regulations are relaxed or unenforced in the aftermath of a conflict or disaster.

Rubble and destroyed buildings in the central Gaza Strip. © Anas-Mohammed / Shutterstock.com, 2024

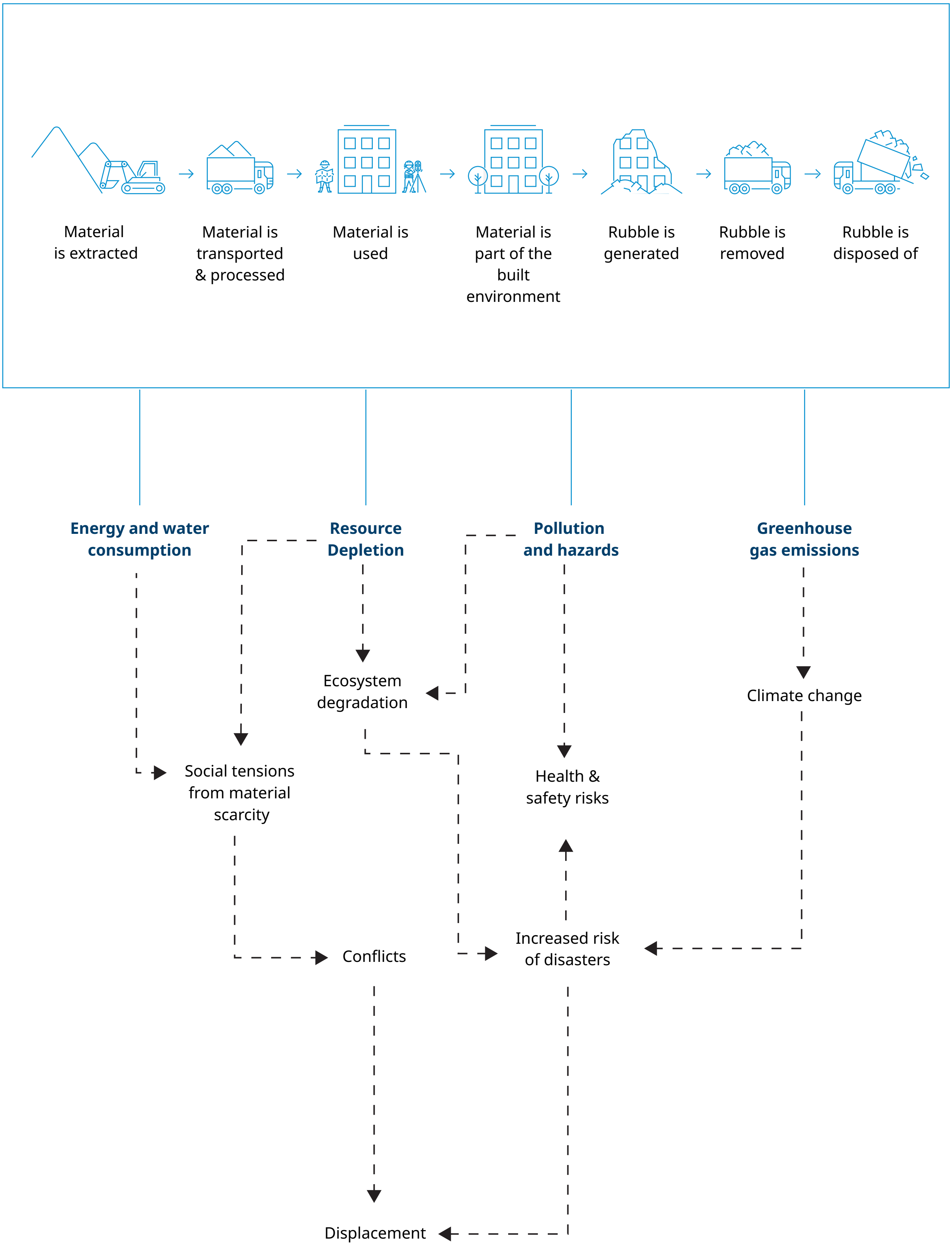
Informality and decent work deficits in the waste management and construction sectors can be heightened after disasters and conflicts, undermining equity in recovery efforts. The waste management and construction sectors in many conflict- and disaster-affected contexts are characterized by high levels of informality, resulting in serious decent work deficits such as unsafe working conditions, low and irregular incomes, lack of social protection, and limited access to skills development opportunities. Women and persons with disabilities remain underrepresented due to barriers such as discriminatory norms, unequal access to opportunities, care responsibilities, and inaccessible work sites – and these inequalities are often exacerbated after conflicts and disasters.[30] These factors can impede recovery for communities, especially for the most marginalized and vulnerable groups.

Unaffordable construction materials can prolong displacement and the socioeconomic recovery of disaster- or conflict-affected communities, worsening the vulnerability of marginalized groups. Disaster or conflict may have damaged production facilities and blocked transport routes, limiting the supply of new materials. At the same time, the massive demand for construction materials can sharply increase their price. This can be worsened by a weakened local currency, high inflation and trade sanctions. These factors can increase the price of common construction materials by 30 to 120 per cent,[31] making them inaccessible to local communities, especially marginalized and vulnerable members of the population. This may in turn lead to people falling into debt to afford materials,[32] rebuilding with makeshift and substandard materials, or remaining displaced for an extended period of time. These inflated prices can also inadvertently incentivize over-extraction of resources, which can contribute to loss of livelihoods and violent social conflicts as observed in Sri Lanka after the 2004 Indian Ocean Tsunami, Nepal after the 2015 earthquake and Mozambique after the 2017 Cyclone Idai.[33] Overall, this can prolong socioeconomic recovery and increase the vulnerability of marginalized communities.

> Disposing of rubble as waste may seem like the fastest and simplest solution, but it can create long-term negative impacts.

Given the negative impacts of a linear model of construction and rubble management, which threaten inclusive community recovery and long-term sustainable development, a more sustainable way to manage rubble and obtain materials for reconstruction is necessary to build better cities and towns.

Figure 1. From construction material to waste: the negative impacts of the linear path of rubble



The opportunity for people-centred circular rubble management and reconstruction

People-centred circular rubble management enables inclusive and sustainable recovery and reconstruction after disasters and conflicts. Circular rubble management turns rubble into locally available, affordable construction materials while reducing waste and natural resource extraction. A people-centred approach maximizes the socioeconomic benefits of the rubble management process for affected communities, including decent job creation, skills development, protection of housing, land, and property (HLP) rights, psychological recovery and well-being, and a healthier and safer place to live.

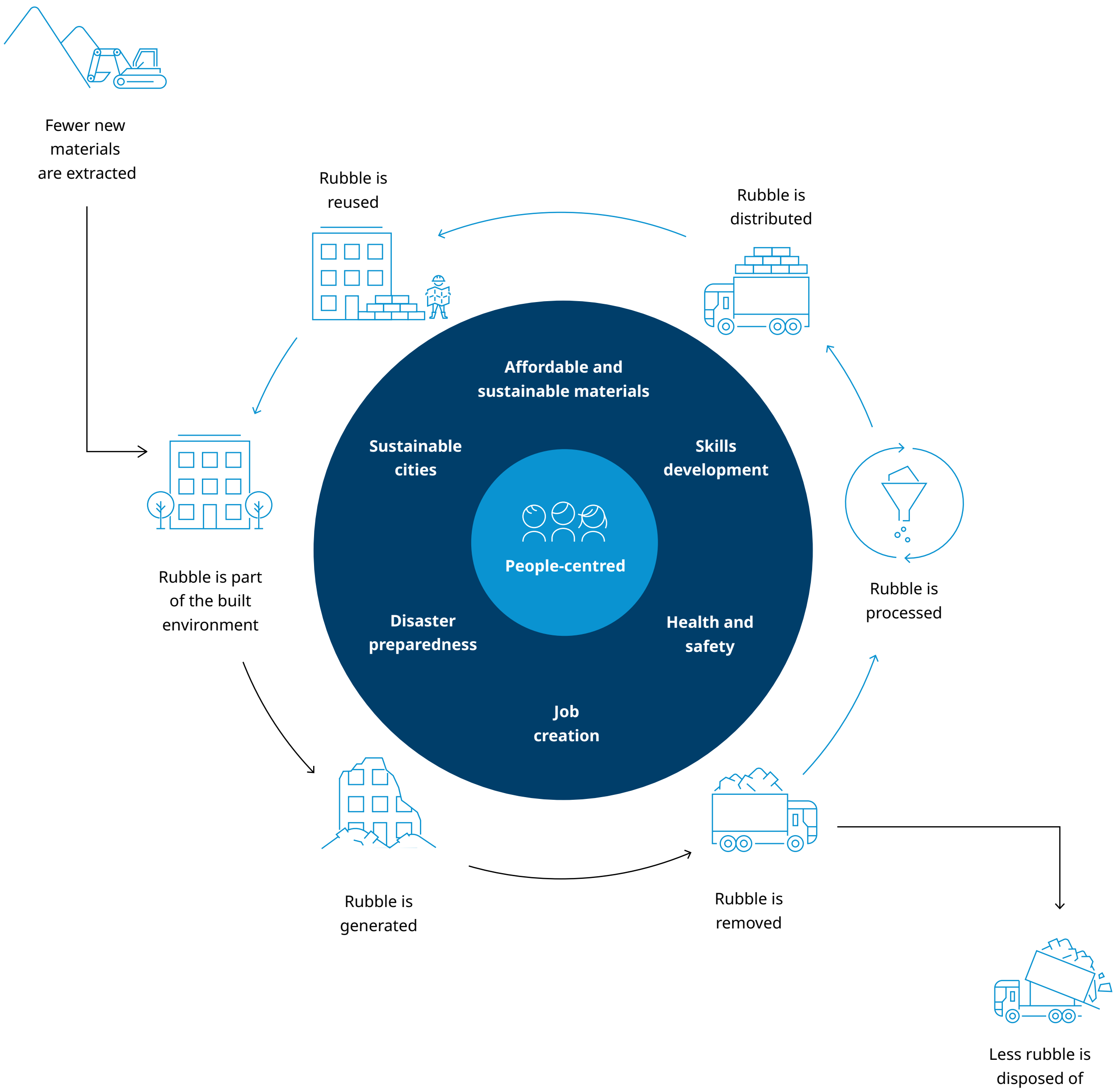
Recycling rubble can be more cost effective than disposal and help countries save millions of dollars in acquiring new materials for reconstruction works. While recycling can have a higher initial cost than disposal, it leads to savings in both the revenue from selling the produced materials, as well as the avoided costs of purchasing an equivalent amount of new materials. Based on analyses across multiple countries comparing disposal and partial recycling of rubble (see Annex B for calculation), **recycling can be up to 49 per cent cheaper than disposal in the long term.** While recycling can be around 25 per cent more expensive than disposal in terms of operation costs, the revenue from selling the recycled materials can recover a significant amount of these expenses. Moreover, using the recycled materials for reconstruction can be between 29 to 49 per cent cheaper than the amount it would cost to dispose of the rubble and buy new construction materials. Recycling locally can also increase transparency in the supply chain of materials, helping to protect workers' rights and minimize delays and costs from supply chain disruptions.

49%

Potential costs savings from recycling rubble

People-centred circular rubble management also supports sustainable development. Rubble management capacities and systems established during a humanitarian response can form the basis for a sustainable construction and demolition waste (C&DW) management sector. This can reduce uncontrolled dumping of rubble, especially near marginalized communities or natural areas. Sorting, cleaning, crushing and processing rubble creates more jobs than landfilling, and a mature C&DW sector can enforce a safer work environment for formal and informal waste workers. A sustainable C&DW management sector also supports the development of circular material enterprises, enhancing economic growth while protecting the environment. Aside from mitigating emissions, ecosystem destruction and air pollution from the extraction and production of construction materials, the widespread adoption of circular materials and practices could generate net economic value gains of $234 billion to $360 billion by 2050,[34] as C&DW can make up to a third of municipal waste, and the global C&DW management market size is expected to grow to $300 billion by 2030.[35] Meanwhile, the recycled concrete aggregates market was valued at $10.6 billion in 2025 and is projected to reach $22.9 billion by 2035.[36]

Figure 2. Changing the story of rubble to achieve more sustainable outcomes



How this guidance aims to help change the story of rubble to drive sustainable reconstruction

Circular rubble management and reconstruction is not a new concept, but it is difficult to operationalize in post-disaster and post-conflict settings. Many disaster waste management and reconstruction frameworks recommend circular rubble management approaches,[37] but field practitioners interviewed for this paper share that operational challenges and realities limit actual implementation. These operational challenges are also underpinned by policy and governance gaps in sustainably managing construction materials and waste. There is a need to improve the enabling environment around the implementation of circular rubble management to support recovery and sustainable development.

This guidance reimagines the role of rubble from an obstacle and hazard to a resource for inclusive and sustainable recovery. It builds on the premise that extending the life and value of rubble materials

Local workers in Haiti learned best practices in construction methods through the first official vocational training programme in the country, provided through a partnership with the International Labour Organization (ILO).
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(through reuse, repurposing and recycling) can magnify the social, economic and environmental benefits of the original material. This includes creating economic opportunities, ensuring equitable access to reconstruction materials, protecting HLP rights and promoting inclusive opportunities for local communities, especially women and marginalized groups. A circular approach also helps establish capacities and systems for a sustainable built environment and C&DW management sector, bridging crisis response with long-term development and building forward better.

This guidance identifies practical solutions to address the implementation barriers limiting the amount of rubble that is recycled, repurposed, and reused in rubble management and reconstruction projects. It investigates ways to balance feasibility and impact, in order to speed up and scale up the implementation of recovery and reconstruction projects in post-conflict and post-disaster contexts for the benefit of local communities, while also setting the stage for long-term sustainable development. It also supports the Global Call to Action for Sustainable Building Materials Management in Post-Disaster Situations by complementing policy recommendations with proven practical solutions for the sustainable management of building materials after disasters.

Who is this guidance for?

This guidance aims to support **practitioners, governments, authorities, funders and financiers involved in rubble management and reconstruction works** to improve the design and implementation of people-centred, circular approaches in their rubble management projects.

Barriers to implementing circular rubble management

Insights from key actors with experience in rubble management, reconstruction and humanitarian response point to significant barriers to implementing circular rubble management and reconstruction in post-conflict and post-disaster settings.

The three primary barriers identified are:

- Limited capacities and systems for circularity;
- Low demand for reused or recycled rubble; and
- Complex operating environments.

Consequently, initiatives to reuse rubble for reconstruction may face rejection and are often seen as more difficult, risky and expensive than using raw materials. Even when circular initiatives are implemented, the lack of an established C&DW sector limits their sustainability and scalability.

Understanding these barriers helps determine which aspects can be influenced by changes in project implementation, and which may require broader interventions.

Limited capacities and systems for circularity

Insufficient capacities and systems for solid waste management and construction can prevent effective rubble management after a disaster or conflict. The following contributing factors may make it difficult to start up, sustain, and scale up rubble recycling initiatives and limit the affordability and credibility of circular rubble materials as alternative building materials.

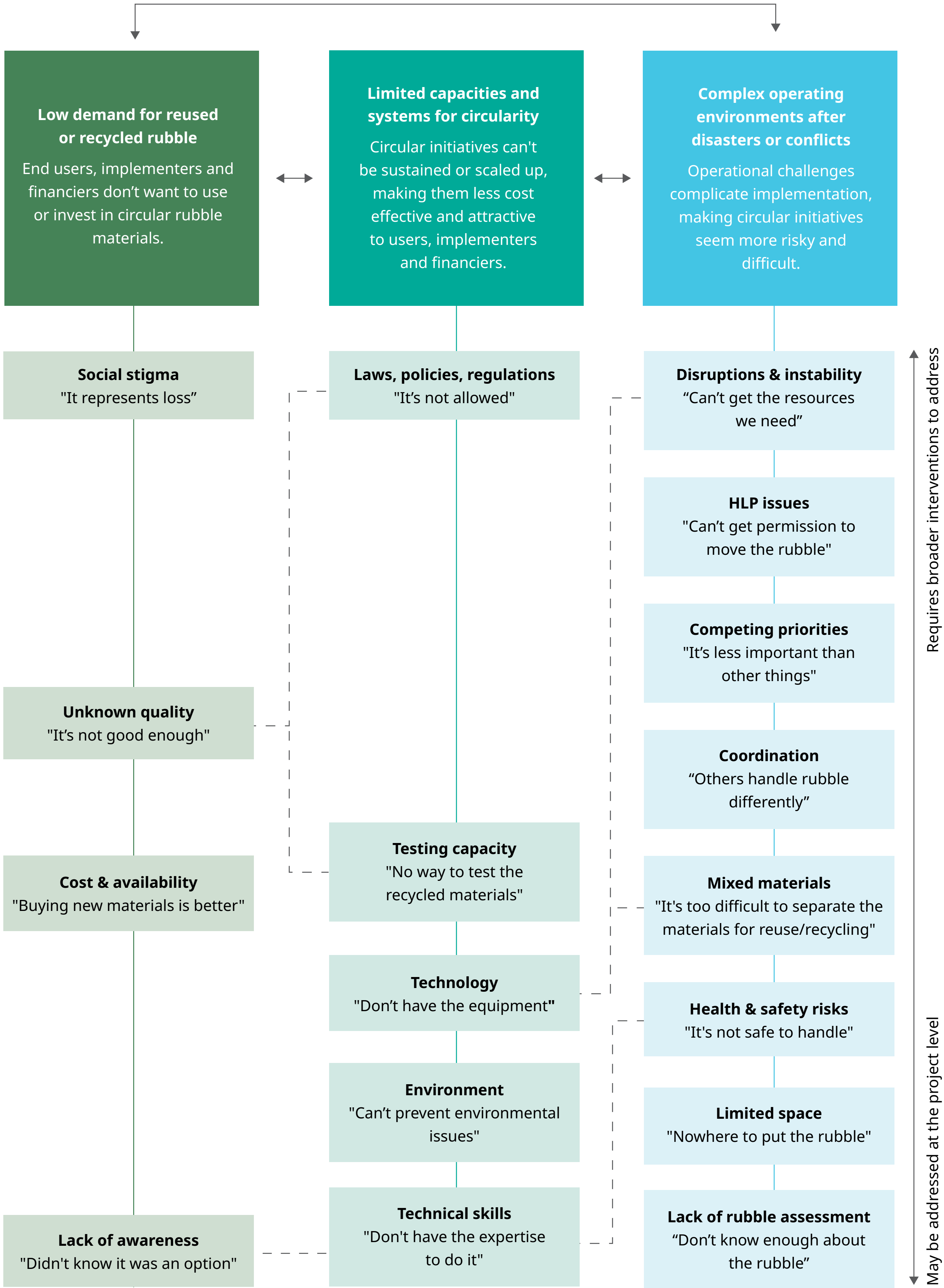
Laws, policies and regulatory frameworks: Waste management policies, building codes, public procurement rules, and disaster risk management frameworks may not incentivize or even allow the recycling and reuse of rubble or C&DW. A lack of coherence and coordination between the relevant public authorities may also hinder rubble management.

Standards and testing capacity: The lack of standards for recycled materials and local testing facilities can limit their use, as demonstrating compliance with local codes and obtaining insurance for resulting structures can be difficult. Lack of testing equipment to assess the presence of hazardous substances can also limit the ability to recycle rubble.

Technical skills and knowledge: The lack of education and vocational training in circularity limits effective rubble management. For example, demolition workers may not know deconstruction techniques, waste management workers and manufacturers may not be aware of methods to sort, clean, and recycle rubble to produce quality materials, and even where informal recycling and reuse are prevalent, builders may be unaware of how to maximize the structural properties of recycled materials. Workers may also lack understanding of occupational safety and health (OSH) standards for rubble or C&DW management activities, including safe management of hazardous substances and safe demolition and construction procedures.

Access to technology and equipment: Limited access to industrial-grade equipment for screening, sorting, washing, and crushing rubble, and manufacturing quality construction materials, can limit the

Figure 3. Barriers



development of economies of scale for recycled material production.

Awareness and capacity to mitigate environmental damage: Large-scale rubble management may generate significant emissions from the use of fossil fuel-based transport and crushing equipment. Specialized handling of hazardous materials, such as asbestos-containing materials (ACMs), is necessary to prevent negative environmental impacts. For example, spraying water on ACMs without proper management and controls can lead to run-off that contaminates soil and groundwater, while improper sealing of ACMs can create long-term environmental risks.

Decent work deficits: Today, much circular activity remains concentrated in primary, subsistence and informal economies, wherein jobs are often precarious, earnings are low, and productivity is limited by insufficient access to tools, capital and technology. In addition, women, persons with disabilities and vulnerable groups face discrimination and barriers to equal participation.

Disasters and conflicts generate millions of metric tonnes of debris and rubble from the destruction of the built environment.

Low demand for reused or recycled rubble

Rubble reuse and recycling is a demand-driven process. Shaped by limited capacities and systems for circularity, the following factors contribute to low demand and can make it difficult to attract financing and ensure that rubble products are actually used and accepted by beneficiaries, not merely disposed of in landfills.

Unknown quality of reused or recycled materials: Lack of testing and certifications to determine the quality and structural integrity of circular rubble materials in compliance with building codes and OSH standards, along with concerns about reputational and liability risks, can deter engineers, architects, contractors and craftspersons from using circular rubble materials in construction.

Lack of awareness of rubble reuse and recycling benefits and methods: A lack of awareness about the positive benefits of reusing, repurposing and recycling rubble, along with insufficient knowledge of implementation modalities, often means that they are not considered in recovery and reconstruction plans.

Social stigma, trauma and cultural resistance: Rubble causes a psychological barrier due to its association with loss and destruction. Cultural beliefs may also prevent the use of materials linked with death, while stigma around accepting or using secondhand materials further reduces the demand for rubble.

Cost and availability of materials: New construction materials may be more available and cheaper, especially when rubble recycling operations have not reached an economy of scale.

Uncontrolled dumping of debris in wadis in Mosul, Iraq.
© UNEP/Hassan Partow

Complex operating environments after disasters or conflicts

Disasters and conflicts disrupt the functioning of society, creating complex operating environments for rubble management and reconstruction. The following factors complicate and delay circular rubble management and reconstruction, and make it appear more risky or difficult than landfilling rubble.

Disruptions, instability and informality: Disasters and conflicts disrupt the systems and processes that support rubble management and reconstruction, including supply chains for equipment and materials, infrastructure (waste management, water and energy), and construction governance. Displacement, trauma and casualties also reduce the capacity for community response and recovery. Informality can be heightened due to the disruptions, which can also make it difficult to plan and implement a coordinated response.

Competing priorities for action and resources: During a crisis, life-saving activities and other urgent response activities take priority, requiring people, funding, energy, space and logistics. These competing priorities slow the mobilization of formal rubble management actors and often lead to the use of quicker rubble management options, such as landfill disposal.

A war-damaged bridge in Ukraine. © Oleksandr Polonskyi/ Shutterstock.com, 2022

Health and safety risks: Rubble management poses significant health and safety risks, including falling debris, collapsing and unstable structures, flammable gas, live electrical components, sharp edges, heavy volumes, explosive remnants of war (ERW) and hazardous materials. In particular, handling ERW and hazardous materials requires specialized expertise and adds time and cost requirements to rubble management.

Rubble contaminated with mixed materials: Rubble often contains both non-hazardous and hazardous materials, including furniture, personal belongings, natural debris, asbestos, unexploded ordnance (UXO) and human remains. This mixture makes processing difficult, and the use of rubble depends heavily on the proper segregation and sorting of waste materials, and the treatment of human remains in accordance with local customs and laws.

Coordination and community engagement: Multiple actors may handle rubble at the same time, such as homeowners, contractors, waste pickers, and military and government actors, requiring a coordinated approach to avoid inefficiencies, excessive costs, danger and environmental damage.

Housing, land and property issues: Disasters and conflicts often lead to displacement and the destruction of public records and physical markers, causing property disputes, tenure discrimination, land grabbing and forced evictions. These issues can delay the issuance of permission to remove rubble, particularly when it is used as proof for compensation or grants.

Adequate space for rubble management: Managing large amounts of rubble caused by a disaster or conflict – often adding up to 5 to 15 times the amount of solid waste generated by the community in a year[38] – requires sizeable stockpiling and processing areas. In dense urban locations, the lack of space may lead to remote disposal or recycling sites, increasing the time, cost and emissions associated with rubble removal. It may also lead to unauthorized dumping, which may expose communities to hazardous materials within the rubble.

Limited capacity for rubble assessment: Destroyed, missing or inexistent records and information about construction materials and technical details of structures, as well as lack of tools and knowledge, can make it difficult to assess rubble composition and volumes for effective rubble management planning.

Practical approaches to enable people-centred circular rubble management and reconstruction

This section contains a selection of approaches to overcome the identified barriers and to reimagine rubble as a sustainable resource and catalyst for long-lasting recovery. These approaches are broadly categorized according to three complementary and interdependent objectives:

1. **Create demand for circular materials:** Recycled materials need to be accepted as viable alternatives to raw materials for reconstruction in order for circular initiatives to be effective. This involves not only changing end-user perceptions about the value of circular materials, but also encouraging governments, financiers and the private sector to invest in creating a circular construction materials sector. Approaches include developing an enabling environment for circular construction materials and waste management through policy, standards, incentives, and financing, and demonstrating the quality of recycled materials to end users.

2. **Optimize implementation in complex environments:** Rubble management in post-conflict and post-disaster settings will always be challenging, but certain tools and strategies can be used to effectively prioritize and implement rubble management approaches. Building on lessons learned from real projects, this objective includes approaches that help to plan and implement rubble management within constraints while achieving positive social and environmental outcomes.

3. **Mobilize local actors to allow them to benefit from circular initiatives:** No single project or organization can address the massive scale of rubble by themselves. Waste management actors, design and construction firms, civil society organizations, academia, workers, and communities make sustainable rubble management and reconstruction possible. This objective includes approaches to work better with local actors to deliver a coordinated and coherent rubble management strategy and ensure that rubble management leads to decent and safe jobs, skills development opportunities, and equitable and safe access to reconstruction materials for all people.

Each approach includes information about when to use it, potential actions to implement it, real-life examples of how it has been implemented in the past, and links to additional resources.

> **Tip:** Use the roadmap to quickly find an approach for a specific stage in a rubble management or reconstruction project.

1.

Create demand for circular materials

This objective presents a selection of six potential approaches to create demand for circular materials. Each approach addresses different barriers related to low demand for reused or recycled rubble and underlying structural factors linked to limited capacities and systems for circularity.

Approach	Barriers addressed
1.1 Review and share examples of successful circular rubble management initiatives	• Lack of awareness of rubble reuse and recycling benefits and methods
1.2 Calculate and plan for the costs and benefits of circular rubble management	• Cost and availability of materials • Lack of awareness of rubble reuse and recycling benefits and methods
1.3 Finance, incentivize and require circular rubble reuse	• Cost and availability of materials
1.4 Create standards and certification mechanisms for circular construction materials	• Lack of laws, policies and regulatory frameworks • Lack of standards and testing capacity • Unknown quality of reused or recycled materials • Cost and availability of materials
1.5 Create laws and regulations for sustainable rubble and C&DW management	• Lack of laws, policies and regulatory frameworks • Lack of technical skills and knowledge • Limited awareness and capacity to mitigate environmental damage • Decent work deficits
1.6 Assess and demonstrate the quality of circular materials	• Unknown quality of reused or recycled materials • Social stigma, trauma and cultural resistance

1.1

Review and share examples of successful circular rubble management initiatives

Objective:
Create demand for circular materials

Barriers addressed:
Lack of awareness of rubble reuse and recycling benefits and methods

Who is this for:
Financiers, funders, governments, practitioners involved in rubble or waste management, disaster response, or reconstruction

Why use this:
You want to convince decision makers and stakeholders (e.g., governments, authorities, community leaders, financiers, investors) that using circular approaches in rubble management and reconstruction is feasible and delivers positive outcomes for local communities

Action:
Review and share examples of successful initiatives

The following are some examples of successful initiatives that can be used to demonstrate circular rubble management's feasibility and positive impacts to decision makers. The examples also include links to additional information.

Example:
Post-earthquake rubble recycling and reconstruction, Haiti

© ILO, 2012

The 2010 earthquake in Haiti caused extensive damage to housing and infrastructure, severely disrupting livelihoods and leaving more than 10 million cubic metres of rubble across the urban areas of Port-au-Prince, Léogâne and Jacmel.

The International Labour Organization (ILO) joined other UN agencies in supporting recovery efforts that linked debris management and reuse with local job creation, skills development and support for micro- and small enterprises. Rubble was sorted and reused to produce non-structural building materials, which were used in the rehabilitation of public spaces, streets and access ways in the affected neighbourhoods, with non-recyclable materials safely transported to controlled disposal sites.

The initiative engaged 896 affected community members, particularly women and youth, who received technical and business training to enable their participation in reconstruction and recovery. The training was complemented by efforts to raise awareness of labour rights and decent work principles, including occupational safety and health standards. A total of 57 small productive units were created, and 359 workers were provided short-term employment and on-the-job training in safe rubble handling and basic construction skills. Complementary microcredit schemes supported income-generating activities.

By combining rubble recycling with decent work principles, the Haiti project demonstrated how debris can be transformed into a valuable resource that supports reconstruction while delivering social, economic, and environmental benefits for and with affected communities.

896

affected community members engaged

359

workers employed and trained

Example:
Great East Japan Earthquake, Japan

The 2011 Great East Japan Earthquake destroyed and damaged more than 900,000 buildings, generating an unprecedented 20 million tonnes of disaster waste and 10 million tonnes of tsunami sediment – equivalent to almost two thirds of the annual municipal waste produced by the country. The Japanese government implemented a large-scale disaster waste management project through which it set up a waste treatment flow plan, guidelines, and technical methods for disaster waste management, including legal exceptions. It also set up a cooperative management scheme across different government levels, affected and supporting municipalities, and the private sector. The initiative led to the successful disposal of all waste in just three years, including the recycling of over 80 per cent of the disaster waste.[39]

20 million
tonnes of disaster waste

80%
of disaster waste recycled

Read more:
Osako, Masahiro and Ryo Tajima, 'An Outline of Disaster Waste Management for the Great East Japan Earthquake from a Technological and Administrative Point of View', *Global Environmental Research*, vol. 18, no. 1, 2014, pp. 73-80.

Example:
Rubble to Mountains, Lebanon

After the Beirut Port explosion in 2020, which generated around 400,000 tonnes of debris, the UN Human Settlements Programme (UN-Habitat) and other partners launched the Rubble to Mountains initiative, which used circular approaches to divert rubble from landfills. UN-Habitat conducted rapid damage assessments of approximately 14,000 buildings and established a rubble collection and sorting site. Rubble was reused and recycled to reinforce mountains severely eroded by quarrying and to produce furniture for Beirut's public spaces. The initiative created opportunities to support local livelihoods and contributed to safer and more sustainable rubble management.

14,000
buildings assessed

Read more:
UN Human Settlements Programme, 'Impact Story 5: Diverting rubble left by the Beirut blast away from Lebanon's landfills', in *UN-Habitat Annual Report 2020*, UN-Habitat, Nairobi, 2021, pp. 49-50.

Example:
Post-conflict circular rubble management, Iraq

© UNEP/Hassan Partow, 2017

The 2017 conflict with ISIL in Iraq generated an estimated 55 million tonnes of debris across 1,556 villages and 63 cities. In Mosul's Old City – one of the most heavily affected areas – the UN Environment Programme (UNEP) and the International Organization for Migration established Iraq's first debris recycling centre. A stationary crusher produced aggregates in three size ranges (0-5 mm, 6-11 mm, 12-25 mm), in compliance with national construction standards. These materials were then used for road foundations, soil stabilization, and the manufacture of pavement blocks and adobe bricks.

Building on this success, additional recycling centres were set up in Sinjar and Al-Hamdaniya, and a mobile crushing system was deployed to support remote villages in Kirkuk. Across these operations, more than 100,000 tonnes of debris was cleared – over a third of which was recycled. Sorting and processing activities also created cash-for-work opportunities for over 700 displaced youth. The recycling centres were later handed over to local authorities, demonstrating the potential for sustainable, locally led rubble management. To further institutionalize these efforts, UNEP supported the Iraqi Central Organization for Standardization and Quality Control in developing the country's first recycled aggregate standards, which were formally adopted in March 2026. These standards should help drive broader market uptake in Iraq's construction and demolition waste sector.

100,000
tonnes of debris cleared

>33%
of cleared debris recycled

Read more:
UN Environment Programme, 'Mosul's recovery moves towards a circular economy', UNEP, 28 July 2022, <www.unep.org/news-and-stories/press-release/mosuls-recovery-moves-towards-circular-economy>.

Example:
Infrastructure for Basic Human Needs project, Afghanistan

© National Consultancy and Relief Organization, 2025

More than 48,000 houses in Herat, Afghanistan, were damaged by several earthquakes in 2023. UNOPS is improving communities' access to essential services through rubble removal and reconstruction of social infrastructure and housing.

Local community members, including women and older persons, were engaged through community agreements in rubble removal and sorting work. The rubble was repurposed to reinforce eroded agricultural land at the request of community members, and recycled into earth block materials (pakhsa walls) for the construction of earthquake-resistant, culturally appropriate and low-carbon livestock shelters. These structures will also function as emergency shelters in case of future disasters.

1.2

Calculate and plan for the costs and benefits of circular rubble management

Objective:
Create demand for circular materials;
Optimize implementation in complex environments

Barriers addressed:
Cost and availability of materials; lack of awareness of rubble reuse and recycling benefits and methods

Who is this for:
Financiers, funders, governments, practitioners involved in rubble management

Why use this:
You want to convince decision makers and stakeholders to support circular rubble management and reconstruction by comparing the costs and benefits of different rubble management options

Action:
Analyze the costs and benefits of different rubble management scenarios in a specific context

Rubble management costs and benefits are highly context-specific, especially since costs are often higher after a disaster or conflict. Comparing the life cycle costs of circular approaches (including the costs of sorting, transport, processing and quality control processes) against disposal-only approaches (including transport and landfill tipping fees) can help identify when circular options are economically viable. The additional social, environmental and economic implications should also be considered, such as the demand for imported or raw materials, local job creation potential, the expected emissions, and the longer-term returns from building local recycling capacity. These extra costs and benefits can be considered through metrics such as:

- Labour days created per 1,000 tonnes of rubble managed;
- Trucking emissions per tonne-kilometre; and
- Volume of natural materials substituted.

Figure 4. Examples of cost-benefit analyses comparing disposal and recycling options in conflict-affected settings[40]

Figure 4A. Aghdam, Azerbaijan (2023)

Amount of debris: 3 million tonnes		
Parameters	**Disposal option**	**Recycling option**
Rubble management scenario	100% disposal + buying new materials	50% decentralized recycling 50% disposal
Time required	18 months	16 months
Costs and revenues of managing rubble and buying raw materials	$4.1 m disposal cost $0 revenue $4.1 m net cost	$5.6 m recycling cost $2.6 m revenue $3.0 m net cost
Amount of recovered reconstruction material	0	1.5 m tonnes
Costs of buying an equivalent amount of new materials	$4.3 m raw material cost	$0 raw material cost
Trucking emissions	8,000 tCO2	2,100 tCO2
Space required for disposal	37.5 hectares	24 hectares

Figure 4B. Northwest Syria (2023)

Amount of debris: 1.48 million tonnes		
Parameters	**Disposal option**	**Recycling option**
Rubble management scenario	100% disposal + buying new materials	50% centralized recycling 50% disposal
Time required	5 months	21 months
Costs and revenues of managing rubble and buying raw materials	$2.2 m disposal cost $0 revenue $2.2 m net cost	$2.8 m recycling cost $1.5 m revenue $1.3 m net cost
Amount of recovered reconstruction material	0	0.5 m tonnes
Costs of buying an equivalent amount of new materials	$2.6 m raw material cost	$0 raw material cost
Trucking emissions	1,268 tCO2	1,268 tCO2
Space required for disposal	18.5 hectares	12 hectares

Figure 4C. Gaza Strip, State of Palestine (2025)

Amount of debris: 57.4 million tonnes		
Parameters	**Disposal option**	**Recycling option**
Rubble management scenario	100% disposal + buying new materials	50% centralized recycling 50% disposal
Time required	7 years	7 years
Costs and revenues of managing rubble and buying raw materials	$1,098 m disposal cost $0 revenue $1,098 b net cost	$1,333 m recycling cost $431 m revenue $902 m net cost
Amount of recovered reconstruction material	0	28.7 m tonnes
Costs of buying an equivalent amount of new materials	$2.6 m raw material cost	$0 raw material cost
Trucking emissions	93,124 tCO2	93,124 tCO2
Space required for disposal	679 hectares	339 hectares

Example:
Analyses of the cost of rubble recycling versus disposal

Given the economic impact of reduced demand for imported or raw materials, a disposal-focused approach will result in a higher cost for imported or raw materials compared to recycling.

Based on examinations (see Annex B) of rubble management cost analyses developed by UNEP for Mosul,[41] Beirut,[42] Aghdam,[43] Northwest Syria[44] and Gaza,[45] this guidance estimates that the costs and savings of a linear 'dispose and buy new' approach versus recycling at least half of the same amount of rubble to be used as reconstruction materials are as follows:

- The operational cost of recycling can be up to 27 per cent higher than the cost of disposal; however, this expense can be recovered through:
  - Revenue from selling recycled materials. Recycling can have an 18 to 48 per cent lower net cost than disposal; and
  - The avoided cost of purchasing materials for reconstruction. By directly reusing recycled rubble for reconstruction, recycling can be 29 to 49 per cent cheaper than disposal.

Resources

- Swedish Civil Defence and Resilience Agency and UN Development Programme, *Debris Management Guidelines*, 2010, pp. 20-23: contains detailed information about calculating the costs and benefits of recycling debris.
- Examples of cost benefit analyses:
  - UN Environment Programme, *Mosul Debris Management Assessment*, 2018
  - UN Environment Programme and UN Development Programme, *Beirut Port Explosion Advisory Note on Debris Management Options*, 2021
  - UN Environment Programme, Aghdam debris modelling, Scenarios, 2023
  - UN Environment Programme, 2023 Turkey-Syria Earthquake – Preliminary Debris Quantification and Optioneering for selected sites in Northwest Syria, 2023

Action:
Incorporate rubble management costs into post-disaster and post-conflict assessment processes

Debris and rubble management and recycling costs can be incorporated by default into routine assessment processes, such as the Humanitarian Needs Overview (HNO), Post-Disaster Needs Assessment (PDNA) and Rapid Environmental Assessment (REA). This can help to secure the necessary financing for circular rubble management.

1.3

Finance, incentivize and require circular rubble reuse

Objective:
Create demand for circular materials

Barriers addressed:
Cost and availability of materials

Who is this for:
Financiers and governments

Why use this:
You want to help circular rubble management initiatives to start up, be sustained and to scale up into viable C&DW industries

Action:

Leverage fiscal and financial instruments to support the production and use of circular materials

Fiscal and financial instruments for the production and use of circular materials (such as targeted subsidies, concessional finance, guarantees and tax incentives) can improve the competitiveness of circular materials by lowering financial barriers and de-risking investment. These instruments must be accessible to small and medium-sized enterprises, informal builders, and homeowners in low-income or marginalized communities, rather than only to large firms. This can help establish viable circular supply chains that enable faster, more affordable, and resource-efficient reconstruction in post-conflict and post-disaster contexts.

Action:

Incorporate circular practices and requirements in public procurement

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Public procurement is one of the most powerful levers for creating demand and jobs, as governments can act as lead markets for circular construction materials. This supports the creation of predictable demand for circular materials and reduces the risk of investing in rubble processing and recycling operations. This can include:

- Requiring a minimum share of circular materials to be used in the construction of public structures;
- Defining performance criteria for construction materials in technical specifications instead of directly specifying materials, to allow circular materials to be considered;
- Integrating total cost of ownership into tender evaluations, instead of selecting contractors based on the lowest bid or upfront costs. This should include considerations of OSH, such as risk prevention and safer working conditions throughout the project life cycle;
- Encouraging innovation from bidders by using weighted criteria that award more points for sustainable practices, instead of using pass/fail criteria;
- Requiring demolition contractors to conduct pre-demolition audits and apply selective deconstruction practices to maximize the safe recovery of non-hazardous materials, while ensuring appropriate risk assessment and safe management of hazardous materials (e.g. silica, asbestos) during dismantling processes;

- Including design for disassembly as a criterion for the construction of public structures, to enable future reuse and recycling; and
- Requiring contractors to have circular skills and expertise in their teams or to acquire them within a certain time period.

Resources

- One Planet Network, Global Framework for Action: Harnessing sustainable and circular public procurement to drive demand for a near-zero emission and resilient built environment, 2025: A framework for leveraging public procurement to achieve a sustainable, inclusive and future-ready built environment.

Action:

Develop policies to support the management of sustainable materials in post-disaster and post-conflict settings

Sustainable waste management and construction policies are often framed for non-disaster and non-conflict conditions, and can be ineffective when supply chains and governance are disrupted. These policies should be updated to reflect disaster preparedness and management considerations, such as by:

- Including the sustainable management of rubble and construction materials in disaster management frameworks and action plans, integrated with the country's climate and environmental goals;
- As part of disaster preparedness, supporting local construction material producers and suppliers to incorporate circularity in their processes; and
- Developing disaster preparedness guidelines for the construction sector that specifically address material shortages, supply chain disruptions and sudden price escalations after conflicts or disasters.

Resources

- World Wildlife Fund and Northwestern University, Global Call to Action: Sustainable Building Materials Management in Post-Disaster Situations, 2025.

1.4

Create standards and certification mechanisms for circular construction materials

Objective:
Create demand for circular materials

Barriers addressed:
Lack of laws, policies and regulatory frameworks; lack of standards and testing capacity; unknown quality of reused or recycled materials; cost and availability of materials

Who is this for:
Government agencies, policy-making bodies, professional or academic institutions, private sector actors

Why use this:
You want to enable circular material markets

Action:
Fast-track interim technical standards for recycled materials

In contexts with limited standards for recycled construction materials, interim technical standards based on international specifications can be developed to guide circular rubble management and reconstruction works. These standards must be communicated to `both formal and informal builders to ensure safe reconstruction.

Action:
Incorporate circular construction materials in building codes and standards

Regulatory frameworks should explicitly allow the use of circular materials for defined structural and non-structural applications and adopt performance-based criteria that ensure safety, quality, and durability. These should not only apply to formal construction, but also accommodate community-led initiatives, incremental construction, slum upgrading, self-building, and other informal or semi-formal construction practices that play a major role in recovery after disasters and conflicts. These measures can help normalize the use of circular materials and build confidence among designers, contractors, insurers and communities. Examples include the following:

- India's standard for aggregates (IS 383:2016) explicitly recognizes the use of recycled aggregates in both structural and non-structural applications, as well as a testing standard (IS 2386) and guidelines for using C&DW in road construction (IRC:121-2017). Many other countries, such as Australia, Brazil, Japan, and the United Kingdom of Great Britain and Northern Ireland, have also adopted standards for recycled aggregates in concrete production.[46]
- France, India, Nigeria, Peru, Zimbabwe, and other countries have adopted standards for earth construction techniques such as adobe, rammed earth, and compressed stabilized earth blocks.[47]
- ISO has issued standards on circular economy, which can help guide the development of circular standards, as well as a design standard for the disassembly and adaptability of buildings and civil engineering works (ISO 20887:2020).

Resources

- UNOPS, UN Environment Programme and UN Human Settlements Programme, National Circularity Assessment Framework, 2024: A toolkit to support countries in assessing circularity in their building sectors and develop roadmaps to promote circularity in construction.
- UN Human Settlements Programme, Circular Construction in Sub-Saharan Africa Action Toolkit, 2024: A toolkit with policy recommendations to advance circular and low-carbon approaches in the housing value chain in sub-Saharan Africa.
- Global Alliance for Buildings and Construction, One Planet Network, and United Nations Human Settlements Programme, Scaling Circular Construction to Realize the Right to Adequate Housing for All: Policy Pathways, 2026: A paper outlining policy recommendations to improve the enabling environment for circular construction.
- ISO, 'Circular economy', <www.iso.org/sectors/environment/circular-economy>.

Action:
Enable affordable testing for construction materials

Make testing and certification of materials accessible and affordable, so that they do not create prohibitive costs or barriers to market entry for circular materials. Governments can work together with academic institutions and professional bodies to establish independent testing laboratories with affordable services.

Action:
Certify the quality of recycled material through pilot projects

Example:
Recycled debris for road construction, Azerbaijan

© UNEP/Hassan Partow

In Azerbaijan, UNEP provided hands-on technical advisory support to the government and Holcim, a supplier of cement and aggregates, to determine whether recycled debris could replace scarce virgin aggregate for road construction in the destroyed town of Aghdam, Karabakh region. Three debris samples were collected comprising limestone debris, river boulders and structural concrete. These were crushed and screened into four standardized fractions (0-5 mm, 5-10 mm, 10-25 mm, 25 mm) aligned with subgrade, subbase, and base course specifications outlined in local and international standards.

Independent testing confirmed that the recycled aggregates complied with the ASTM D1241 and AASHTO M147 requirements for Type B subbase. Adding stabilizer to the aggregates increased the strength (California Bearing Ratio or CBR) to more than five times the minimum requirement. The aggregates also met ASTM C33 requirements for M100-M350 grade concrete in screed, slab and lightweight concrete applications. These results were then shared at a debris recycling workshop with the government and other stakeholders.

Building on the positive test results, Holcim established a joint-venture enterprise that has since been implementing debris recycling operations across several destroyed villages in Aghdam.

Action:
Introduce rubble tracking and quality certification mechanisms

Clear tracking of where and how rubble has been removed can help monitor uncontaminated rubble that is suitable for reuse and recycling. This process can be formalized through quality certifications to help provide confidence in rubble materials.

1.5

Create laws and regulations for sustainable rubble and C&DW management

Objective:
Create demand for circular materials

Barriers addressed:
Lack of laws, policies and regulatory frameworks; lack of technical skills and knowledge; limited awareness and capacity to mitigate environmental damage; decent work deficits

Who is this for:
Government agencies and policy-making bodies

Why use this:
You want to enable sustainable rubble and C&DW management

Action:
Develop sustainable debris and rubble management procedures and regulations

Procedures and regulations can help develop a coherent approach to rubble management despite a complex operational environment. These can be temporary or interim instruments that can later be transformed into C&DW management legislations. Additional considerations include:

- Providing financing and other support to local governments to enforce sustainable rubble management, including any compensation schemes and reconstruction grants for homeowners;
- Developing technical guidance regarding safe and sustainable rubble management processes;
- Strengthening and supporting the enforcement of environmental regulations for debris and rubble management, including preventing illegal dumping;
- Explicitly classifying hazardous wastes in rubble and debris in regulations and specifying how these should be managed; and
- Identifying public health and environmental requirements for the permitting of the treatment, processing, and disposal of rubble – including rubble contaminated with hazardous materials such as asbestos – and the licensing of facilities that carry out these processes.

Resources

- World Bank, Recommendations Toward a Policy Note: Municipal Debris Management in Ukraine, 2025: A policy note that provides recommendations for both operational and policy actions for debris management in Ukraine.

Action:
Establish circular C&DW management legislation and regulation frameworks

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Effective circular construction depends on robust waste management legislative and regulative frameworks (including mandatory sorting of C&DW at source, pre-demolition audits, and requirements for selective deconstruction), supported by appropriate infrastructure and enforcement. These frameworks should incorporate decent work principles for both formal and informal waste workers in the sector.

Example:
C&DW management protocol, European Union

The European Union has established the EU Construction & Demolition Waste Management Protocol to foster trust in recycled materials through comprehensive processes and quality assurance in C&DW management.

Action:
Establish Extended Producer Responsibility for construction materials

Extended Producer Responsibility (EPR) schemes can further strengthen circular systems by shifting the responsibility for waste management to producers and contractors, incentivizing design for reuse and recycling, and supporting secondary material markets.

Example:
Mandatory C&DW recycling for large projects, Delhi

The Public Works Department and Municipal Corporation of Delhi have made it mandatory for large projects to send C&DW to authorized recycling facilities and reuse processed materials in road works, paving blocks and drain covers.[48] The city's recycling plants, operated by private concessionaires under public-private partnership models, process up to 2,000 tonnes of material per day, producing certified aggregates, sand and tiles. The local authorities have also begun piloting the use of recycled aggregates in non-structural applications within public housing and government buildings. Early institutional acceptance can de-risk the market and establish new performance benchmarks.

1.6

Assess and demonstrate the quality of circular materials

Objective:
Create demand for circular materials

Barriers addressed:
Unknown quality of reused or recycled materials; social stigma, trauma and cultural resistance

Who is this for:
Rubble management practitioners, governments, authorities

Why use this:
You want to convince building owners, architects, engineers, craftspersons, and contractors to use circular rubble materials in reconstruction, or governments, financiers and private sector actors to finance rubble recycling

Action:
Invite stakeholders to personally test circular materials

Example:
Homes Not Houses project, Sri Lanka

Habitat for Humanity, World Vision and the European Union supported war-affected communities in Sri Lanka to rebuild homes using compressed stabilized earth blocks (CSEBs) and earth concrete blocks. Local stakeholders, including homeowners and masons, were engaged in consultations to gain their acceptance of the new materials. In addition to discussing the advantages of CSEBs, these stakeholders were invited to try to break the CSEBs and compare them with the blocks that they typically used. Visiting model houses in other villages and directly experiencing the advantages of the material, such as the appearance and cooling factor, helped to convince some stakeholders.[49]

Read more:
Habitat for Humanity, 'Masons' tale', 2018, <www.habitat.org/ap/stories/masons-tale>

Action:
Conduct quality testing of recycled rubble materials

Example:
Study on recycling concrete from different sources, Syria

Researchers from Syria, Türkiye and the United Kingdom of Great Britain and Northern Ireland studied the performance of concrete made from recycled concrete aggregates (RCA) from destroyed buildings in Syria.[50] Using rubble from different urban and rural sites around the city of Al-Bab, different samples of RCA concrete were created and tested. The study demonstrated that RCA created from diverse sources of post-conflict rubble could replace 50 per cent of natural aggregates in concrete without significantly affecting its performance, while still meeting Syrian code requirements.

Read more:
Rashwani, Abdulkader, et al., 'Rebuilding Syria from the Rubble: Recycled Concrete Aggregate from War-Destroyed Buildings', *Journal of Materials in Civil Engineering*, vol. 35, no. 4, April 2023.

Action:

Build a demonstration project using recycled materials

Example:

School building made with recycled aggregates, India

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Habitat for Humanity partnered with PCS Industries Pvt. Ltd. to construct a hall for Panchayat Union Middle School in Tamil Nadu, to demonstrate the practical applications of recycled aggregates.

Manufactured sand (M-Sand) was made by processing C&DW materials. It was then used as an aggregate for concrete, plaster sand and concrete solid blocks in accordance with nationally approved proportions. The compressive strength of the materials was then tested in a certified laboratory before being used to construct the hall. An event was held to showcase the project and highlight the roles of the community, municipal officials, waste management teams and local stakeholders in sustainable C&D waste management.

2.

Optimize implementation in complex environments

This objective presents a selection of eight potential approaches to optimize the implementation of people-centred circular rubble management. Each addresses different barriers related to complex operating environments and limited capacities and systems for circularity.

Approach	Barriers addressed
2.1 Develop a people-centered circular rubble management strategy	• Lack of awareness of rubble reuse and recycling benefits and methods • Social stigma, trauma and cultural resistance • Disruptions, instability and informality • Competing priorities for action and resources • Rubble contaminated with mixed materials • Coordination and community engagement • Lack of adequate space for rubble management • Limited capacity for rubble assessment • Limited access to technology and equipment • Decent work deficits
2.2 Assess resource requirements for rubble management	• Disruptions, instability and informality • Competing priorities for action and resources • Cost and availability of materials
2.3 Use damage and hazard assessments to prioritize rubble removal and reconstruction works	• Health and safety risks • Rubble contaminated with mixed materials • Competing priorities for action and resources • Limited capacity for rubble assessment
2.4 Address housing, land and property issues related to rubble management and reconstruction	• Housing, land and property issues • Social stigma, trauma and cultural resistance • Disruptions, instability and informality • Coordination and community engagement

2.5 Manage hazards before removing rubble	• Health and safety risks • Rubble contaminated with mixed materials • Decent work deficits
2.6 Maximize circularity while removing rubble	• Rubble contaminated with mixed materials
2.7 Apply sustainable, safe and efficient methods for recycling and reusing rubble	• Limited awareness and capacity to mitigate environmental damage • Disruptions, instability and informality • Health and safety risks • Cost and availability of materials
2.8 Refuse, rethink and reduce reconstruction to minimize material consumption and rubble generation	• Competing priorities for action and resources • Limited awareness and capacity to mitigate environmental damage • Lack of technical skills and knowledge

2.1

Develop a people-centred circular rubble management strategy

Objective:
Optimize implementation in complex environments

Barriers addressed:
Lack of awareness of rubble reuse and recycling benefits and methods; social stigma, trauma and cultural resistance; disruptions, instability and informality; competing priorities for action and resources; rubble contaminated with mixed materials; coordination and community engagement; lack of adequate space for rubble management; limited capacity for rubble assessment; limited access to technology and equipment; decent work deficits

Who is this for:
Government agencies, rubble management practitioners, disaster risk reduction and management actors

Why use this:
The best way for rubble to be managed depends on what it will be used for, what the intended benefits are for local communities, and what is feasible in the operational context. A rubble management strategy can reduce inefficiencies and help navigate a complex operational environment.

Action:
Prepare for rubble management as a part of disaster preparedness

Being prepared for rubble management can be an investment in resilience. It can help speed up response and recovery efforts and reduce the amount of materials needed for reconstruction by pre-establishing a use case for rubble materials after an emergency. This can include:

- Creating rubble generation scenarios based on the local hazard risks and building stock vulnerability. Hazard data (such as Global Earthquake Model datasets) and national infrastructure and building registries can support these assessments;
- Identifying and pre-approving circular rubble use cases based on expected rubble types and volumes;
- Assessing current waste management capacities and securing relevant environmental permissions for potential rubble management sites; and
- Adding the projected costs to disaster response budgets.

Resources:

- United States Environmental Protection Agency, Pre-Incident All-Hazards Waste Management Plan Guidelines: Four-Step Waste Management Planning Process.
- Swedish Civil Defence and Resilience Agency and UN Development Programme, *Debris Management Guidelines*, 2010, pp. 28-30: contains information about debris preparedness planning.
- Global Earthquake Model, ‘Global Earthquake Model Foundation’, <www.globalquakemodel.org>.

Example:
Tools for disaster debris preparedness, United States of America

The United States Environmental Protection Agency has developed tools to support logistical preparedness during emergencies. This includes the Disaster Debris Recovery Tool, an interactive mapping tool that identifies approved recyclers and landfills for sustainable disaster debris management, as well as the All-Hazards Waste Management Planning Tool, which helps plan disaster waste management.

Action:
Prioritize sites for rubble removal and hazard management

Rubble removal and management of hazards and explosive threats should be prioritized according to the community’s recovery needs as determined by relevant stakeholders (See Approach 3.4), considering available capacities. For example, this might entail prioritizing:

- ‘Green’-tagged or safe structures, which can facilitate the return of people to their homes and reduce the need for emergency camps;
- Main transport corridors, which can provide access to deliver humanitarian aid and allow private contractors and non-governmental organizations (NGOs) to conduct rubble removal in low-hazard areas; and
- Hospitals, emergency centres, food providers, water and energy facilities, and other infrastructure that can facilitate access to essential services, especially for vulnerable groups.

Action:
Assess the technical qualities of rubble

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In order to determine use cases, it can be useful to know:

- **Composition:** What types of rubble have been generated based on typical construction methods and materials in the local context;
- **Quantities:** How much of each type of rubble has been generated; and
- **Location:** Where the rubble is located, especially in relation to potential processing, reuse and disposal sites.

Engaging local masons, craftspersons and construction workers can help assess the types of materials present in the rubble.

Action:
Identify applications for rubble

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Rubble applications can be selected or prioritized based on the operational context and the objectives we want to achieve. As the community starts to recover from the disaster or conflict, more complex rubble applications can become more suitable.

Table 1. Rubble applications based on context-specific suitability factors and people-centred, circular objectives supported

Rubble use case or application	Potential context-specific factors for suitability	People-centred, circular objectives supported
1. Public assets and infrastructure	• Lack of trust in recycled materials, including the social stigma attached to materials associated with death, trauma and cultural resistance • Limited space for landfilling	• Build confidence in circular rubble materials • Create short-term decent jobs and skills development opportunities • Reduce psychological impacts of rubble • Minimize landfill volume • Substitute raw materials
1.1. Road sub-base	• Significant damage to roads • Large quantities of relatively clean rubble (less than 2 per cent organic material)	• Quickly restore transport access
1.2. Quarry rehabilitation	• Existing closed quarries in the local context	• Mitigate environmental damage and erosion risk
1.3. Land grading	• Strict compliance with environmental regulations • Levelling of steeply sloped areas, planned parks or reconstruction sites • Large quantities of mixed debris, with minimal degradable materials	• Substitute raw materials • Increase available land for development or public spaces
1.4. Erosion control (fills for gabions, embankments)	• Eroded areas nearby • Large quantities of relatively clean rubble, with some inorganic materials	• Strengthen resilience to landslides, land subsidence
2. Public space assets (e.g., paving blocks, curbs, outdoor furniture)	• Significant damage to public spaces • Large quantities of relatively clean rubble	• Substitute raw materials • Improve public spaces for social interaction and recreation
3. Cultural or heritage site restoration	• Important cultural or heritage sites have been damaged • Structures built with similar materials to be deconstructed	• Respect and preserve local cultural and historical sites

Rubble use case or application	Potential context-specific factors for suitability	People-centred, circular objectives supported
4. Alternative building materials (e.g., aggregates, blocks, veneers) See Annex F for more detailed examples	• Large amounts of clean rubble collected through sorting and intentional deconstruction • High cost of or limited access to reconstruction materials • Uniform construction methods and structural quality of destroyed structures • Stable energy and water supply	• Maximize short-term decent job creation and skills development opportunities • Improve long-term circular C&DW management capacities • Minimize landfill volume • Substitute raw construction materials
5. Stockpiling for future recycling	• Limited capacity to recycle rubble in the short term • Available space for stockpiling • Large amounts of clean rubble collected through sorting and intentional deconstruction	• Quickly clear rubble • Create long-term supply of materials for the C&DW industry
6. Disposal	• High levels of contamination with hazardous materials • Large quantities of mixed debris, with a high percentage of degradable and non-recyclable materials	• Reduce public health risks • Reduce psychological impacts of rubble's presence through a faster removal process • Reduce physical hazards caused by large quantities of rubble (e.g., slope failures, flash flooding)

Resources

- See Annex F for more detailed information about reusing, repurposing and recycling rubble into alternative building materials.
- UN Environment Programme, *Mosul Debris Management Assessment*, 2018: contains information about different types of debris and debris management options.

Example:
Building resilience with reused debris, Sierra Leone

Through the Freetown Emergency Recovery Project, UNOPS and the World Bank supported the government of Sierra Leone in moving debris produced by the 2017 landslide and flood disaster in Freetown. Around 120,000 cubic metres of landslide debris was reused to stabilize slopes, and 21,000 native trees (including threatened species) were planted to support the stabilization of the land, while also providing food and medicine to the local communities. A no-build zone was established, and the area was designated as a national park. The slope stabilization project reduced the risk of landslides for around 3,000 people.

Example:
Upgrading roads with recycled debris, Iraq

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Extensive damage caused by conflict resulted in large volumes of debris spread across Al Mansuriya. In 2023, the International Organization for Migration and UNEP supported the village to use the debris to pave over existing dirt roads. The debris was crushed on site using mobile jaw crushers, then screened to separate it into standardized aggregate fractions. These recycled aggregates were used as the primary sub-base to upgrade the road, eliminating the need for virgin quarried materials. Testing confirmed that the recycled aggregates met Iraqi road standards and no cement stabilization was required.

Example:
Debris stock exchange, Haiti

Stockpiles can function as a marketplace for local community members and businesses to find reconstruction materials. In Haiti, the UN Development Programme (UNDP) established a debris stock exchange to connect producers and users of recycled construction materials.

Read more:
UN Development Programme, Haiti Technical Guide for Debris Management, 2013

Action:
Determine rubble management sites and transport routes

The selection of processing, recycling and disposal sites depends on the location and transport routes open to access the rubble, as well as existing facilities for C&DW management and available public land.

For rubble recycling, the site needs to be large enough to accommodate the planned storage and recycling operations, depending on the scale of the rubble generated and number of sites available.

Location of rubble recycling site	Target size
Within urban area	0.5 to 2 hectares
Outside urban area	Over 2 hectares

Geospatial tools can be used to conduct a multicriteria analysis of potential sites based on an acceptable distance to the rubble (for economic feasibility, low emissions and operational speed), environmental risks (e.g., potential for seepage of pollutants into soil, proximity to water bodies), and potential overlaps with other crisis operations using the same transport routes.

Sensitive feature	Minimum recommended distance from recycling sites
Surface water/wells	150m
Social infrastructure (schools, hospitals)	250m
Residential areas	200m
Ecological areas (parks, protected land)	100m

Note: These distances are based on a synthesis of international best practices. Consult national and local environmental agencies to determine appropriate setback distances, and increase distances if prevailing winds blow directly towards sensitive receptors.

Rubble processing and disposal sites can be centralized or decentralized. The decision can be based on the availability and cost benefit of using industrial-scale versus mobile crushers, as well as the intended circular application of the rubble. For example, reusing rubble for a widespread purpose, such as for road sub-base, may suit decentralized processing, compared to reusing it for quarry rehabilitation, which entails delivering the rubble straight to the quarry site.

For privately owned sites, ensure the rental agreement is long enough and can be amended and extended. Make sure that the end state of the site upon completion of works is defined, i.e., a landscape restoration agreement.

The location of the approved sites should be communicated to all stakeholders to avoid rubble being dumped on vacant land, on top of already sorted rubble, and on private properties.

Resources

- See Annex G: Rubble Recycling Site Assessment template
- See Annex G: Rubble Disposal Site Assessment template

Action:
Conduct social and environmental risk assessments

Marginalized groups are often disproportionately impacted by disasters and conflicts. A social risk assessment helps understand which social groups will be affected by rubble management operations (due to temporary resettlement, health risks, heightened risk of sexual harassment and exploitation, etc.) as well as each group's specific needs and vulnerabilities, and potential risk mitigation measures. This can be paired with a Gender Equality and Social Inclusion (GESI) analysis to understand how to best include and empower vulnerable groups in circular rubble management and reconstruction (see Approach 2.4 for more information about HLP issues and Approach 3.4 on community participation).

Environmental risk assessments are necessary to identify and mitigate risks such as emissions caused by transport and crushing, ground and water pollution from hazardous materials, air pollution from dust and transport, and resource consumption.

Action:
Select implementation modalities after considering local capacities and needs

Different types of implementation modalities can be employed to support rubble management and reconstruction, depending on existing capacities and context-specific factors. See Objective 3 for more information about engaging and building the capacity of local actors to manage rubble and promote circular reconstruction.

Implementation modalities can include:

- **Public employment programme approaches:** Under this approach, governments or implementing organizations usually hire individual community workers directly and pay them either on the basis of days worked or tasks completed. This is also referred to as a public works programme, cash for work, or cash for production.
- **Social enterprise grants or contracts:** This method engages communities and civil society organizations to participate in social enterprises related to rubble management.
- **Private sector contracts:** This method engages private companies and enterprises as service providers for rubble management activities.
- **Public-private partnerships:** This method involves a long-term contract between a government entity and a private company, through which the private partner may secure the initial capital for the rubble management works, which is then paid back over the life of the contract.

Table 2. Implementation modalities based on context-specific suitability factors and people-centred, circular objectives supported

Implementation modality	Potential context-specific factors for suitability	People-centred, circular objectives supported
Public employment programme approaches	• Large under-employed workforce in need of income • Lack of existing C&DW management systems	• Create immediate/ short-term jobs • Support formal certification pathways and continuous upskilling in C&DW management, in close collaboration with education and training institutions, to enhance workforce quality and long-term employability
Social enterprise grants or contracts	• Strong presence of NGOs, cooperatives, trade unions or workers' organizations • Prevalent informal waste picking practices • Decentralized processing	• Improve long-term C&DW management capacities • Support informal waste pickers to establish C&DW businesses
Private sector contracts, public-private partnerships	• Existing private sector capacities related to C&DW management • Centralized processing	• Improve long-term C&DW management capacities • Encourage the growth of a circular C&DW industry

Action:

Create decent jobs with safe and healthy working conditions

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Across all implementation modalities, it is essential that the jobs created are decent, in line with international labour standards and the Fundamental Principles and Rights at Work. This includes ensuring safe and healthy working conditions given the risks associated with rubble handling and construction, fair and timely remuneration, and respect for workers' rights. Workers should have the right to organize and engage in collective dialogue, and be able to work free from discrimination, forced labour, child labour, and violence or harassment. Special attention should be paid to vulnerable groups – such as women, youth, persons with disabilities, and informal workers transitioning into formal roles – to ensure they have equal access to opportunities and protections. Embedding decent work principles not only safeguards workers' well-being but also enhances productivity and the quality and sustainability of rubble reuse and reconstruction efforts. See Approaches 3.3-3.5 for additional information.

Resources

- International Labour Organization, *Policy guidelines for the promotion of decent work in recycling*, 2025.
- International Labour Organization, *Employment-Intensive Infrastructure Programmes: Labour Policies and Practices*, 1998.
- International Labour Organization, *Environmental and social safeguards guidelines*, 2022.
- International Labour Organization, *Developing the construction industry for employment-intensive infrastructure investments*, 2019.

Action:
Determine when to use heavy machinery or labour-intensive approaches

Both heavy machinery and labour-intensive approaches can be used in circular rubble management and reconstruction. Heavy machinery can support fast removal but requires equipment, fuel and skilled operators. Labour-intensive approaches provide a key opportunity to generate jobs for local communities, but require due attention to health and safety issues to ensure a safe working environment. While labour-intensive approaches are often used to generate immediate, short-term jobs, they should aim to include built-in exit strategies and capacity building of workers to strengthen their long-term employability.

Implementers may consider using a combination of approaches depending on the rubble type and location.

Table 3. Rubble management activities suitable for heavy machinery or labour-intensive approaches

Rubble management activities suitable for heavy machinery	Rubble management activities suitable for labour-intensive approaches
• Knocking down large multi-storey structures • Knocking down unstable structures that are not safe for workers to enter • Rapid rubble removal • Rubble management in contexts where social stigma or cultural beliefs prevent people from directly handling materials associated with death	• Soft stripping stable structures to generate clean rubble for recycling • Removing mortar from high-value and weakly bonded bricks/blocks • Removing rubble where heavy equipment cannot reach (e.g., narrow roads in slums) • Rubble management in historical and cultural sites that need careful handling

Note: It is estimated that manual deconstruction generates six to eight jobs for every job created by standard demolition.[51]

Example:
Mixed approaches for rubble removal, Afghanistan

In Herat, UNOPS required contractors to use both labour and heavy machinery to remove earthquake rubble, in order to maximize job generation while reducing safety risks. Heavy machinery (excavators and bulldozers) was used to knock down structures above 1.2 metres. Workers then conducted manual deconstruction of the remaining structure to reclaim the materials. For hauling, rubble could be moved within 200 metres by wheelbarrow and by dump truck for further distances.

The estimated labour days generated by rubble removal were:

- Manual deconstruction – 1 labour day per 3 m^3 of rubble;
- Excavation or removal – 1 labour day per 2 m^3 of rubble;
- Hauling and loading – 1 labour day per 4 m^3 of rubble; and
- Grading and levelling – 1 labour day per 4 m^3 of rubble.

Resources

- UN Web Buy Plus: A platform for sustainably procuring equipment and products of high quality, including trucks and construction equipment.
- Swedish Civil Defence and Resilience Agency and UN Development Programme, *Debris Management Guidelines*, 2010, pp. 32-38: contains information about debris processing equipment specifications.

Action:
Establish coordination and cooperation mechanisms

Successful implementation requires the cooperation of many stakeholders, such as disaster risk management agencies, public works ministries, the military, first responders, environmental management agencies, and local governments, among others. Preparations to support this collaboration can include:

- Establishing agreements with waste management operators, logistics firms, construction and demolition firms, and equipment and material manufacturers to support implementation of the rubble management strategy;

- Consultations to identify the necessary upskilling of stakeholders, including in deconstruction, sorting and recycling methods;
- Incorporating provisions in disaster plans and private-public agreements for the creation of employment opportunities for affected communities;
- Reviewing or creating standards and regulations to support circular rubble management and reconstruction (See Approach 1.4); and
- Preparing a communication plan and/or information management system (See Approach 3.1).

Example:
Centralized and coordinated debris management response, Ukraine

Ukraine established a Coordination Platform on Demolition Waste Management to avoid duplication of efforts across numerous debris management initiatives and adopt a systematic approach to the reuse of materials for reconstruction. The Debris to Resource project consortium also supports the development of a systematic approach to circular debris management in the country through the creation of replicable methodologies, circular business models, capacity building activities and policy recommendations.

Action:
Plan a phased approach

A rubble management strategy can include a combination of different applications or use cases for rubble that can be carried out at different stages. It may not be possible to have a single application for significant amounts of rubble, so exploring different options can help maximize the reuse of rubble materials. These decisions can be affected by timing, availability of rubble or equipment, technical capacities and constraints in the local context, or by the objectives we want to achieve in rubble management. Social, economic and environmental factors should all be considered in the analysis.

Table 4. Example of a phased approach to rubble management activities

Phase	Objectives	Potential rubble management activities
Emergency clearance	Enable emergency response and life-saving activities	• Rapid removal and disposal of available rubble with minimal sorting • Hazard removal from priority sites • Establishment of sorting and stockpiling sites
Controlled sorting & stockpiling	Prepare rubble for recycling and reuse while recycling sites are being set up	• Sorting and stockpiling of rubble • Reuse of large pieces of rubble for erosion control, quarry rehabilitation and other applications with minimal processing requirements • Demolition and deconstruction of damaged structures • Establishment of recycling facilities • Restoring water and energy supply

Phase	Objectives	Potential rubble management activities
Circular reuse & market development	Integrate rubble into reconstruction supply chains	• Demolition and deconstruction of damaged structures • Processing and recycling of clean rubble from deconstructed structures to create alternative building materials

Resources

- UN Environment Programme and UN Office for the Coordination of Humanitarian Affairs, *Disaster Waste Management Guidelines, 2nd ed.*, 2013.
- UN Development Programme, *Guidance Note on Debris Management*, 2015.
- Ministry of Environment, Lebanon, and UN Development Programme, *Standard Operation Procedures for Post Disaster Rubble Management*, 2025.
- Gaza Debris Management Working Group, *Debris Recycling Site Operations – Guidance Note*, 2026.

Action:

Create an exit strategy to ensure long-term sustainability and acceptance of circular practices

Beyond the recovery and reconstruction phases, it is important to consider how circular rubble initiatives can have a longer-term positive impact on the local community. The exit strategy might include providing training to build technical capacity or transferring ownership of equipment to local governments, businesses, or cooperatives to allow them to operate and maintain rubble recycling facilities (see Approaches 3.2-3.5 for more information about capacity building).

Resources

- Swedish Civil Defence and Resilience Agency and UN Development Programme, *Debris Management Guidelines*, 2010, pp. 40-42: contains information about handover options.

2.2

Assess resource requirements for rubble management

Objective:
Optimize implementation in complex environments

Barriers addressed:
Disruptions, instability and informality; competing priorities for action and resources; cost and availability of materials

Who is this for:
Government agencies, local authorities, rubble management practitioners

Why use this:
Diverse resources, including heavy equipment and machinery, personnel, labour, energy, and water, are needed for effective rubble management. The specific configuration of these resources depends on the scale of destruction, rubble composition, and local availability of resources and supply chains.

Action:
Determine requirements for the use of heavy equipment and machinery

Heavy equipment and machinery speed up and scale up rubble management operations. While fleet requirements vary by phase and context, the following breakdown of equipment serves as a planning benchmark for prioritizing procurement and logistics across the four primary stages of operation: sorting and selective demolition, primary volume reduction, collection and transportation, and centralized processing and recycling.

Table 5. Heavy machinery for different rubble management stages

Equipment	Function	Average capacity (tonnes/ day	Energy source options	Average energy consumption per day	Staff requirements
Stage 1: Sorting and selective demolition **Objective:** Precision separation to maximize recycling value					
Excavator with bucket, shear and breaker attachments (tracked or wheeled)	Demolition of damaged structures	250-500	Diesel	100-150 L	One operator and one bankperson
Grapple excavator (20 t)	Material sorting/picking	150-250	Diesel	100-150 L diesel/day	One operator and one bankperson
Skid-steer loader	Small space clearing	50-80	Diesel/ electric	65-100 L diesel/day	One operator and one bankperson
Stage 2: Primary volume reduction **Objective:** Breaking oversized debris into transportable feedstock					
Hydraulic breaker (attachment to excavator)	Breaking concrete slabs	200-400	Via excavator	+35-50 L diesel/ day	One operator (excavator)
Hydraulic shears (attachment to excavator)	Cutting rebar and steel	100-150	Via excavator	+25 L diesel/ day*	One operator (Excavator)

Equipment	Function	Average capacity (tonnes/ day	Energy source options	Average energy consumption per day	Staff requirements
Stage 3: Collection and transportation **Objective:** Efficient bulk movement of sorted waste					
Wheel loader (3 m³)	Loading trucks	600-1000	Diesel	100-130 L diesel/day	One operator
Dump truck (25 t)	Hauling to rubble recycling site	150-200**	Diesel	60-100 L diesel/day	One driver
Stage 4: Centralized processing and recycling **Objective:** Turning rubble into construction-grade aggregate					
Mobile jaw crushers	Concrete crushing	1,000-1,500	Diesel/ hybrid	150-320 L diesel/day	One operator and one ground hand
Screener (vibrating twin deck)	Sizing aggregate	800-1,200	Diesel	100-130 L diesel/day	One operator

* In addition to host excavator energy consumption.

** Based on 6-8 trips per day within a 10 km radius.

Resources

- UN Web Buy Plus: A platform for sustainably procuring vetted equipment and products of high quality.

Action:

Determine personnel and labour requirements

Rubble management requires a mix of technical expertise and manual labour, and provides an opportunity for local employment and vocational upskilling. The following roles are needed to conduct a rubble management operation:

1. **Management:** Project managers are needed to coordinate the various personnel and stages of the operation.

2. **Engineers and logisticians:** Civil and structural engineers are needed to assess the structural condition of buildings and infrastructure assets, while logisticians are required to map out transport routes.

3. **Skilled operators and drivers:** Certified operators and drivers are required to operate heavy machinery and drive trucks.

4. **Mechanics:** Mechanics are needed for on-site repairs and maintenance of machinery.

5. **Specialists:** UXO technicians are needed in post-conflict contexts, and environmental technicians are needed for handling hazardous waste.

6. **Safety officers:** Safety officers are vital for monitoring hazardous materials (e.g., asbestos, chemicals) and ensuring site safety.

7. **Manual labour:** Teams are required to sort debris by hand to recover valuables or recyclables that machines may miss.

Refer to Approach 3.5 for additional information about the skills required for different roles.

Action:

Determine energy requirements for rubble management

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The energy demands for rubble operations are listed by type of machinery in Table 5 and can be grouped into any of the following three categories:

1. **Mechanical breaking demands:** High-pressure hydraulic systems used to demolish or break down rubble require the machinery to consume high levels of fuel to sustain enough torque power (i.e., stages 1 and 2 in Table 5).

2. **Processing demands:** Mobile crushers are the single largest energy consumer in the rubble management process, requiring significant start-up torque and consistent power to maintain rotational momentum.

3. **Transportation demands:** Fuel demands for the transport of rubble are highly sensitive to distance and topography. A dump truck hauling 25 tonnes of rubble uphill consumes nearly double the fuel compared to a truck on flat terrain, making route planning critical.

Resources

- KTH Royal Institute of Technology, Energy Planning Tool for Post-Conflict settings: A tool for estimating energy demands in post-conflict scenarios, including energy requirements for circular rubble management.

Action:

Assess and restore energy supply for rubble management

In post-disaster and post-conflict zones, energy is one of the primary constraints for recovery. The fundamental challenge in these contexts is the near certainty of localized or total grid failure, either due to structural damage caused by natural disasters or the targeted destruction of utilities in conflict. While diesel is an immediate reliable source due to its energy density and portability, supply chains may be disrupted by infrastructure damage and instability.

After disasters and conflicts, restoring energy supply requires a multi-layered approach that could include the following:

1. **Bulk diesel supply:** Diesel is the most reliable fuel for heavy machinery and requires established contracts for delivery via 10,000 to 20,000 litre tanker trucks.
2. **Mobile fuel trucks:** Smaller fuel trucks are required to bring fuel to the machinery, rather than the machine traveling to a central fuel point.
3. **Diesel generators:** For centralized debris recycling sites, large gen-sets (i.e., 150-500 kilo-volt-amperes) can be used to power some smaller equipment such as screeners, site lighting and water pumps.

Action:

Improve the sustainability of energy use in rubble management

While initial stages of rubble management operations favour diesel for its flexibility, as the post-disaster or post-conflict context stabilizes, the sustainability of operations can be enhanced through the following strategies.

1. **Transition to electric machinery:** Utilizing electric skid-steer loaders or mini excavators as the main electricity grid stabilizes or via generator-charging, which is more efficient than running multiple small diesel engines.
2. **Solar augmentation:** Deploying mobile solar container systems to support site lighting, water pumps and other administrative loads.
3. **Idle reduction:** Implementing 'zero-idle' policies, wherein engines are cut if stationary for more than five minutes. This can reduce total site fuel consumption by up to 15 per cent.
4. **On-site crush and reuse:** Crushing rubble on site eliminates the energy consumption associated with transporting heavy rubble to recycling sites and back for reconstruction.
5. **Emission scrubbing:** Procuring Tier 4 emission-scrubbing machinery (e.g., Selective Catalytic Reduction and Diesel Particulate Filter systems) to protect the community's respiratory health.

Action:

Determine water requirements for rubble management

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Water is necessary for rubble management activities such as:

1. **Dust suppression:** The primary demand for water in rubble operations is for dust suppression. The movement and crushing of concrete, brick, and mortar release high concentrations of silica and potentially asbestos. Continuous misting is required at demolition and crushing sites and on transport roads to prevent respiratory illness in workers and nearby residents.

2. **Decontamination:** In sites involving hazardous materials, water may be required to wash down equipment and personnel to prevent the tracking of toxins off site.

3. **Potable water for drinking, sanitation and hygiene:** Drinking water is necessary to help personnel stay hydrated and prevent heat stress in warm climates. Water is also needed to support adequate water, sanitation and hygiene (WASH) facilities and may also be needed for workers' cultural and religious practices.

Action:

Assess and restore water supply for rubble management

Similar to energy, water infrastructure is often damaged in post-disaster or post-conflict contexts, requiring independent sourcing for rubble operations. Some sources of water include:

1. **Non-potable water:** Water sourced from local rivers or lakes, as well as groundwater, must be screened for debris that could clog spray nozzles, but otherwise does not require treatment to be used for dust suppression and decontamination.

2. **Potable water:** Purified water is needed for drinking and hygiene purposes. Bottled water can be transported in, or water can be processed on site using portable reverse osmosis (RO) units (though ROs add to on-site energy demands).

3. **Water tankers:** Larger water supplies are typically delivered by 10,000 to 15,000 litre trucks.

Action:

Improve sustainability of water use in rubble management

High pressure/low-volume (HPLV) misting systems can be used for dust suppression instead of standard spraying. HPLV systems create small droplets to bind to the dust and can reduce water consumption by 80 per cent compared to standard spraying.

2.3

Use damage and hazard assessments to prioritize rubble removal and reconstruction works

Objective:
Optimize implementation in complex environments

Barriers addressed:
Health and safety risks; rubble contaminated with mixed materials; competing priorities for action and resources; limited capacity for rubble assessment

Who is this for:
Government agencies; emergency response practitioners; damage assessment practitioners; reconstruction planners

Why use this:
You want to make operations safer and more efficient, facilitate the return of people to undamaged homes, and reduce unnecessary demolition and the generation of rubble.

A structure-level damage assessment is a key tool to determine the amount and location of both available and unreleased rubble that needs to be managed, and to assess the safety of affected structures. Hazard assessments determine risks posed by hazardous objects that should be removed, such as unexploded ordnance, asbestos and toxic waste. It is critical to assess the presence of both hazards and structural damage to ensure people's safety and factor in the time and cost of hazard management in rubble management plans.

Important note: Structural damage and other hazards (UXO, asbestos, etc.) may be present even if a structure shows no visible exterior damage.

Resources

- See Annex D for more information about the tools and equipment used to conduct rapid damage and hazard assessments.
- See Annex G, the Community Damage Assessment Questionnaire for initial area screening and Building Assessment Form for detailed assessments.

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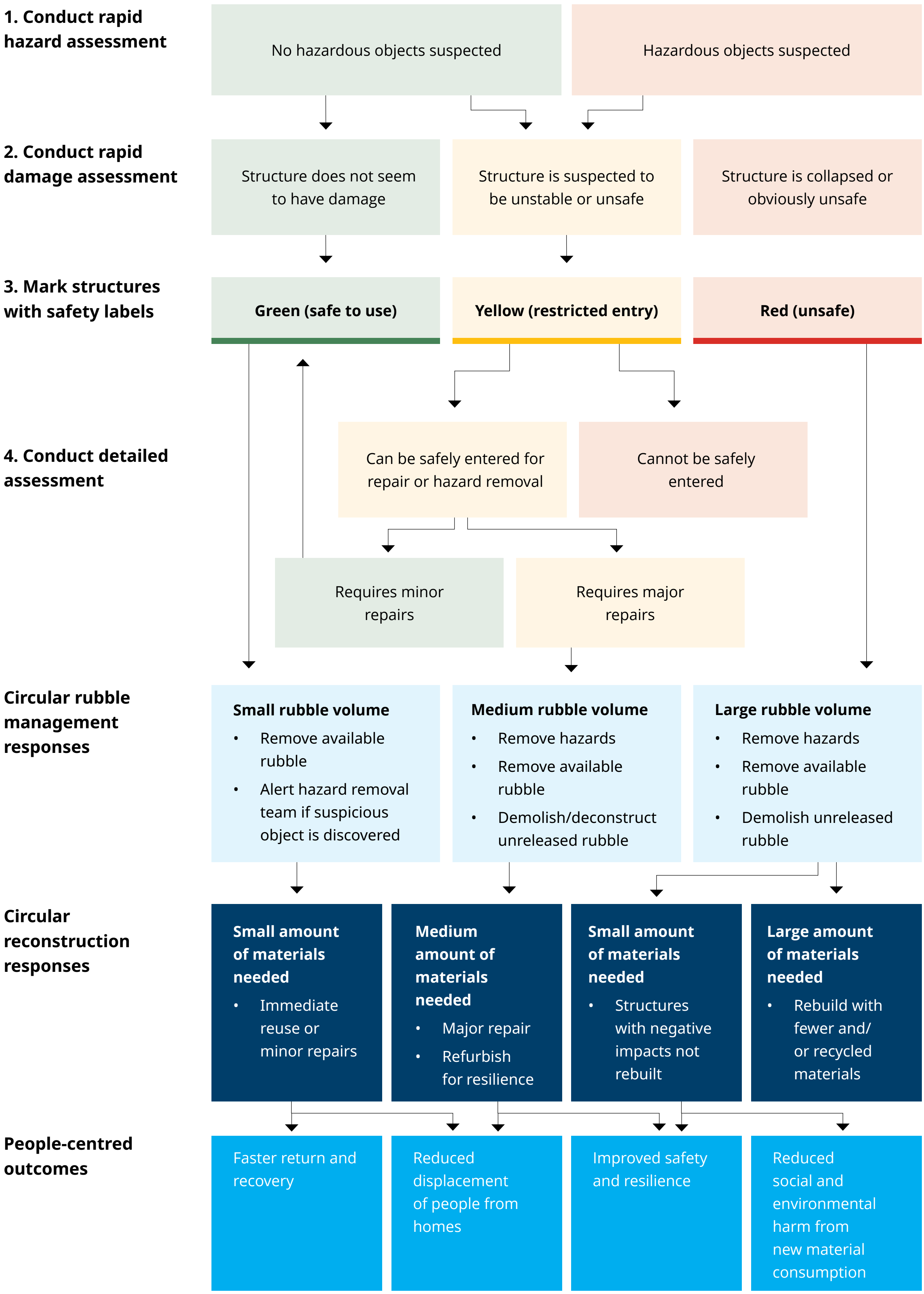
Action:

Plan rubble management and reconstruction responses based on safety risks and targeted people-centred outcomes

Many post-disaster damage assessment frameworks use a 'traffic light' rating system (green, yellow and red) to inform people of the safety of a structure. This system can also be used to categorize structures under various rubble management and reconstruction responses (see Figure 5).

Figure 5. Using hazard and damage assessments to inform circular rubble management and reconstruction responses



Example:
Faster explosive threat management through remote sensing

UNOPS Compass is a geospatial innovation and analytics facility that supports crisis response and recovery across fragile, conflict-affected and climate-vulnerable contexts. They use advanced remote sensing technologies and artificial intelligence to speed up explosive threat management during rubble removal and other crisis response situations. In Syria, 3D modelling of infrastructure based on stereo imagery produced accurate replications of building heights and estimated rubble volumes to inform damage assessments. The ability to remotely and automatically conduct damage assessments helped to inform the extremely dangerous operations of explosive threat management and to advise governments and communities about high-risk areas quickly.

Read more:
Collins, Rory and Lionel Fragniere, 'Leveraging new technology for a mine-free future', UNOPS, 2024, <www.unops.org/insights/leveraging-new-technology-for-a-mine-free-future>

Example:
Linking damage assessment to labour market recovery, Syria

In the aftermath of the earthquakes in Syria in 2023, the ILO linked structural damage assessment with labour market recovery planning as part of its post-earthquake response in Aleppo. The rapid assessment of households and workers was used to identify the scale of livelihood disruption and urgent employment needs, including those caused by widespread income loss and job displacement among affected households.

In parallel, the ILO channelled support through the Syrian engineering syndicate to strengthen the capacity to assess structural damage through training of trainers, and by providing equipment and specialized training to help determine which buildings could be rehabilitated and which required demolition. This helped align technical decisions regarding damaged buildings with employment-intensive recovery priorities, including rubble removal. The same recovery approach also included OSH-related support for rubble removal and construction works, helping connect safer building assessments with safer labour-based implementation on the ground.

Learn more:

- International Labour Organization, Factsheet – ILO in Syria: Early recovery through community resilience in earthquake-hit areas (February – December 2023), 2024.
- International Labour Organization, *Rapid Assessment of the Needs of Households and Workers Affected by the Earthquake in Aleppo-Syria 2023*, 2023.

2.4

Address housing, land and property issues related to rubble management and reconstruction

Objective:
Optimize implementation in complex environments

Barriers addressed:
Housing, land and property issues; social stigma, trauma and cultural resistance; disruptions, instability and informality; coordination and community engagement

Who is this for:
Government agencies, local authorities, rubble management practitioners

Why use this:
It can be difficult to determine property boundaries and ownership when traditional markers or records are destroyed. Removing rubble without due attention to HLP rights may contribute to unlawful dispossession, land grabbing, secondary occupation and rising social tensions – undermining recovery efforts and trust between affected communities and response actors.

Action:

Recover human remains, cultural objects and personal belongings in a respectful manner

Human remains should be handled in a respectful and dignified manner, in accordance with local cultural and religious customs, and local and international laws. In coordination with local authorities, the evidence from the scene should be preserved and collected to support the identification of the human remains. In post-conflict situations, this can support potential war crime investigations.

Cultural and religious objects and buildings must also be handled with care and in line with international best practices.

In all cases, removal and deconstruction implementers should do their best to preserve and label personal items, documents and valuables for return to their owners. This can include developing procedures to allow homeowners to safely retrieve items before removal or deconstruction.

Resources

- Pan American Health Organization, World Health Organization, International Committee of the Red Cross, and International Federation of Red Cross and Red Crescent Societies, *Management of Dead Bodies after Disasters: A Field Manual for First Responders*, 2006.
- UN Mine Action Service, 'Technical Note for Mine Action 07.50/01: Practical guidelines on the management of human remains in mine action, Annex D (informative) – Actions when encountering human remains', 2023, <https://www.mineactionstandards.org/standards/07-50-01>.
- Interpol, 'Disaster Victim Identification (DVI)', <www.interpol.int/en/How-we-work/Forensics/Disaster-Victim-Identification-DVI>.
- Gaza Debris Management Working Group, *Debris Management in Gaza – Human Remains in Debris: Standard Operating Procedure*, 2025.

Action:

Verify property ownership and gain permission to remove rubble

Before removing rubble, it is important that authorization is secured through HLP-sensitive procedures that recognize the diversity of tenure arrangements and the realities of conflict- and disaster-affected contexts. Some ways this can be done include the following:

In areas with significant damage and a high risk of hazards, a condemnation of the entire zone by the government can be secured. This can help protect people from entering unstable structures or hazardous areas.

If the owner or resident is known and contactable, it is best to secure individual homeowner authorization for rubble removal. The authorization may include provisions so that the owner may retrieve personal items and valuable materials before the dismantling of the structure, but relinquishes ownership of the remaining rubble.

If the owner or resident cannot be contacted, interim permissions for rubble removal can be secured from relevant community leaders or local authorities. Phased consent can also be used as a way to manage urgent situations without undermining the rights of residents and owners.

Resources

- See Annex G: Owner Demolition and Debris/Rubble Removal Waiver.
- UNOPS, *Management of Rubble Removal Operations in Explosive Hazard Impacted Environments: Requirements and Guidelines*, Annex B: Pre-Clearance Liability Waiver, forthcoming in 2026.
- UN Human Settlements Programme and Global Land Tool Network, Social Tenure Domain Model: a tool to enable the participatory documentation of diverse tenure relationships, including informal, customary, and undocumented claims, which are common in crisis-affected urban contexts.
- UN Human Settlements Programme, *Housing, Land and Property-Sensitive Urban Law: Enhancing urban law to protect housing, land and property across the conflict cycle*, 2024.
- Housing, Land and Property Technical Working Group Palestine and Gaza Debris Management Working Group, Mainstreaming Housing, Land, and Property (HLP) Rights into Debris Management infographic, 2025.

Example:
Protecting property rights through authorization procedures

In Haiti, UNOPS worked with UNDP and other UN agencies to establish and enforce a demolition authorization procedure, making sure to reject authorization forms that were not completed properly in order to prevent land grabbing or unwanted demolition of people's houses. While it took some time to mainstream this procedure, document collectors and community leaders eventually accepted it as a way to protect the community, which led to a faster and smoother process. Residents from informal settlements were able to have the demolition permits as the first legal and verified documents acknowledging their residence, a first step towards more secure tenure.

Action:
Create a digital database to document damage and HLP-related issues to support fair compensation and reconstruction grants

Securing permission may be challenging in cases where owners want to retain the rubble or structure as is in order to seek compensation for the damages. In coordination with local authorities, damage assessments prior to rubble removal can be leveraged to create the documentation needed for reconstruction grants or compensation (see the example of Nepal under Approach 3.5).

Strict documentation should be maintained on demolition authorization procedures, all works carried out, ownership decisions and any disputes. This should be shared with relevant authorities, including those involved in reconstruction, to help guide an HLP-sensitive approach and ensure transparency in rubble management and reconstruction works.

Action:
Establish grievance mechanisms to prevent land grabbing and forced evictions

Grievance mechanisms and reporting channels for disputes and complaints can help manage HLP issues. These should be kept open after the removal operations to prevent land grabbing and forced evictions.

Action:

Ensure that women and marginalized groups are recognized in legal documentation

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In some contexts, women, older persons, persons with disabilities, indigenous peoples, and marginalized groups may not be recognized as property owners, placing them at risk of displacement in case of property disputes. This risk should be identified as part of the social risk assessment or GESI analysis (see Approach 2.1). Some ways to support their HLP rights are:

- Including both the legal owner and their spouse(s) as signatories for demolition authorization and cash assistance contracts to allow the spouse(s) to be recognized and benefit from housing reconstruction;
- Providing widows, divorced women, persons with disabilities, older persons, and other marginalized groups with legal assistance to help them gain tenure and legal ownership of their homes; and
- Coordinating with indigenous peoples and local authorities to recognize indigenous land rights.

Action:

Leverage technology and remote analysis processes to set up a digital cadastral database

Geospatial analysis tools can be used to encode cadastral deeds or records to create a digital cadastral database, allowing the government to better keep track of property ownership and boundaries. These tools can be paired with remote assessments to track and assess any changes to property markers due to conflicts or disasters, helping protect property owners from land grabbing. For more information, see Approach 3.1.

Digital twins can also be used to create virtual replicas of destroyed infrastructure and buildings, affected land formations and water bodies, and contaminated areas to support reconstruction, rehabilitation and long-term management.

Action:

Mark property boundaries before and after rubble removal

Before and after rubble removal, property boundaries should be marked and documented using permanent references in collaboration with communities and local authorities. This is important to prevent land grabbing and property disputes. Some ways this can be done include:

- Ensuring that any existing survey markers are not damaged during the removal process;
- Leaving some parts of the structure (such as foundation corners and property walls) undemolished to act as a reference; and
- Conducting social mapping with neighbours and community leaders to establish the boundaries of the property.

2.5

Manage hazards before removing rubble

Objective:
Optimize implementation in complex environments

Barriers addressed:
Health and safety risks; rubble contaminated with mixed materials; decent work deficits

Who is this for:
Government agencies, local authorities, rubble management practitioners, mine action specialists, hazardous waste specialists

Why use this:
Hazardous materials and substances in rubble need careful handling to ensure safety and protect the environment.

Action:
Carefully remove and dispose of hazardous substances and waste

Contamination from hazardous materials is a major occupational health and safety risk for rubble management workers. It can also result in the entire batch of rubble being considered as contaminated, limiting the potential reuse of the non-hazardous material. Hazardous substances in rubble can include asbestos-containing materials, medical waste, radioactive waste, highly flammable substances and other toxic waste. In addition, exposure to dust (such as respirable crystalline silica) can pose severe health risks to workers.

Where possible and safe to do so, these hazardous materials should be separated for controlled disposal. All workers should be trained in proper OSH procedures for the management of hazardous waste and should have the necessary personal protective equipment (PPE) or respiratory protective equipment.

Resources

- See Annex E for more information about managing asbestos-containing materials.
- See Annex G, PPE List for Hazardous Waste.
- Guidance materials for the management of hazardous waste:
  - UN Environment Programme and UN Office for the Coordination of Humanitarian Affairs, *Disaster Waste Management Guidelines, 2nd ed.*, 2013.
  - World Health Organization, *Safe management of wastes from health-care activities, 2nd ed.*, 2014.
  - International Committee of the Red Cross, *Medical Waste Management*, 2011.
  - United States Environmental Protection Agency, 'Polychlorinated Biphenyls (PCBs) in Building Materials', <www.epa.gov/pcbs/polychlorinated-biphenyls-pcbs-building-materials>.

Action:
Integrate explosive threat management in rubble management

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In post-conflict settings, rubble may contain explosive remnants of war (ERW) including explosive ordnance (EO), such as landmines, unexploded ordnance (UXO), improvised explosive devices (IEDs), booby traps, and toxic weapons. These contaminate rubble, put structures at risk of collapse, and make rubble management a dangerous and complex task.

In areas with actual or suspected contamination, rubble removal operations should only proceed in accordance with explosive hazard risk assessment and clearance procedures, with strict movement control and close supervisory oversight. Certified explosive ordnance disposal (EOD) experts should assess and/or remove any suspected or confirmed explosive threats. The cost of and time required for explosive threat management should be considered in rubble management planning.

For large conflict areas, it may not be possible to deploy EOD teams at all sites. Trained safety supervisors should monitor rubble handling activities, watch for suspicious items and unstable conditions, and ensure that work stops immediately if hazards are identified. A certified Ammunition Site Safety Adviser (ASSA) or banksperson and medical personnel can be deployed to supervise the safe operation and movement of engineering plant and machinery in rubble removal sites with a low to medium risk of ERW. If an ERW hazard is identified, the ASSA has the authority to stop all work and alert the EOD team.

See guidance materials for explosive threat management:

- International Mine Action Standards, 'Technical Note for Mine Action 10.10/03: Explosive hazard risk assessment in debris management (rubble removal) operations', 2018, <www.mineactionstandards.org/standards/10-10-03>.
- UNOPS, *Management of Rubble Removal Operations in Explosive Hazard Impacted Environments: Requirements and Guidelines*, forthcoming in 2026: A quality standard to support the safe and effective management of ERW concealed within or obscured by rubble, based on UNOPS operational experience in explosive threat management and aligned with International Mine Action Standards and ISO 9001.
- Gaza Debris Management Working Group, *Guidance Note: Explosive Ordnance Risk Management for Debris Operations*, 2025.

Example:
Ensuring safe rubble management through EOD, Gaza

UNOPS, on behalf of the UN Mine Action Service (UNMAS), is supporting efforts to mitigate explosive ordnance risks associated with rubble removal operations in Gaza. This includes conducting explosive hazard assessments of sites intended for debris management activities, as well as delivering explosive ordnance risk education to rubble removal workers to help them recognize potential hazards and understand safe reporting procedures. When workers identify a suspected explosive hazard, activities in the immediate area are suspended until EOD teams can assess the situation and recommend appropriate risk mitigation measures.

Example:
Integrating explosive hazard management across all stages of rubble management, Ukraine

UNDP has been supporting the government of Ukraine in establishing an integrated debris management system that combines safe demolition, explosive hazard risk management, and circular approaches for reconstruction. This includes risk-informed debris removal procedures, specialized EO risk education training for demolition and removal personnel tailored to their specific roles, and supporting the national government to develop standard operating procedures covering the full debris management cycle to reduce risks and maximize circularity where possible. By 2025, more than 1 million tonnes of debris had been safely managed, enabling the clearance of over 1,800 damaged sites and supporting the recovery of public spaces and residential areas.

Action:
Require private contractors to engage in safe practices

Ways to ensure contracted firms engage in safe practices include:

- Require mandatory training in humanitarian principles, independent pre-engagement inspection, and third-party monitoring to ensure that works are of sufficient quality and do no harm to communities.
- Train contractors and workers to prevent and address sexual exploitation, abuse and harassment, forced labour and child labour. In post-conflict settings, teams should also receive conflict sensitivity training.
- Require contractors to implement OSH management measures. These include conducting risk assessments, organizing worker induction and toolbox talks, providing and enforcing the use of appropriate PPE, and establishing safe systems of work, incident reporting procedures, and measures to prevent violence and harassment in the workplace (see Approach 3.3.)
- Require contracted firms to maintain the minimum safety standards for mechanical work in areas with suspected explosive hazards, including hiring an accredited ASSA or bankssperson, having medical personnel on site, and developing a verified Medical Emergency Response Plan that covers casualty evacuation capability.

Example:
Supporting the psychological well-being of disaster-affected communities, Afghanistan

In Herat, UNOPS required contractors to engage both male and female psychological counsellors to provide regular counselling services to community members to help them cope with the trauma resulting from the earthquake. Services included individual counselling, group counselling, community meetings, and mental health awareness raising sessions, as well as mental health case management and referrals.

Example:
Ensuring operational safety for contractors, Ukraine

In Ukraine, UNDP has been conducting specialized EO risk education training for personnel of demolition and debris removal contractors. The training content is tailored to the specific responsibilities of each professional group, such as machine operators, demolition engineers, truck drivers, site supervisors and manual workers. They are trained in recognizing explosive hazard indicators in damaged structures and debris, safe behaviour protocols, reporting procedures, and coordination with explosive threat management specialists. This targeted approach significantly reduces risks during activities involving hazards, such as demolition, sorting, loading and transportation.

2.6

Maximize circularity while removing rubble

Objective:
Optimize implementation in complex environments

Barriers addressed:
Rubble contaminated with mixed materials

Who is this for:
Government agencies, local authorities, rubble management practitioners

Why use this:
Sorting at the source is the most effective way to maximize the recyclability of rubble

Action:
Conduct a deconstruction audit before starting demolition or deconstruction

Where possible, an audit can be carried out to assess the materials in a structure before deconstruction. This helps to evaluate the circular opportunities for materials, as well as any specialized handling requirements for hazardous materials.

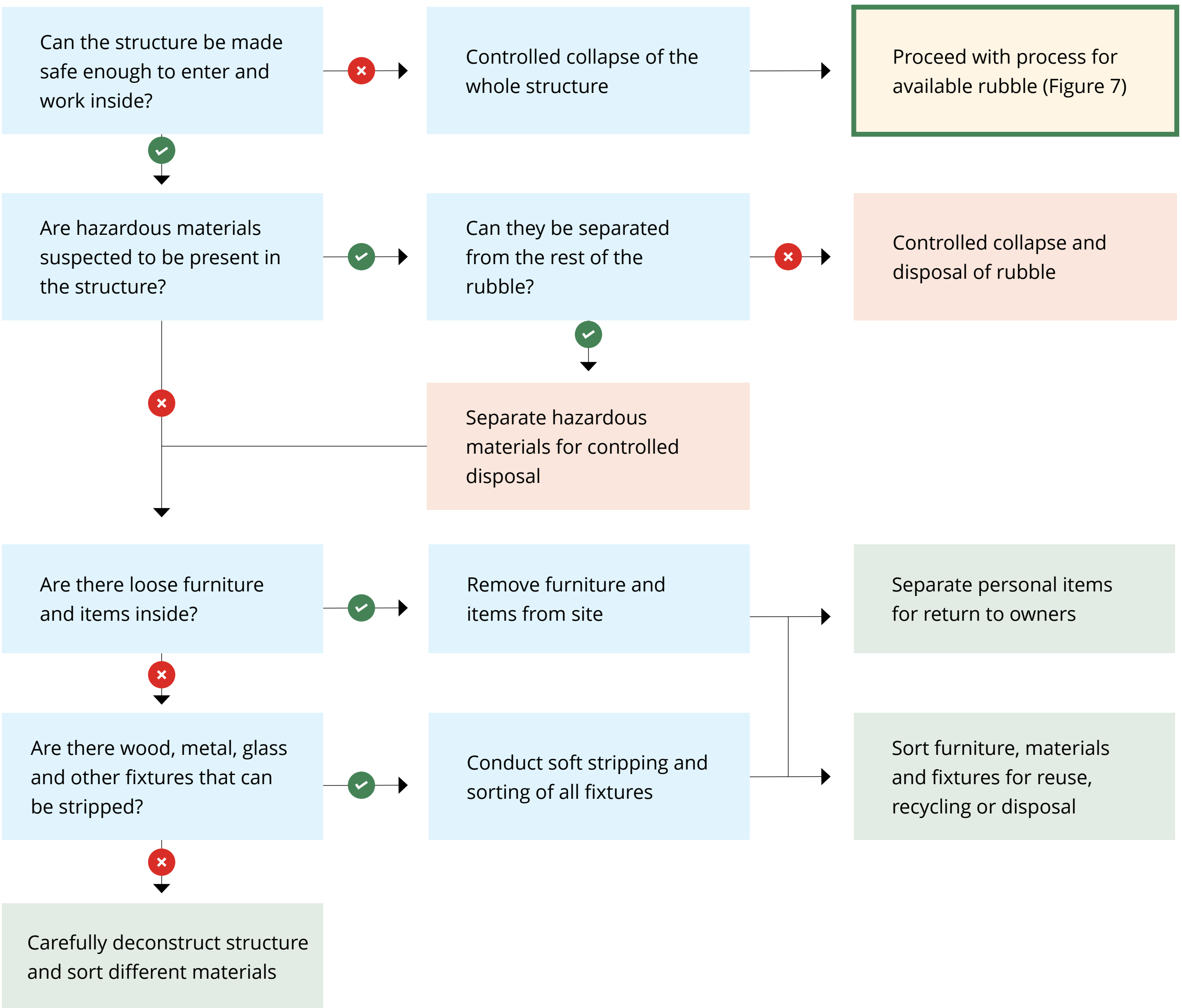
Resources

- United States Environmental Protection Agency, 'Deconstruction Rapid Assessment Tool' <www.epa.gov/large-scale-residential-demolition/deconstruction-rapid-assessment-tool>.
- Wahlström, Margareta, et al., *Pre-demolition audit - overall guidance document: PARADE. Best practices for Pre-demolition Audits ensuring high quality RAw materials*, EIT RawMaterials, 2019.
- See Annex G, Demolition Assessment Form.

Action:
Deconstruct unreleased rubble from partially standing structures

Intentional deconstruction of damaged structures is the best way to obtain clean rubble with very little contaminants for recycling into circular building materials. This should only be carried out after ensuring that the structure can be made safe enough for workers to enter and work inside. (See Figure 6)

Figure 6. Decision flowchart for deconstructing unreleased rubble from partially standing structures



Action:
Carefully plan and execute demolition of multi-storey buildings

Damaged multi-storey buildings can be very complicated to demolish and deconstruct due to lack of space, instability of the structures and specialized equipment needs. Careful planning and execution is needed to ensure the safety of workers and surrounding communities.

Example:
Advanced multi-storey demolition techniques, Japan

Japanese companies have developed demolition methods such as the Tecorep System and Kajima Cut and Take Down Method, which help reduce noise and dust generation while also improving the recycling rate of materials.

Read more:
Web Japan, 'High-Tech Demolition Systems for High-Rises: Safe & Environmentally Friendly Methods', <https://web-japan.org/trends/11_tech-life/tec130325.html>.

Resources

- United States Occupational Safety and Health Administration, 'Demolition Standards', <www.osha.gov/demolition/standards>.

Action:
Sort available rubble (debris piles and completely destroyed buildings)

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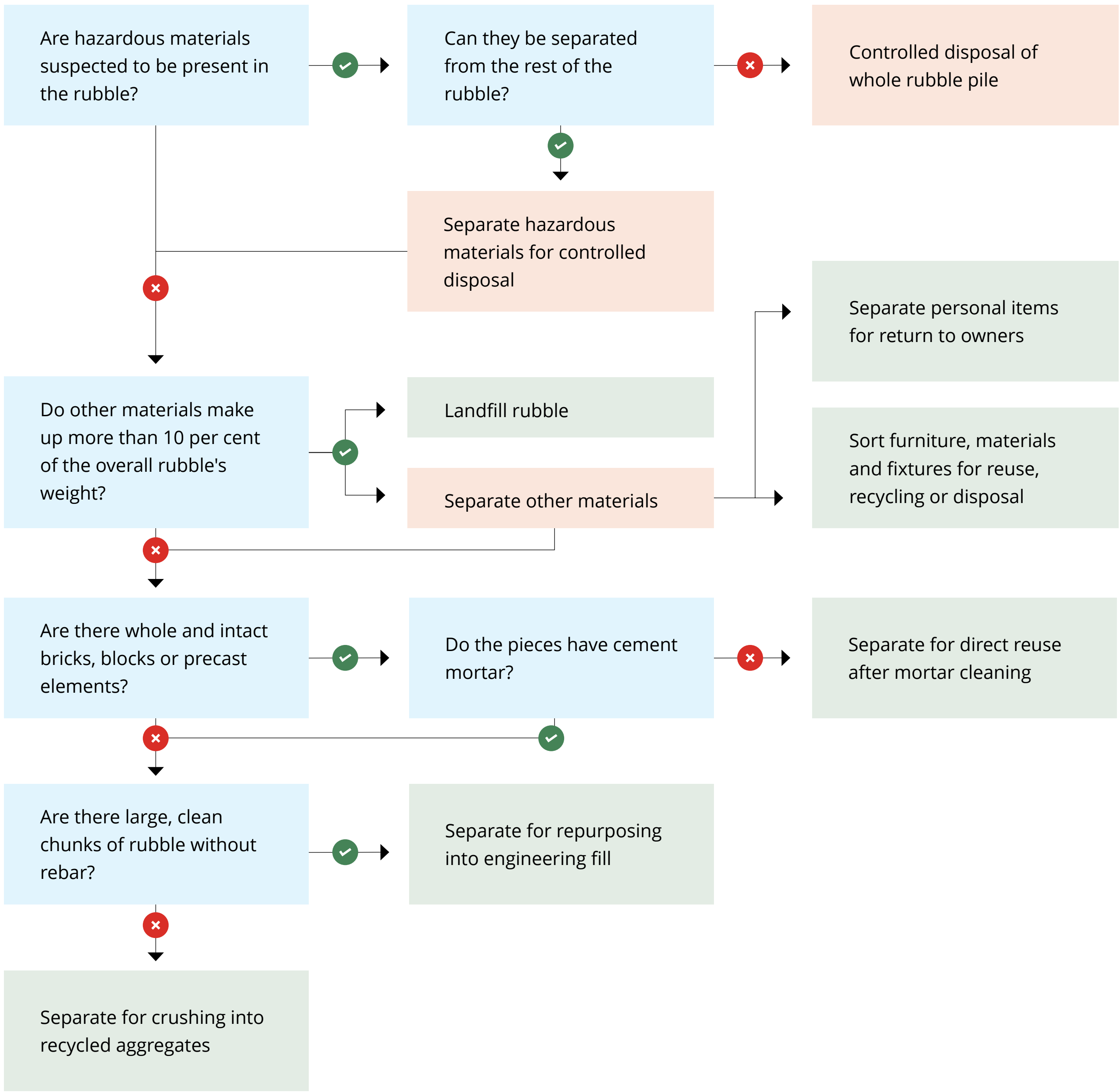
On-site sorting of available rubble can increase the efficiency of material recovery, especially when it is not significantly mixed with objects such as furniture, organic waste and other building materials. The sorting of mixed rubble may be considered depending on the selected implementation modality, type and amount of contaminants involved, cost of landfilling, and availability of construction materials.
(See Figure 7)

Resources

- See Approach 2.4 on the recovery of human remains, cultural objects, and personal belongings, as well as the marking of property boundaries before and after rubble removal.
- See Annex F for detailed options for reusing, repurposing and recycling rubble.

Figure 7. Decision flowchart for sorting available rubble from debris piles and completely destroyed buildings



Action:
Maintain information about rubble after removal

Transportation logs can help ensure that the rubble reaches the intended destination for processing, recycling, stockpiling or disposal.

Resources

- See Annex G, Loading/Unloading Ticket.
- See Annex G, Rubble and Debris Loading and Tracking Form

2.7

Apply sustainable, safe and efficient methods for recycling and reusing rubble

Objective:
Optimize implementation in complex environments; Create demand for circular materials

Barriers addressed:
Limited awareness and capacity to mitigate environmental damage; disruptions, instability and informality; health and safety risks; cost and availability of materials

Who is this for:
Government agencies, local authorities, rubble management practitioners, reconstruction practitioners

Why use this:
Improving the processing and recycling of rubble can help mitigate negative impacts and improve the affordability of circular rubble materials.

Action:
Mitigate the negative environmental and health impacts of rubble recycling and disposal

An environmental management plan should be developed for rubble processing, recycling or disposal sites. The plan should address negative environmental and health impacts such as noise, dust (especially from hazardous substances such as respirable crystalline silica and asbestos), odours, emissions and air pollution. It should also find ways to mitigate flooding on site from storm-water, the generation of litter and the attraction of vermin.

Rubble contaminated with hazardous materials such as chemicals, asbestos, and radioactive substances should be disposed of in compliance with international safety and environmental standards. Spraying and washing of hazardous rubble (such as that mixed with asbestos-containing materials) should be managed carefully to avoid contaminated run-off from seeping into the soil, which can lead to environmental damage and health risks.

Resources

- UN Environment Programme and government of Iraq, *Iraq: Environmental Management Guidelines for Debris Recycling Sites*, 2020.
- See Approach 3.3 for more information about occupational safety and health.

Action:
Explore innovative methods for sustainable and efficient rubble recycling and reconstruction

© ILO, 2024

Innovative methods for rubble recycling and reconstruction can improve the efficiency of recycling and reduce resource consumption. This can improve the affordability and accessibility of circular rubble materials for local communities. Some examples include:

- **Concrete upcycling methods:** The S3RoU consortium is developing concrete upcycling methods that include using Advanced Dry Recovery Technology, which reduces the energy needed to separate concrete components and allows more mobile applications. It is also using a heating air classification system and hybrid electric (microwave-assisted) heating technology to produce activated concrete fines from hardened cement paste.

- **Rubble blocks with coal ash:** GreenCake in Gaza produces affordable, lightweight building blocks from coal ash and war-damaged rubble, reducing reliance on imported cement or sand.
- **Rubble-based concrete for 3D printing:** Researchers at the Kyiv National University of Construction and Architecture in Ukraine are working on identifying concrete blends using rubble to be used for 3D printing of structures during reconstruction.
- **Compressed earth blocks from waste soils and rubble:** RamBrick is made of waste soil and crushed rubble that is compressed into blocks without water. This results in a low-carbon product that is also thermally efficient, soundproof and inexpensive (up to 45 per cent cheaper than fired clay bricks and 16 per cent cheaper than concrete blocks).
- **Stronger recycled aggregates through carbonation:** Recycled concrete aggregates can undergo a process of carbonation, during which carbon dioxide from the atmosphere is effectively captured through a chemical reaction with old mortar on the surface of recycled aggregates. Techniques to accelerate carbonation have been shown to enhance carbon sequestration while improving the mechanical properties and durability of RCA.

When energy supply becomes more stable, low-emission equipment can further support the sustainability of rubble management operations.

- **Electric dump trucks:** Electric trucks are being used in many countries for waste management. An electric dump truck developed in Switzerland can transport 65 tonnes of cargo while also generating more energy than it uses through a regenerative braking system.
- **Electric recycling equipment:** Some rubble crushing, screening and conveying equipment can be powered through electric and hybrid diesel-electric drives. In Germany, a recycling plant owner uses solar panels to generate energy for the electric drives powering the rubble crushing plant.
- **Zero-emission construction sites:** In Oslo, municipal construction sites are using electric machinery to mitigate emissions as well as reduce noise and air pollution.

2.8

Refuse, rethink and reduce reconstruction to minimize material consumption and rubble generation

Objective:
Optimize implementation in complex environments

Barriers addressed:
Competing priorities for action and resources; limited awareness and capacity to mitigate environmental damage; lack of technical skills and knowledge

Who is this for:
Government agencies, local authorities, reconstruction practitioners

Why use this:
People-centred circular rubble management and reconstruction aim to use fewer new materials and generate less waste, while enabling the equitable recovery of communities after disasters or conflicts. Aside from reusing rubble for reconstruction, this can also be achieved by deciding not to reconstruct, or deciding to repair or repurpose structures instead of demolishing and rebuilding. These alternative choices can also reduce the amount of time and resources used up during reconstruction.

Action:
Identify structures that don't need to be reconstructed

After a conflict or disaster, the needs of the community may change, and it may not be necessary to rebuild exactly what was there before. Developing alternative plans reduces the material consumption associated with reconstruction and is also an opportunity to develop natural infrastructure such as parks, wetlands and reserves.

- Refusing to rebuild in unsafe areas can mitigate future disaster casualties, costs and rubble generation. For example, following the 2010 and 2011 earthquakes in Christchurch, New Zealand, several areas were deemed uninhabitable and were turned into parks, outdoor community spaces and wetlands.
- Refusing to rebuild structures that had negative social and environmental impacts can help create a more sustainable, resilient and inclusive built environment. For example, the Cypress Street Viaduct was a freeway that reinforced racial segregation and increased air and noise pollution in marginalized communities. After an earthquake in 1989 damaged the freeway, local residents chose to reroute the freeway, and the Mandela Parkway was built along the previous route, serving as a green median that reconnected the previously bisected communities.

Action:
Manage existing assets to extend their lifespan

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Asset management maximizes the value of infrastructure and buildings for the benefit of communities. Some ways that this can support circularity include the following:

- Repairing, maintaining, repurposing, refurbishing, upgrading, and retrofitting structures can extend their lifespan and reduce the need for new construction.
- Digital twins and asset inventories can be used as a reference for estimating the volume and composition of rubble generated by conflicts or disasters. This can help plan rubble management activities and identify potential reuse options for various materials, as well as plan the reconstruction and repair of damaged structures.

Action:

Design structures according to sustainable, resilient and inclusive principles

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'Building forward better' during reconstruction requires an effort to establish sustainable, resilient, and inclusive infrastructure that can help communities mitigate and withstand the impacts of future conflicts and disasters. Resilience and repairability built into the design helps mitigate destruction and future rubble generation; resource-efficiency reduces consumption of resources; reusability extends the usability of materials and systems; and inclusiveness ensures the equitable recovery of communities.

Resilience and repairability in design: Structures can be designed to withstand hazards and to be easily repaired afterwards. This can be done by:

- Designing infrastructure assets to withstand hazards as well as potential cascading failures within the infrastructure systems they are embedded in; and
- Using structural fuses that are design ed to fail safely while dissipating shocks and protecting the main skeleton of a structure. As these parts can be easily unbolted and replaced, the structure can be quickly repaired, reducing the need for costly reconstruction.

Resources

- UNOPS, *Scaling Infrastructure Resilience: A Suite of Tools for Resilient Infrastructure Planning*, 2025 – recommends tools to support resilient infrastructure planning through a system-of-systems approach that considers risk across and between various infrastructure sectors.
- UN Office for Disaster Risk Reduction, *Principles for resilient infrastructure*, 2022.

Resource-efficiency in design: This aims to reduce the production of materials and the consumption of resources and energy in rebuilding and operating structures. Ways to do this include:

- Prioritizing reused, repurposed and recycled materials;
- Using energy-efficient materials and systems and passive design principles;

- Conducting life cycle assessments to analyze the potential impact of a structure in terms of carbon emissions, energy consumption and environmental burdens across the asset's life cycle;
- Designing buildings to be multifunctional to encourage higher utilization and avoid building more than necessary; and
- Using building information modelling (BIM) to help reduce material inefficiencies by streamlining systems design and quantifying materials before construction. BIM can also support analyses of thermal efficiency and structural stability, and act as an asset management library for long-term maintenance.

Reusable structures: Reusability in design aims to maximize the potential buildings and infrastructure have as future material banks. Design for Disassembly is an approach to developing structures in such a way that their parts are easier to deconstruct, recover and reuse. This can include:

- Making use of reversible connections, such as using lime-based mortar for bricks;
- Prioritizing highly recyclable materials and construction techniques, such as earthen construction;
- Designing simplified and separate building systems;
- Using local and vernacular material in building design, which local communities will know how to reuse, recycle or safely dispose of;
- Not using hazardous and difficult-to-reuse materials in reconstruction;
- Creating material passports and deconstruction plans; and
- Developing a modular design and construction of structures.

Inclusive design: Reconstruction is critical to support the recovery of communities, but it is also an opportunity to fix inequalities in the built environment. Inclusive built environments can ensure all people have access to the essential services, livelihood opportunities and social infrastructure they need to recover from the impacts of conflicts or disasters.

Resources

- UNOPS, *Infrastructure for gender equality and the empowerment of women*, 2020.
- UNOPS, *Inclusive Infrastructure for Climate Action*, 2022.
- UNOPS, International Labour Organization, UN Entity for Gender Equality and the Empowerment of Women, and Arup, *Guidelines for developing inclusive transport infrastructure*, 2023.
- UNOPS, UN Children's Fund, International Labour Organization, WaterAid and Arup, *Guidelines for developing inclusive water, sanitation and hygiene infrastructure*, 2024.
- UNOPS, International Energy Agency and Arup, *Guidelines for developing inclusive energy infrastructure*, 2024.
- UNOPS, Arup, WaterAid and African Development Bank, *Guidance for developing inclusive health infrastructure*, 2024.

3.

Mobilize local actors to allow them to benefit from circular initiatives

This objective presents a selection of five potential approaches to mobilize local actors to help them benefit from circular rubble management and reconstruction. Each approach addresses different barriers related to complex operating environments and limited capacities and systems for circularity.

Approach	Barriers addressed
3.1 Establish an information management system for coordinated rubble management	• Competing priorities for action and resources • Lack of coordination and community engagement
3.2 Support the development of a sustainable C&DW sector	• Lack of technical skills and knowledge • Lack of access to technology and equipment • Lack of awareness of rubble reuse and recycling benefits and methods • Cost and availability of materials • Decent work deficits
3.3 Enforce occupational safety and health standards	• Health and safety risks • Decent work deficits
3.4 Enable safe and meaningful community participation in rubble management and reconstruction	• Lack of awareness of rubble reuse and recycling benefits and methods • Social stigma, trauma and cultural resistance • Lack of coordination and community engagement • Health and safety risks • Decent work deficits
3.5 Identify and strengthen skills and capacities to maximize job creation in circular rubble management and reconstruction	• Lack of technical skills and knowledge • Lack of awareness and capacity to mitigate environmental damage • Social stigma, trauma and cultural resistance • Health and safety risks • Decent work deficits

3.1

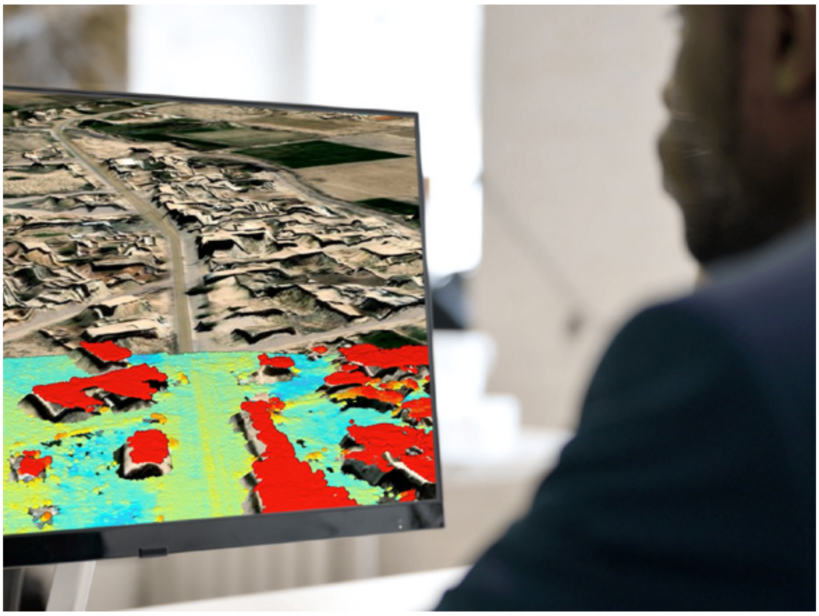
Establish an information management system for coordinated rubble management

Objective:
Mobilize local actors to allow them to benefit from circular initiatives; Optimize implementation in complex environments

Barriers addressed:
Competing priorities for action and resources; lack of coordination and community engagement

Who is this for:
Government agencies, local authorities, rubble management practitioners

Why use this:
This approach helps to coordinate priority rubble removal to enable critical operations, reduce inefficiencies and contamination due to uncoordinated rubble handling, and strengthen accountability through real-time monitoring, verification, and reporting.



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Information management systems can help implementers to effectively work in a complex operating environment by creating a centralized source of information. This can help to:

- Document planning decisions, such as priority areas for rubble removal;
- Keep track of damage, hazard and explosive threat assessments;
- Assign and track tasks to support smooth coordination between different actors carrying out connected activities (e.g., rubble removal actors can know whether a site has already been cleared of hazards before proceeding);
- Track material flows to determine how much rubble has been cleared from an area, where it is being processed or disposed of, and how much recycled material is available at any given time;
- Document assets and property boundaries; and
- Monitor, report, and verify real-time implementation progress for accountability and citizen engagement.

Resources

- UNOPS Compass – a geospatial innovation and analytics facility that supports situation assessment, planning, prioritization and monitoring during crisis response (see the example of Syria under Approach 2.3.)

Example:
Damage assessment consolidation through an information management system

Following the 2010 earthquake in Haiti, over 30 organizations conducted building damage assessments. However, these assessments were not coordinated, and the government of Haiti did not have a comprehensive overview of all the results. UNOPS supported the Haitian Ministry of Public Works in developing a national geographic information system (GIS) database containing data from 400,000 structures. This helped the government to officially designate undamaged houses as safe for reinhabitation, speeding up the return of approximately 2,000 Haitians to their homes.

3.2

Support the development of a sustainable construction and demolition waste sector

Objective:
Mobilize local actors to allow them to benefit from circular initiatives; Create demand for circular materials

Barriers addressed:
Lack of technical skills and knowledge; lack of access to technology and equipment; lack of awareness of rubble reuse and recycling benefits and methods; cost and availability of materials; decent work deficits

Who is this for:
Government agencies, local authorities, rubble management practitioners, reconstruction practitioners

Why use this:
Private sector engagement is critical to conduct large-scale rubble management works and to ensure that circular capacities become embedded into the local construction sector and materials industries.

Action:
Develop risk-sharing mechanisms for circular C&DW management between public and private actors

Governments can encourage the private sector to engage in circular C&DW and rubble management by reducing the perceived risks. This can be done by:

- Providing advance purchase agreements or demand guarantees for recycled C&DW or rubble materials at a set price;
- Developing frameworks for circular C&DW business models linked to sustainable waste management regulations;
- Implementing subsidies or levies to offset any price gaps between the raw materials and circular materials; and
- Reinvesting landfill tipping fees into recycling infrastructure and circular materials research and development.

Example:
Mobile mini C&DW crushing and processing enterprise, India

The government of Kerala in India has introduced regulations for the management of C&DW, including models wherein a public or private entity invests in mobile mini crushing units that can be transported to demolition sites. These units can be rented out to allow C&DW to be processed on site, minimizing transportation costs and enabling immediate reuse of aggregates for backfilling, sub-base layers or local construction works. Another model allows the investor to deploy the mobile units for crushing and then transport the rubble to their stockyard for reselling.

Action:
Work with civil society organizations and academia to promote circular C&DW practices

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Work with civil society organizations that have a strong rapport with the private sector to identify potential companies that are interested in engaging in circular rubble management practices, as well as to introduce or promote circular practices.

Academic institutions can also support circular C&DW practices by conducting training sessions, incorporating circular practices into learning curricula, developing research on circular materials and methods for rubble management and reconstruction, and supporting the testing and certification of circular materials in alignment with national and international standards.

Example:
Waste material exchange platform, India

The Confederation of Indian Industry (CII) developed the CII Waste Material Exchange, a platform to facilitate waste material exchange between buyers and sellers.

Action:
Provide concessional financing, subsidies and technical support to C&DW recycling enterprises

Provide green credit lines, grants, blended finance, technical assistance, or other support mechanisms to informal waste worker groups, micro, small, and medium-sized enterprises, social enterprises, NGOs, and civil society organizations to conduct circular rubble management operations.

This can also include leadership and management training in running a business, technical training in the circular process, in-kind assistance for equipment, and support with business formalization.

In exchange for assistance or grants, preconditions can be set regarding hiring local workers and requiring that enterprises continue to provide rubble management services for a fixed period of time.

Resources

- International Labour Organization, *Local economic development to facilitate the transition to formality in crisis situations – Operationalizing the Humanitarian-Development-Peace Nexus through decent work*, 2024.

3.3

Enforce occupational safety and health standards

Objective:
Mobilize local actors to allow them to benefit from circular initiatives; Optimize implementation in complex environments

Barriers addressed:
Health and safety risks; decent work deficits

Who is this for:
Government agencies, local authorities, rubble management practitioners, reconstruction practitioners

Why use this:
To support safe recovery and decent working conditions, it is critical that participation in rubble management activities is limited to tasks compatible with the level of risk and the training and protections available.

Action:
Categorize work activities by level of risk

From an occupational safety and health perspective, it is essential to distinguish between lower-risk activities that can be organized through employment-intensive modalities and higher-risk activities that require specialized teams.

- **Higher-risk activities requiring specialized teams:** Entry into unstable or partially collapsed structures, demolition of unsafe buildings, work in confined spaces, crushing operations, and the handling of explosive remnants of war, asbestos, silica-generating processes, or other hazardous materials should only be undertaken by trained and properly equipped personnel under strict supervision and with appropriate control measures in place.
- **Lower-risk activities that can be employment-intensive:** Community-based or labour-intensive work should be limited to tasks that are demonstrably safe following a hazard assessment and, where relevant, hazard clearance.

Action:
Enforce safety and health measures in the work site

Proper occupational safety and health measures can ensure that rubble management contributes not only to immediate jobs and incomes, but also to safer and more sustainable recovery. The following practical measures support safe and productive work, including in employment-intensive initiatives:

- Provide occupational safety and health training to all workers. This training should be based on the specific hazards of rubble work, including unstable structures, falling debris, sharp materials, manual handling, dust (including respirable crystalline silica), noise, heat stress, explosive hazards and, where present, asbestos and other hazardous substances.
- Provide workers with task-specific induction and daily toolbox briefings.
- Monitor and enforce safe work procedures.
- Where work may involve potentially hazardous exposures, enforce measures to safely manage hazards, including dust suppression, control of exposure to hazardous substances, and arrangements for exposure recording and follow-up.

- Provide workers with appropriate tools and personal protective equipment that fits their physiques.
- Provide access to drinking water, shade, sanitation and first aid.
- Establish simple systems for incident reporting and referral.
- Ensure that workers are not exposed to extreme heat stress.
- Provide training, enforce codes of conduct, and develop an appropriate work site design and accessible reporting mechanisms to prevent and address sexual exploitation, abuse and harassment, gender-based violence and discrimination, forced labour and child labour.
- In post-conflict environments, require contracted firms to maintain the minimum safety standards for mechanical work in areas with suspected explosive hazards, including hiring an accredited ASSA or banksperson, having medical personnel on site, and developing a verified Medical Emergency Response Plan that covers casualty evacuation capability (see Approach 2.5).
- In post-conflict settings, teams should receive conflict sensitivity training.

Resources

- International Labour Organization, *Safety and health in construction. ILO code of practice. Revised edition*, 2022.
- UN Development Programme, UN Environment Programme and Gaza Debris Management Working Group, *Dos & Don'ts: Demolition Of Damaged Buildings – Identifying potential hazards and adopting good practices in the demolition process*, 2025.

3.4

Enable safe and meaningful community participation in rubble management and reconstruction

Objective:
Mobilize local actors to allow them to benefit from circular initiatives; Create demand for circular materials

Barriers addressed:
Lack of awareness of rubble reuse and recycling benefits and methods; Social stigma, trauma and cultural resistance; lack of coordination and community engagement; health and safety risks; decent work deficits

Who is this for:
Government agencies, local authorities, rubble management practitioners, reconstruction practitioners, community liaisons

Why use this:
To support the recovery of local communities, especially marginalized groups, ensure that they benefit from and are empowered to participate in rubble management and reconstruction activities. This also helps to build social acceptance of circular processes and materials and to rebuild social trust and cohesion.

Action:
Ensure meaningful community participation and consultation with due consideration of power imbalances and structural biases

Community participation and empowerment are critical to the long-term success of any development project. Without them, there is a risk of further disenfranchising and marginalizing people who have already been negatively impacted by conflict and disaster, and of reconstructing an exclusionary, inaccessible, and culturally insensitive built environment.

Some ways to support meaningful community participation and mitigate social harms include the following:

- Map the national and local stakeholders and community groups to identify entry points for meaningful participation with regard to potential contribution, strategy and intended outcomes. The stakeholder mapping should consider power imbalances and structural biases that should be navigated to ensure social inclusion, gender equality and non-discrimination.
- Develop a participation plan as part of rubble management and reconstruction plans.
- Engage community liaisons to facilitate interactions with local communities.
- Establish grievance mechanisms and reporting channels for disputes and complaints, including for HLP issues as well as sexual exploitation, abuse and harassment.
- Document all HLP decisions and issues related to rubble management and reconstruction (such as demolition authorization, rubble removal works conducted, property disputes, etc.) and work with local authorities to protect and raise awareness of HLP rights.
- Conduct participatory and inclusive consultation processes with the local communities regarding the operations, including understanding local preferences and knowledge of construction materials and buildings or infrastructure designs.
- Establish a gender-sensitive and culturally appropriate information sharing mechanism to communicate about the operations for meaningful citizen engagement.
- Consult communities to identify structures of local historical or cultural significance and plan specialized handling during operations.
- Ensure that all contractors, grant implementing partners, and workers receive training to prevent and address sexual exploitation, abuse and harassment, forced labour, and child labour. In post-conflict settings, teams should also receive conflict sensitivity training.

Action:
Educate people about risks from hazards in rubble

It is important to educate community members, especially children and youth, about the hazards that may be present in rubble in order to reduce risk-taking behaviour and ensure they know what to do if they encounter a hazard. This can include explosive ordnance risk education, risk education on asbestos and hazardous waste, as well as general information about safety risks from falling debris, sharp materials, and heavy rubble.

Action:
Use public employment programmes to create jobs for local communities

Public employment programmes (which can include cash for work or cash for production modalities) can create formal employment opportunities for community members. They can be designed to also include informal waste pickers to improve their productivity and working conditions. Due to the risks and hazards present in rubble, such approaches must integrate strict OSH measures, supervision, and training to ensure safe and decent work opportunities.

These programmes can make an important contribution to income generation and local recovery. Even in fragile contexts, they should be designed to create decent work from the outset, in line with international labour standards and the Fundamental Principles and Rights at Work. Programmes should be designed to incorporate elements like fair and timely remuneration, clear and transparent terms of employment, respect for workers' rights (including the right to organize and engage in collective dialogue), work free from discrimination, forced labour, and child labour, and a safe and healthy work environment (see Approach 3.3).

Particular attention should be paid to providing equitable access to opportunities for women, persons with disabilities and other groups who may otherwise be excluded (see Approach 3.5 for more detailed information). Tasks should be assigned based on the level of risk and the competencies of workers, with adequate supervision. Not all work opportunities need to involve heavy manual labour; they can also include sorting of clean materials, site organization, tagging and record keeping, traffic management, community liaison, and other support functions.

Resources

- International Labour Organization, *Employment in the circular economy: Leveraging circularity to create decent work*, 2025.
- International Labour Organization, *Promotion of decent work and a just transition in the building materials industry, including cement*, 2024.
- International Labour Organization, *Policy guidelines for the promotion of decent work in recycling*, 2025.
- International Labour Organization, *Employment-Intensive Infrastructure Programmes: Labour Policies and Practices*, 1998.

Action:
Support communities to enable them to participate in circular rubble management and reconstruction

Communities can also directly participate in circular rubble management and reconstruction. Some ways to support this include the following:

- Consult and hire local craftspersons and builders to assess the rubble types and identify circular reconstruction opportunities based on the existing technical expertise and construction practices in the community.
- Provide local communities with rubble management kits that include informational pamphlets, equipment, and PPE to enable decentralized management and recycling of low-risk and non-hazardous rubble.
- Establish rubble recycling banks, markets, or stock exchanges where homeowners and contractors can sell or exchange clean and

recyclable rubble that they have removed from their homes or work sites. This may help incentivize people to sort rubble and minimize contamination, and can reduce the number of contractors being hired for rubble removal.

- Provide grants to artisans and tradespersons to create public furniture such as planter boxes or public seating using rubble materials.
- Work with youth-led and women-led organizations and other local groups to share ideas and local solutions for circular rubble management, and allow them to provide feedback on operations.
- Work with universities and research centres to explore partnership opportunities and expand access to circular solutions in rubble and waste management.
- Develop simple and culturally appropriate communications material and knowledge products to raise awareness of the social and environmental benefits of circular rubble management and reconstruction to foster ownership, commitment and active participation.
- Develop and disseminate easy-to-understand guidance and technical standards on how to safely and effectively use recycled rubble materials for reconstruction, especially in contexts where informal reconstruction is prevalent. For example, this could include recommended proportions for how much recycled aggregate can replace natural aggregate in different concrete products while retaining the required strength.

Example:
Post-Haiyan Self-Recovery Housing Programme, Philippines

Following the 2013 Typhoon Haiyan in the Philippines, CARE Philippines supported over 15,500 households in rebuilding safer homes. The programme encouraged the use of salvaged materials and locally recovered debris, including coco lumber from fallen palm trees and recycled hardwood from destroyed housing. Prioritizing local and reused materials limited reliance on imported, high-carbon construction products, reducing environmental impacts while keeping reconstruction affordable. Salvaged timber was processed locally through small chain mills, creating livelihood opportunities within affected communities. Technical guidance ensured that reused materials were safely integrated into more disaster-resilient housing designs. The approach enabled households to rebuild locally, strengthened local skills and livelihoods, and supported recovery at scale.

Read more:
World Habitat, 'Post-Haiyan Self-Recovery Housing Programme', 2017, <https://world-habitat.org/awards/winners/post-haiyan-self-recovery-housing-programme/>.

3.5

Identify and strengthen skills and capacities to maximize job creation in circular rubble management and reconstruction

Objective:
Mobilize local actors to allow them to benefit from circular initiatives; Optimize implementation in complex environments

Barriers addressed:
Lack of technical skills and knowledge; lack of awareness and capacity to mitigate environmental damage; social stigma, trauma and cultural resistance; health and safety risks; decent work deficits

Who is this for:
Government agencies, local authorities, rubble management practitioners, reconstruction practitioners

Why use this:
To maximize the positive impacts of employment opportunities for local communities and support long-term C&DW management capacities.

Action:
Identify local expertise that could support rubble management and reconstruction

In a post-disaster or post-conflict setting, it may not be easy to find people with proven rubble management experience. However, there could be skills from other industries that could form a good basis for a specific rubble management or reconstruction activity. Hiring local workers can help improve acceptance of circular materials and practices through awareness and personal involvement.

Example:
Job creation through household damage assessments

Following earthquakes in 2015, UNOPS and the World Bank supported the government of Nepal in conducting a comprehensive damage survey of more than 850,000 rural households. Over 4,000 short-term employment opportunities were created for Nepalese engineers, social mobilizers and other staff to conduct the surveys. UNOPS also procured 2,000 survey kits, tablets and additional equipment from Nepalese companies. As a result of the initiative, more than 600,000 beneficiaries were identified as eligible for reconstruction grants.

Action:
Provide upskilling opportunities to create additional value for workers

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Providing upskilling opportunities for workers in collaboration with education and training providers, particularly technical and vocational education and training providers, can encourage professional development and strengthen the community's long-term capacities for circular C&DW management and construction. Ensuring that training is relevant, certified and aligned with labour market needs can potentially mitigate the risk of fluctuating worker volumes as they receive additional value from the work. (See Table 6)

Table 6. Upskilling recommendations for rubble management and reconstruction activities

Activity	Who may have relevant skills	Upskilling recommendations
Damage assessments	Civil/structural engineers, architects, building inspectors, GIS analysts, professional engineer associations	• Training in what to do when encountering human remains or hazards • Training in adopting the damage assessment methodology • Upskilling for structural assessment with technical equipment
Explosive threat management	Organizations with expertise in demining explosives	• Partnering of international demining actors with national mine action authorities
Worker protection measures	Local labour inspectorate, employers' associations, trade unions, health workers	• Training in OSH standards
Debris and rubble sorting	Formal and informal waste management workers	• Rubble sorting procedures • Training in what to do when encountering human remains or hazards
Deconstruction of structures	Construction or demolition workers, craftspersons, masons, builders	• Training to assess the safety of structures before starting work • Training in what to do when encountering human remains or hazards • Training in handling personal possessions • Training in soft stripping, material harvesting and deconstruction • Training in managing noise, vibration and dust
Rubble processing	Construction or manufacturing workers	• Manual or mechanical methods for cleaning, sorting and crushing rubble • Standards for making construction materials with recycled aggregates
Transport of rubble	Logistics and transport workers	• Training in what to do when encountering hazards en route

Activity	Who may have relevant skills	Upskilling recommendations
Rubble reuse	Civil/structural engineers, architects, craftspersons, masons, builders	• Examples of how reused, repurposed or recycled materials can be used in reconstruction • Standards for using recycled materials to achieve the required structural properties
Disposal and landfilling	Formal and informal waste management workers	• Safe disposal methods for hazardous wastes • Training in what to do when encountering human remains or hazards

Action:

Provide equal and inclusive employment opportunities for women, persons with disabilities and members of marginalized groups

An intersectional approach is critical to providing inclusive employment opportunities for diverse communities. For instance, women with disabilities and other marginalized groups may face compounded forms of exclusion that require tailored and context-specific solutions.

Persons with disabilities often face barriers in accessing rubble reuse and recycling activities, including inaccessible work sites, limited outreach, and exclusion from training and employment. Interventions should take concrete steps to address these barriers by ensuring accessible work sites, transport, and information, and by applying accessibility standards and universal design principles in reconstruction. Providing reasonable accommodations (e.g., adapted tools, flexible roles) is essential, as is engaging organizations of persons with disabilities – not only for outreach but also to draw on their expertise in designing and implementing accessible reconstruction solutions. Setting participation targets and diversifying roles across the value chain further supports inclusive livelihoods and outcomes.

Women's participation in rubble management and reconstruction is often constrained by unpaid care responsibilities, restrictive social norms, safety concerns, and unequal access to resources and pay. Interventions should promote women's inclusion by setting participation targets, ensuring safe and gender-responsive work sites, and addressing structural barriers through childcare support, flexible work arrangements, and targeted skills training. Measures to ensure equal pay for work of equal value, prevent violence and harassment, and support women's access to leadership and enterprise opportunities are essential to achieving equitable outcomes.

Resources

- International Labour Organization, *Illustrated guidelines for gender-responsive employment intensive investment programmes*, 2015.
- International Labour Organization, *Disability Inclusion in EIIP: Stocktaking and way forward*, 2022.

Recommendations

The approaches in this guidance lead to the following recommendations for stakeholders to prepare for the management of rubble in future disasters and conflicts:

In order to create demand for circular materials:

- **Governments should enable the market for the use of sustainable materials and support the development of a sustainable and inclusive C&DW management sector.** Legalizing and incentivizing the creation of a market for recycled construction materials should go hand-in-hand with establishing a circular waste management sector that can adapt to the demands of managing disaster- and conflict-related rubble, while enforcing decent work principles and environmental protections.
- **Financiers, funders, donors and governments should subsidize the upfront costs of circular rubble and C&DW management to enable long-term sustainability benefits.** Circular rubble and C&DW management has a higher upfront cost than disposal, but can generate significant savings and benefits for communities in the long term and act as the foundation for a circular economy. Incentives, subsidies and technical assistance are necessary to help create an economy of scale for circular rubble and C&DW management.
- **Circular economy actors, civil society organizations and academics should continue to advocate for and support countries to transition to circular systems.** Discourse, coalition building, and research and development help shift perceptions and influence policy on circular materials and sustainable C&DW management.

In order to optimize implementation in complex environments:

- **Implementers, decision makers and disaster management actors should plan early for circular rubble management.** Without a plan for its reuse, rubble will be treated as waste and may become too contaminated to feasibly reuse and recycle at later reconstruction stages. Handling of rubble should be incorporated into disaster preparedness plans to mitigate operational challenges.
- **Built environment practitioners should design, build and maintain sustainable and resilient structures to mitigate rubble generation and ensure service continuity during shocks**. A resilient built environment prevents structural and system failures, protecting people, reducing rubble generation and ensuring service continuity. Sustainable water and energy systems also prevent negative environmental impacts that could be caused by resource-intensive rubble recycling. This means not only designing new structures for resilience and sustainability, but maintaining and retrofitting existing structures to better withstand future shocks and stresses.

In order to mobilize local actors to allow them to benefit from circular initiatives:

- **Governments and construction sector actors should ensure that people have equitable access to affordable and sustainable reconstruction materials after conflicts or disasters.** To support equitable reconstruction, disaster preparedness and management planning should account for disaster-induced material shortages, as highlighted in the Global Call to Action: Sustainable Building Materials Management in Post-Disaster Situations. Governments should consider how to guide people to safely and effectively reuse rubble materials, especially in informal reconstruction, which may become more prevalent after disasters and conflicts.
- **Governments should support decent job creation and the formalization of enterprises in circular waste management.** Circular waste management is often performed by informal workers. Governments should improve working conditions, provide skills development opportunities and support the formalization of C&DW enterprises.

Annex

A. Method for developing this guidance

This guidance was developed through the following steps:

1. Research was conducted on rubble management, waste management and recycling, circular economy, community engagement, and post-conflict and post-disaster recovery and reconstruction through:
   - A literature review of existing methods, case studies, standards, new research, and innovations; and
   - Semi-structured expert consultations with 44 professionals who have experience in post-conflict and post-disaster recovery and reconstruction project implementation, whose roles spanned the fields of debris management, project management, procurement, engineering and architecture, explosive threat management and mine action, GIS analysis, cultural strategy, community mobilization, social development, circular economy and more.
2. Synthesis and validation of findings:
   - A synthesis of findings to identify the barriers and map potential solutions; and
   - The validation of findings and peer review with experts and organizations working in post-conflict and post-disaster recovery and reconstruction, humanitarian works, and the circular built environment.

B. Calculation of potential savings from circular rubble management

Based on cost benefit analyses carried out by the UN Environment Programme for Mosul, Beirut, Aghdam, Northwest Syria, and Gaza,[52] this section compares the potential costs and savings between two scenarios:

1. A disposal scenario in which 100 per cent of the rubble is landfilled and needs to be replaced by new materials for reconstruction; and
2. A recycling scenario in which at least half of the rubble is recycled into reconstruction materials (60 per cent of the rubble in Beirut and Mosul, and 50 per cent in the others) while the rest is landfilled.

In order to understand the costs and benefits of both scenarios, the following formulae were used:

- Net cost of rubble management (without reconstruction) = cost of rubble management - revenue from selling recycled materials.
- Total cost of rubble management and reconstruction = cost of rubble management (e.g., removal, hauling, recycling, landfilling) + cost of purchasing construction materials.

Table B.1. Comparison of rubble management costs between disposal and recycling scenarios

Location	Rubble amount (tonnes)	Rubble management costs		Recycling is more expensive than disposal by
		Disposal scenario (Removal and hauling costs*)	Recycling scenario (Removal, hauling and recycling costs)	
Mosul	7,651,837	$33,352,555	$34,030,504	1.99%
Beirut	900,000	$16,700,000	$14,760,000	-13.14%
Aghdam	2,998,755	$4,100,000	$5,600,000	26.79%
Syria	1,480,540	$2,207,800	$2,815,500	21.58%
Gaza	57,438,348	$1,098,397,947	$1,333,232,423	17.61%

*Note: Recurring costs of landfilling were not added to the operational cost due to unavailable data and an unspecified time frame.

Excluding Beirut, all cases show that the recycling scenario has a higher operational cost than disposal, ranging from 2 to 27 per cent higher.

Table B.2. Comparison of net rubble management costs between disposal and recycling scenarios

Location	Revenue from recycled materials		Net rubble management costs (Costs in Table B.1 less revenue)		Recycling is cheaper than disposal by
	Disposal scenario	Recycling scenario	Disposal scenario	Recycling scenario	
Mosul	$0	$16,695,704	$33,352,555	$17,334,800	48.03%
Beirut	$0	$2,160,000	$16,700,000	$12,600,000	24.55%
Aghdam	$0	$2,600,000	$4,100,000	$3,000,000	26.83%
Syria	$0	$1,554,500	$2,207,800	$1,261,000	42.88%
Gaza	$0	$430,787,610	$1,098,397,947	$902,444,813	17.84%

All cases show that the revenue generated from selling recycled materials lowers the net costs of the recycling scenario by 18 to 48 per cent compared to the net costs of the disposal scenario

Table B.3. Comparison of total rubble management and reconstruction costs between disposal and recycling scenarios

Location	Cost of reconstruction materials*		Total rubble management and reconstruction costs (Costs in Table B.1 plus cost of reconstruction materials)		Recycling is cheaper than disposal by
	Disposal scenario	Recycling scenario	Disposal scenario	Recycling scenario	
Mosul	$33,391,407	$0	$66,743,962	$34,030,504	49.01%
Beirut	$4,320,000	$0	$21,020,000	$14,760,000	29.78%
Aghdam	$4,334,000	$0	$8,434,000	$5,600,000	33.60%
Syria	$2,600,000	$0	$4,807,800	$2,815,500	41.44%
Gaza	$775,417,698	$0	$1,873,815,645	$1,333,232,423	28.85%

*Note: This figure only considers the amount of new materials equivalent to the amount of recycled materials.

All cases show that using recycled rubble materials for reconstruction is cheaper than buying an equivalent amount of new materials. The total cost of rubble management and reconstruction in the recycling scenario is 29 to 49 per cent lower than in the disposal scenario.

C. Circular R-strategies applicable to rubble management and reconstruction

Application of circular R-strategies to rubble and construction materials

R strategy	How to do this for materials	When to do this
R0 Refuse	Not using hazardous and non-circular materials	When planning and designing infrastructure for reconstruction
R1 Rethink	N/A	
R2 Reduce	Reducing material use, using more efficient building materials	
R3 Reuse	Reusing building components for the same application	When salvaged materials are whole and intact
R4 Repair	N/A	N/A
R5 Refurbish	N/A	N/A
R6 Remanufacture	Disassembling high-value parts and remanufacturing them to meet original specifications	When high-value components can be collected
R7 Repurpose	Reusing rubble materials for a different purpose without additional processing	When large, clean rubble can be used as is for limited structural applications
R8 Recycle	Breaking down or crushing rubble for alternative uses	When rubble is broken, shattered, in small pieces, or mixed with rebar or mortar
R9 Recover	Incinerating non-recyclable debris to generate heat or electricity	When combustible and non-recyclable debris is segregated from rubble
Landfill	Storing rubble in a landfill as waste	When rubble is too mixed or contaminated with other materials to be recycled in a cost-effective manner

Application of circular R-strategies to damaged and destroyed structures

R strategy	How to do this for structures	When to do this
R0 Refuse	Deciding not to rebuild structures that aren't needed	When planning and designing infrastructure for reconstruction
R1 Rethink	Rebuilding structures to be multifunctional, have higher utilization, repairable, and possible to disassemble in the future	
R2 Reduce	Designing structures with more efficient building systems	
R3 Reuse	Reusing structures that are undamaged	When a structure is assessed to be safe for reinhabitation
R4 Repair	Fixing damaged structures	When a structure is assessed to be safe with minor repairs
R5 Refurbish	Updating a structure to modern standards or to be more resilient	When a structure could be made safer and more resilient to future crises
R6 Remanufacture	See previous table on materials	See previous table on materials
R7 Repurpose	Changing the original function of a structure while keeping its main structural elements intact	When a structure is still stable but its function is no longer useful
R8 Recycle	Deconstructing structures and collecting clean materials for recycling	When structures are too damaged to be repaired but still stable enough for deconstruction
R9 Recover	See previous table on materials	See previous table on materials
Landfill	Demolishing structures and collecting materials for disposal	When structures are too damaged to safely deconstruct or contain a high percentage of hazardous materials

D. Tools to support rapid damage and hazard assessments

In addition to visual assessments, tools such as hazard maps and technologies such as geographic information systems, artificial intelligence, remote sensing and drone surveillance can be leveraged to conduct rapid assessments of damage and hazards. This can help make plans and prioritize areas that require immediate intervention, including:

- Coordinated prioritization and tasking of different humanitarian actors based on the assessment of structural damage, presence of risks, and criticality or importance of the structure; and
- Site selection and route planning based on identified priority areas, available resources and accessible routes.

What is being assessed	What can be used	How it can be used
Screening potential areas for structural damage caused by seismic events	Local seismic risk maps or a combination of maps showing shaking intensity, soil condition/liquefaction susceptibility, and building vulnerability/type	Identify areas or structures at high, medium or low risk of damage from seismic events during disaster preparedness or when detailed damage assessment tools are not yet available.
	Global Earthquake Model data and models	
Identify structures with suspected major damage from earthquakes or explosive threats (unsafe or limited entry)	Interferometric synthetic aperture radar (InSAR)	High-precision assessment of structures that haven't collapsed but may have internal failures or have shifted off the foundation.
	High-resolution aerial photographs and optical satellite imagery, plus change detection software	Identify rubble and debris piles or collapsed roofs to mark destroyed structures and blocked access routes.
	Digital elevation or surface models (DEM/DSM)	Identify buildings that appear shorter than before, indicating soft story failure or collapse. LiDAR can be used for interior damage assessments.
	Light Detection and Ranging (LiDAR)	
Identify areas with potential unexploded ordnance (UXO) (non-technical survey)	Historical data on conflict (e.g., military strike logs, ACLED data), including legacy contamination data, aerial imagery from drones or satellites	Identify discrepancies between recorded strikes and the presence of craters or damaged structures; identify locations of trenches and defensive positions, which mines may be buried around.
	Data on conflict and soil maps	Identify areas where UXO may not have detonated due to soft soil.

What is being assessed	What can be used	How it can be used
Areas posing the risk of hazardous waste	Local zoning maps showing building and infrastructure types, age of structures	Flag buildings or infrastructure that may contain hazardous waste based on occupancy or age. More information in the next section.
Areas at risk of experiencing landslides	InSAR	Carry out a high-precision assessment of ground deformation and slope movements.
	Local landslide susceptibility maps	Identify areas at high risk of experiencing landslides following earthquakes.

For a follow-up assessment of specific structures, especially ones that may need more detailed checking after the initial rapid screening, non-destructive structural testing tools can be used, including rebound hammer, penetration resistance, and ultrasonic pulse velocity, among others.

Using spatial analysis to flag structures with suspected hazardous waste

It can be useful to assess the type of structure and its history where rubble is being cleared in order to determine potential risks associated with hazardous waste.

Hazardous material and examples	Type of infrastructure where these may be found in large quantities
Heavy metal-contaminated materials (lead, mercury, cadmium, chromium) • Lead: lead-based paint, roofing and flashing, solder, pipes • E-waste	• Lead: older buildings, solar panels • Industrial smelters and foundries • Electronics manufacturing plants
Hydrocarbons • Oil • Fuel	• Auto repair shops • Gas stations • Manufacturing facilities • Airport hangars • Bus depots

Hazardous material and examples	Type of infrastructure where these may be found in large quantities
Polychlorinated Biphenyls (PCBs) • Door and window caulk, grout, expansion joints, and other joint materials • Paints, sealants, coatings, varnishes, and lacquers • PCB- and asbestos-coated metal sheets, asphaltic roofing, and tar paper materials • Fluorescent light ballasts	• Power plants, substations with transformers • Older buildings, depending on the context
Paint, varnishes and solvents	• Hardware stores and DIY centres • Auto body and paint shops • Furniture workshops • Art studios and schools
Pesticides and fertilizers	• Garden centres and nurseries • Agricultural warehouses • Golf courses and sports stadiums • Pest control companies • Residential sheds and garages
Household cleaning products	• Supermarkets and grocery stores • Industrial laundries and dry cleaners • Hospitals and clinics • Residential buildings
Healthcare risk waste • Sharps waste (needles, syringes, etc.) • Hazardous chemicals or pharmaceuticals, genotoxic or radioactive substances • Pathological waste (blood, body fluids, tissues, organs) • Infectious waste (e.g., items soiled with body fluids, lab cultures)	• Hospitals, clinics and other healthcare infrastructure
Materials for making weapons and explosive devices	• Ammunitions factories • Combatant workshops (may be located in different types of infrastructure, but may be known by local authorities)

E. Detailed information about managing asbestos-containing materials

Asbestos is a group of naturally occurring silicate minerals composed of long, thin fibres. Used as a building material for its fire-resistant and insulation capabilities, it has been discovered to have adverse health effects such as mesothelioma, asbestosis, and cancers of the lung, larynx, and ovary. Due to its previously widespread use in construction, asbestos-containing materials (ACM) may be present in rubble, and asbestos dust may be released as a result of damage to structures.[53]

There is no safe level of exposure to asbestos.[54] Therefore, the primary objective of ACM management is to prevent exposure of workers and communities by safely removing, containing and disposing of asbestos in controlled landfills according to international health, safety and environmental standards. Some health and safety information to consider when removing debris and rubble with asbestos:

- Removal workers should be provided with training in handling asbestos, measures to minimize unnecessary exposures, personal protective equipment (PPE) and respiratory protective equipment (RPE). PPE alone is not enough; it must be part of a broader system of controls including training, work procedures, containment and supervision.
- Do not disturb, break, or cut ACMs unless strictly necessary and carried out under controlled conditions by trained personnel using appropriate protective measures.
- If it is necessary to move or break the materials, it is important to minimize the release of airborne fibres. This can be done by wetting the materials (making sure to capture and process the water run-off) using sealants or penetrative lockdown encapsulants, or using physical enclosures with controlled airflow.[55]
- Never burn suspected ACMs.
- Cover and wrap ACMs before disposal.
- Keep records of any exposure to ACMs at or above the permissible exposure limit (0.1 fibre per cubic centimetre of air) and support long-term health surveillance, given the long latency of related diseases.

Some ways of disposing of asbestos waste: [56,57]

- Landfilling: The traditional method of disposal includes sealing asbestos waste in specially designed landfill sites. While this method is relatively inexpensive, the asbestos remains hazardous for hundreds of years. The containers need to be continuously monitored for leaks or cracks, and take up space in landfills.
- Stabilization and solidification: Asbestos waste is mixed with cement, epoxy resins, or other binding materials to capture and immobilize the asbestos fibres. PVA glue diluted in water can be a cost-effective and easy option for immediate handling, though it is not as effective for long-term stabilization as epoxy resins. On-site solidification can help reduce transport risks.
- Biodegradation: Research is being done on the degradation of asbestos by soil microorganisms and plants, including fungi and lichens. Some lichen species can create a cap over asbestos, which minimizes the dispersal of fibres. Some fungal species can release compounds that remove iron from asbestos minerals, which is considered responsible for the inflammation and carcinogenic activity of asbestos.

While asbestos treatment and recycling are more expensive than disposal methods such as landfilling, they can significantly minimize the volume of asbestos waste. Where feasible, this is important to consider as a means to completely eliminate the risk of asbestos by converting it into non-hazardous materials. Treatment methods for recycling include: [58]

- Thermal and chemical treatment: ACMs can be made inert by altering the chemical structure of the asbestos minerals, which can occur at very high temperatures (700°-1,200° C).
  - Thermal treatment is the most established method of converting ACMs into secondary raw materials that can be used for manufacturing concrete, geopolymers, clay bricks, ceramic pigments, rock-wool glasses and magnesium phosphate cement.
  - Chemical or thermochemical treatment can denature asbestos, completely disintegrating it or transforming its structure, resulting in residues that can be used as filling materials in mortars.
- Mechanical treatment, such as high-speed milling, can also result in asbestos-free powders, which can act as a partial substitute for cement.

Resources

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F. Detailed examples for reusing, repurposing and recycling rubble materials

Reuse, repurposing and recycling are different circular approaches to maximizing the value of rubble materials. Repurposing and recycling may result in the rubble being used for purposes that have a structural or economic value that is lower (downcycling) or higher (upcycling) than before. Where possible, upcycling is preferred.

- Reuse requires the least intervention and means that the rubble is used directly for the same purpose as it originally served. This is typically applicable for clean and intact pieces of rubble that are not mixed with other materials such as mortar.
- Repurposing involves using rubble for other uses than its original purpose. This may also require little intervention such as processing and cleaning, and is typically applicable for large pieces of rubble.
- Recycling involves breaking rubble down to recover raw materials, requiring more intensive processing than reuse and repurposing.

Example reuse, repurpose and recycle applications for concrete rubble

Type	Reuse	Repurpose	Recycle
Precast concrete components	Clean, intact components can be tested and directly reused	Large pieces can be recast into new precast slabs	Small pieces may be used for pavements
Concrete masonry units	Intact, ungrouted, dry-stacked units can be reused	Intact, ungrouted, dry-stacked units can be repurposed for landscaping and public furniture	• Can be crushed into aggregate to make new masonry units • Can be crushed to make lightweight fill, ballast and road base
Cast-in-place concrete chunks	N/A	Without protruding rebar, they can be used for: • Large pieces above 300 mm: riprap, plum concrete • 100-300 mm: gabion fill	After separating metal components, they can be crushed into different particle sizes to create: • Coarse recycled aggregate • Fine recycled aggregate • Recycled concrete fines: can be used to partially replace clinker in cement • Recycled powder

Example reuse, repurpose and recycle applications for earthen construction materials

Earthen construction materials are almost completely recyclable without any loss in value, making them a unique rubble material.[59] When they are unstabilized with cement or lime, these materials are considered 'reversible', as they can be returned to the earth. Stabilized earthen materials are more similar to concrete materials.

Type	Reuse	Repurpose	Recycle
Compressed earth blocks (CEBs) (unstabilized)	After the mortar is cleaned, CEBs can be reused for interior partition walls, paving and hardscaping	After the mortar is cleaned, CEBs can be repurposed as facing/veneer bricks, garden walls and beds, fireplaces, paving, hardscaping	• Crushed and rehydrated to make workable mud for new blocks • Crushed into agricultural soil amendment
Compressed stabilized earth blocks (CSEBs)	Materials from CSEBs laid with lime or mud mortar can be obtained similar to CEBs	Landscaping, pier foundations for lightweight structures, veneers	Crushed into aggregate for new blocks, backfill and road sub-base
Adobe blocks	After the mortar is cleaned, adobe blocks can be reused for interior partition walls, paving and hardscaping	After the mortar is cleaned, adobe blocks can be repurposed as facing/veneer bricks, garden walls and beds, fireplaces, paving, hardscaping	Crushed and rehydrated to make workable mud for new blocks, earthen floor sub-layers or wall plaster
Rammed earth (unstabilized)	N/A	Large chunks can be used for landscaping	• Crushed and rehydrated to make workable mud for new blocks • Crushed into agricultural soil amendment
Rammed earth (stabilized)	N/A	Large chunks can be used for retaining walls and gabion fill	Crushed into aggregate for new blocks, backfill and road sub-base

Example reuse, repurpose and recycle applications for brick and stone masonry

Type	Reuse	Repurpose	Recycle
Clay bricks (dry-laid or bonded by lime mortar)	After the mortar is cleaned, the bricks can be reused for interior partition walls, paving and hardscaping	After the mortar is cleaned, the bricks can be repurposed as facing/veneer bricks, garden walls and beds, fireplaces, paving, hardscaping	After the mortar is cleaned, the bricks can be crushed into powder and used for pozzolan, geopolymer bricks, and sports surfaces
Clay bricks (bonded by cement mortar)	N/A	Large clumps of bricks can be used for gabion fill, landscaping	• Bricks with minimal amounts of mortar can be crushed into 10-40mm chips for decorative mulch • Brick dust and crushed bricks with mortar can be used as aggregate for road sub-base and backfill
Granite setts, cobblestone, curbstones	• Can be directly reused after bitumen/tar is cleaned • Curbstones can be reused for road edging For street applications, avoid using these stones along the path of travel to increase accessibility for wheelchair users and persons with visual impairments.	• Drainage channels, plant areas and veneer for low walls • Curbstones can be laid flat for garden steps, paving	• Larger rocks can be used for gabion fill • Can be crushed into aggregates for road sub-base, backfill, drainage

Type	Reuse	Repurpose	Recycle
Flagstones	Patios, interior flooring	Fireplace bases	• Larger rocks can be used for gabion fill • Can be crushed into aggregates for pipe bedding, landscaping mulch
Ashlar blocks	Dry-laid or bonded by lime mortar: After the mortar is cleaned, the blocks can be directly reused as facing stone or quoins, or for the repair of heritage structures	Drylaid or bonded by lime mortar: After the mortar is cleaned, the blocks can be repurposed for garden walls or sawn into thin slips for internal wall cladding	Sandstone or limestone blocks can be crushed into decorative gravel
Dry-laid stone/ fieldstone	As there is no mortar, these can be reused immediately for dry stone walls	Gabion fill	Can be crushed into aggregates for gravel
Stone sills and lintels	After the mortar is cleaned, the stone must be tested for structural integrity before being reused as window sills and door lintels	Can be cleaned and polished to be repurposed as fireplace headers, garden benches	Can be crushed into aggregates for gravel
Natural slate roofing	After removing old nails and creating new holes, it can be reused as roofing	Slightly damaged or small tiles can be used for vertical cladding	Broken tiles can be crushed for garden mulch, decorative gravel

G. Template forms and checklists

No.	Document name	Primary user	Purpose	Key data captured
1.	**Assessment & authorization**			
1.1	**Community Damage Assessment Questionnaire**	Field surveyors	Initial area screening: to conduct a rapid damage assessment at the community level to inform prioritization, planning and resource allocation	Building damage levels, building functions, construction materials, and rubble and debris removal resources
1.2	**Building Assessment Form**	Structural engineers/ technical officers	Building assessment: to technically evaluate damage and estimate resource needs for an individual structure	Damage assessment, debris and rubble volume and type, landfill access, labour requirements
1.3	**Demolition Assessment Form**	Demolition teams	Demolition planning: to plan for a specific demolition site, ensuring safety protocols are upheld and identifying destinations for rubble and debris	Destinations for and composition of rubble and debris, contamination, and on-site hazards
1.4	**Owner Demolition and Debris/ Rubble Removal Waiver**	Legal/ property owners	Demolition authorization:to secure legal permission to clear private property	Signatures of owner and demolition organization representative, and estimated start date
2.	**Site selection & evaluation**			
2.1	**Rubble Recycling Site Assessment**	Rubble teams/field surveyors	Recycling site selection: to evaluate and select suitable locations for rubble recycling operations	Land ownership, site size, topography, proximity to sensitive areas, logistical feasibility
2.2	**Rubble Disposal Site Assessment**	Rubble teams/field surveyors	Disposal site selection: to evaluate the suitability of existing dumpsites in terms of capacity, access, surroundings and current practices	Legal status, capacity, access road conditions, site surroundings, current practices

No.	Document name	Primary user	Purpose	Key data captured
3	**Operations & logistics**			
3.1	**Loading/ Unloading Ticket**	Drivers	Rubble and debris transportation logs: to maintain a chain of custody for every vehicle load of rubble and debris	Date/time, vehicle ID, GPS at source/ destination, and supervisor signatures
3.2	**Rubble and Debris Loading and Tracking Form**	Rubble and debris site supervisor	Rubble and debris load composition: to track material composition and destination of each load	Driver details, rubble and debris source, rubble and debris composition and destination for each, supervisor signatures
4	**Resources & safety reference**			
4.1	**PPE List for Hazardous Waste**	Site workers	PPE requirements: To recommend the PPE required for each type of hazardous waste	N/A – no data captured

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