UNEP

Disaster Waste Management Mechanism

A Practical Guide for Construction and Demolition Wastes in Indonesia

ISWA

ASIA PRO ECO II B

EUROPEAID CO-OPERATION OFFICE

LINGKUNGAN HIDUP

United Nations Environment Programme

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Foreword

The aim of the project - Demonstrating ESTs for Building waste Reduction in Indonesia ("DEBRI") - is to demonstrate a waste management mechanism, which will first be applied to tsunami-generated debris and would subsequently be used for day-to-day construction/demolition waste in the rehabilitation/reconstruction efforts of the affected communities in Banda Aceh, Indonesia.

The project looks at (a) technology support, (b) capacity building and (c) economic instruments. Innovative and appropriate Environmentally Sound Technologies (ESTs) for management of debris will be identified and demonstration projects on reuse and recycling will be carried out, along with training programmes for local and national stakeholders.

Within the context of the DEBRI Project, this publication serves to assist decision makers in national and local government agencies in Indonesia to understand the issue of disaster waste management. It outlines the development of a waste management mechanism that will facilitate local strategies on waste issues, bringing together knowledge and experience on existing and ongoing work on waste and debris clean-up.

The Waste Management Mechanism presented here provides the overall, larger context within which environmentally sound technologies can be used for disaster wastes.

The publication is part of the EU Funded Asia Pro Eco II B Programme. The contents included in the publication cuts across all activities of the project, and will specifically be used to implement capacity building, training and awareness raising activities.

EUROPEAN COMMISSION

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- The International Solid Waste Association (ISWA)
- Dinas Kebersihan dan Pertamanan (DKP), Banda Aceh
- Banda Aceh Municipality
- Environmental Impact Management Agency of Nanggroe Aceh Darussalam Province (BAPEDALDA) Banda Aceh
- Badan Rehabilitasi dan Rekonstruksi (BRR) NAD-Nias
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- United Nations Environment Programme and its various divisions
- DEBRI Project Team, including consultants who provided various inputs to the project's activities.

This document also benefited from the extensive work carried out by UNEP staff members in Banda Aceh during the immediate aftermath of the Tsunami, and the reports and documents produced at that time.

And finally, our grateful thanks go to the people and communities of Banda Aceh, for the inspiration and strength that they have showed in the face of tragedy.

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1 Introduction to the DEBRI Project

The DEBRI Project, "Demonstrating Environmentally Sound Technologies for Building Waste Reduction in Indonesia (DEBRI)" aims to support the reconstruction and rehabilitation in Banda Aceh through developing partnerships for the application of environmentally sound technologies (ESTs) to the treatment, reuse, and recycle of post-disaster waste, and subsequently the construction/demolition waste generated on a day-to-day basis.

1.1 Background

The Indian Ocean Tsunami hit many parts of Asia in December 2004, particularly hitting Banda Aceh and surrounding areas very hard. Besides the huge human tragedy, the tsunami also resulted in a large amount of building waste. Presently, this waste has, in most cases, been moved out of the built area and dumped into existing landfill sites to give way for reconstruction. More waste is likely to be generated as the old foundations and remaining debris are removed to construct new buildings. Not only are the landfill sites full, it is difficult to find avenues for permanent disposal of this waste.

Under the circumstances, the aim of the DEBRI Project is to support the reconstruction and rehabilitation in Banda Aceh through developing partnerships for the application of environmentally sound technologies (ESTs) to the treatment/reuse/recycle of debris waste generated by the Indian Ocean Tsunami, and subsequently the construction/demolition waste generated on a day-to-day basis. The project is executed by building partnerships with the Indonesian Ministry of Environment, and working closely with local governmental agencies, civil society organizations, technology suppliers, and other UN Agencies. The International Solid Waste Management Association (ISWA) provides expert input to the project.

The project takes a three-pronged approach, looking at the issues of technology support, capacity building and economic instruments. The project develops a waste management mechanism for handling, treatment, reuse and recycling of tsunami-generated debris, which can subsequently be applied to day-to-day construction/demolition wastes. It identifies and demonstrates ESTs for debris management, and builds capacity of local government officials in debris handling and processing. It also develops a package of economic instruments to ensure long-term viability of ESTs, and disseminates knowledge and experiences gained to other affected countries in Asia.

The project supports, and is inherently linked to, ongoing programmes and projects of the local government in the affected region. The experience gained from the project is to be shared to strengthen the ongoing post-tsunami recovery and rehabilitation work in other affected countries as well.

1.2 Objectives

To support the (a) reconstruction/rehabilitation in Banda Aceh through developing partnerships for the application of environmentally sound technologies (ESTs) to the treatment/reuse/recycle of debris waste generated by the Indian Ocean Tsunami, and (b) subsequently the construction/ demolition waste generated on a day-to-day basis. EU-Asia Pro Eco II B - Post-Tsunami Programme 2005

Specific Objectives

- To develop a waste management mechanism for handling, treatment, reuse and recycling of tsunami-generated debris, which can subsequently be applied to day-to-day construction/demolition wastes.
- To identify and demonstrate ESTs for debris management, particularly reuse/recycle technologies - including the installation of vital equipment for converting debris waste into useable aggregate for construction of buildings and infrastructure.
- To build capacity of local government officials in debris handling and processing, technology assessment methodologies, reuse/recycling and related issues using experiences and technologies from Europe, so as to ensure sustained application of ESTs in waste management not only in the post tsunami

programmes, but for everyday municipal wastes and future disasters as well.

- To develop a package of economic instruments to ensure long-term viability of ESTs, including the development of appropriate tax structures and subsidies to promote the use of aggregates generated from the waste processing, in consultation with national and local governments.
- To disseminate knowledge and experiences gained to other affected countries in Asia.

1.3 Main Activities

DEBRI Project covers 8(eight) core activities. Figure 1 shows DEBRI project flow and interdependencies among each component.

Activity 1. Baseline data creation.

As no comprehensive/reliable information on tsunami generated waste is available, conduct a study on the initiatives already undertaken/ongoing/proposed in Banda Aceh on management of tsunami-generated debris, including those that were in place for management of day-to-day construction/demolition wastes in pre-tsunami periods. One of the key aspects apparent in the immediate aftermath of the tsunami disaster was the lack of data on the quality and quantity of waste debris generated. This activity takes into account existing studies and estimates of different types of wastes generated: types of debris generated, estimates of volume generated, locations where debris are located (in-situ, temporary sites, including illegal dumps, landfill sites, including the main Gampong Jawa municipal dump site, potential hazardous and toxic wastes that may have been mixed up in the debris). This activity also studies other aspects of waste management, including existing institutional arrangements and responsibilities in clearing municipal wastes.

Activity 2. Organizational Management Planning.

Identification and securing concurrence on responsibilities of different partners in formulating and implementing the integrated waste management mechanism. Managing the debris requires clear concurrence among all the partners of the project. This activity first of all identify the various public and private sector partners to be involved in the project. It brings them together to discuss the framework of partnership among the partners. The activity also designate roles and responsibilities for each partner in meeting the objectives of the project, and in developing the waste management mechanism.

Activity 3. **Operational setting up**.

Formulation of a waste management mechanism, addressing the tsunami-generated debris, and subsequently applicable to day-to-day construction/demolition waste. The mechanism specifically elaborates the elements related to waste collection, treatment, reuse/recycle, covering aspects of policy, technology and financing. Through a series of meetings and discussions among the project partners, a waste management mechanism is formulated. This will develop a local strategy for Banda Aceh on waste issues, bringing together knowledge and experience on existing and ongoing work on waste and debris clean-up by the project partners.

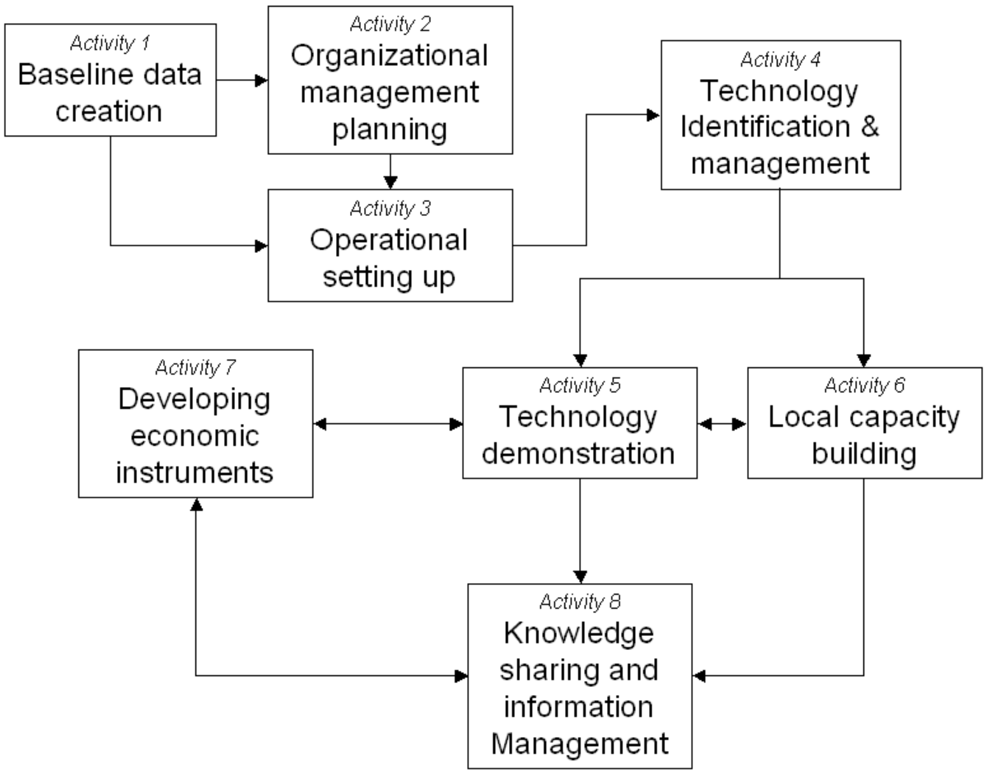

Figure 1: Activity Flows and Dependencies

It will specifically look at the issue of demolition and construction waste to develop the waste management mechanism. It will address the issues of -

- How demolition wastes can be collected, including clearing of debris, buildings slated for demolition, and foundations of buildings that need to be cleared before reconstruction can begin.
- How demolition and building/construction debris can be treated in order to make it reusable - in what form and for what purposes.
- What possible treatment will be needed - for example, separation of metal and wood, or cleaning of debris to remove soil and vegetative waste from reusable concrete blocks before crushing.
- What is the potential for reuse/recycling of the different debris categories, including concrete, brick, wood, metal, glass etc.

The above issues will be studied from the perspective of four aspects - the local and national *policy* that will be needed to carry out the activity, especially the economic instruments; the appropriate *technology* components needed for the activity; the *financing* needed to be invested to commence the activity, and the *capacity building* required for sustained implementation of the strategy.

Activity 4. Technology Identification and Management.

Identification of most appropriate and locally suited ESTs for managing and utilizing debris - particularly reuse/recycle technologies - and including identification of potential technology suppliers. Environmentally sound technologies (ESTs) are those technologies that have a minimum negative impact on the environment, in its entire life cycle from production, manufacture, use and decommissioning. This activity will identify the most appropriate ESTs that are locally suited for the context of the target area. It will also identify the barriers to use of such ESTs and the information/knowledge needed to make informed choices on technologies. The activity will focus on technology components, identified through field assessments, needed for size reduction, crushing equipment, sorting equipment, aggregation equipment etc.

The activity will identify the key factors that will have to be considered for technology selection. It will also determine the subsidiarity of decisions to be taken, and the capacity development that will have to be instituted to make such informed choices.

Activity 5. **Technology Demonstration.**

On site demonstration of vital components of ESTs for reuse/recycle of debris. While it is difficult to predict exactly what these components will be unless an on-the-ground assessment is made, it is expected that these would be technology components like size reduction/crushing equipments, sorting equipments, aggregation equipments etc. It will specifically aim to demonstrate reuse and recycling technologies for utilization by affected communities.

This activity will first of all implement a detailed assessment of the technology needs for debris management. The assessment will take into consideration the information collected in earlier activities (1 to 4), and identify the appropriate technology components that can be applied and demonstrated on the ground.

Identification of the technology components will be based on a number of criteria, including the nature of debris to be processed, the need for the aggregate generated from the crushing machines, sorting of different sizes of aggregate, and the use to which it will be put. This activity will manage technologies that will be sourced from reputed suppliers, install and commission them locally, and provide training on operation and maintenance of the technology and equipments.

The activity will look at the entire method of processing the construction and demolition waste and demonstrate reuse and recycling technologies.

Activity 6. Local Capacity Building.

Capacity building of local stakeholders viz. local government officials, civil society, technology users, by identifying target groups, developing training packages, and delivering training. This activity will be done in three stages:

- Appropriate target groups who will use ESTs, will be identified for capacity building. These users will be drawn from (a) local government agencies and representatives of national government agencies located in the Banda Aceh area; (b) the NGO sector, comprising of both local NGOs and local representative offices of international NGOs, (c) political and local leaders and associations
- Training packages will be developed to be used for capacity building of the identified target groups, using material already developed by UNEP and ISWA, and customized for Banda Aceh

Activity 7. Economic Instruments.

Identify economic barriers and develop potential economic instruments, including microfinance, for addressing those barriers in cooperation with local and national authorities. The empowerment and involvement of the target community in all aspects of the project, as decision-makers and as beneficiaries, is critical to ensure success of the project. Hence this activity is divided into two stages. The first stage will identify the essential economic barriers that may prevent both the government (in investing) and the community (in having purchasing power) to be actively involved in the project and ensure its local ownership. The second stage will explore the development of appropriate economic instruments to overcome the barriers in close consultation with local and national agencies.

Annex 3 provides a brief write-up on the contextualization of economic instruments in the DEBRI Project.

Activity 8. Knowledge Sharing and Information Management.

Establish a regional communications and knowledge sharing system, using 'Environmentally Sound

Technologies Information System (ESTIS), with associates and other stakeholders in the region. The ESTIS tool, developed by UNEP, facilitates (a) creation and management of websites on the Internet, (b) sharing and searching of information across multiple ESTIS websites, (c) publishing of information by non-web designers, (d) decentralized management of content, in local and/or multiple languages and (e) creation of a common search engine that indexes different websites created by ESTIS. The use of ESTIS will also help record progress achieved by the project, thus facilitating effective and continual monitoring and evaluation. This activity will train the project's target groups in the use of the ESTIS tool, and assist them in preparing of databases of ESTs and other practices employed during the project. This will be shared with other communities and regions affected by the tsunami.

1.4 Expected Outputs and Benefits

Overall, the proposed action will achieve the following key results:

- A waste management mechanism is established for treatment, re-use and recycling of tsunami generated debris.
- New and appropriate ESTs for debris management, particularly reuse/recycle technologies, are successfully applied and utilized in Banda Aceh in handling tsunami-generated debris. This can be seen by an increase in the amount of debris handled by using the new ESTs.
- The capacity of local government officials to handle debris and processing, technology assessment methodologies, reuse/recycling and related issues, is enhanced. This will ensure sustained application of ESTs in waste management not only in the post-tsunami programmes, but for everyday municipal wastes and future disasters as well. This will see an increasing number of local government officials who understand the issues related to technology assessment methodologies and reuse/recycling.
- A number of economic instruments to foster for long-term viability of ESTs are established, which includes the development of appropriate tax structures and subsidies to promote the use of aggregates generated from the waste processing.

- There will be improved communications, knowledge sharing and technical competence in handling ESTs by the other affected countries in Asia. This will be facilitated by use of the ESTIS tool, developed by UNEP. This will also be enhanced by sharing that will take place in regional meetings and workshops organized among the tsunami affected countries.

A number of impacts on the target groups are expected as a result of the project, particularly at the local level in Banda Aceh.

Impact on Target Groups

- Impact on house owners and other building owners/occupiers: Rehabilitation and reconstruction facilitated by removal of potential physical hazards (access restrictions, possibility of collapse) posed by the presence of destroyed buildings and construction waste.
- Impact on local public: Reduction of public health risks through the sound and environmentally safe handling, removal and disposal of disaster wastes; and additional remunerative opportunities created from waste management
- Impact on Construction and road building agencies: Increased local availability of construction
- Impact on Republic of Indonesia: Reduced demand on extracting natural resources due to availability of recycled raw materials

Technical Management Capacity

- Impact on local government: Local capacity built on developing and implementing waste management mechanisms capable of handling disaster waste and subsequently day-to-day wastes; and capacity built in formulating and implementing appropriate economic instruments for promoting recycle/reuse of construction/demolition waste
- Impact on local public: Development of facilities and management capacities to handle day-to-day construction/demolition waste; and additional market created for waste processing and using technologies/equipments
- Impact on Republic of Indonesia: Increased awareness on the scope and potential of recycling waste materials
- Impact on communities in general: Capacity built on managing and reusing demolition debris in case of future disasters

2 Disaster Waste Characteristics

2 Disaster Waste Characteristics

As highlighted by the Indian Ocean Tsunami that struck Indonesia on 26 December 2004, natural and man-made disasters can generate enormous volumes of debris, including soil and sediments, building rubble (brick, concrete and timber), vegetation (leaves, branches and trees), personal effects, hazardous materials (oil drums, asbestos and batteries), mixed-up domestic and clinical wastes and, all too often, human and animal remains.

This waste represents in many cases, a risk to human health from biological sources (flies, rodents, rotting carcasses), chemical sources (asbestos, oils, solvents) and physical sources (cuts, abrasions, collapse). The waste also impedes pedestrian and vehicle access and blocks services (drains, sewers).

Disaster wastes need to be handled in an environmentally sound manner including proper handling of scrap metals (copper, steel, aluminium), timber (for reconstruction and heating/cooking), demolition waste from buildings/structures (for re-use, re-working as an aggregate or infilling/protection material) and uncontaminated soil/sediment (for restoration or in-filling). Disaster waste materials place an additional burden on a nation or community already struggling to cope from the disaster.

2.1 Disasters and wastes

The amount and type of debris generated from a disaster varies from situation to situation, including the following:

1. **Natural Disasters**

- *Tsunami*: widespread deposition of wastes on relatively narrow coastal fringe, potentially pan-oceanic (including sub-sea deposition)

- *Earthquake*: localized generation of building material waste (and sediment from landslides) from seismic activity
- *Flood*: generally localized generation of soil, sediment and building material waste
- *Hurricane:* high-velocity winds and storm surge generally impact region of first landfall with high volumes of building material and vegetation waste being generated
- *Forest Fires:* although low volumes of waste are generated, includes building material waste; de-vegetated slopes are more vulnerable to mud-slides/landslides

2. Man-Made Disasters

- *Industrial Accidents:* generally localized, waste types dependent on chemical release (or combustion by-product)
- *Dam Breach:* similar to flood above
- *Conflict*: bomb-damaged buildings (domestic and industrial) potentially impacted by depleted uranium (DU) and unexploded ordinance (UXO)

Box 1: Tsunami-generated Debris in Banda Aceh

It has been estimated 4.7 million tonnes of recyclable demolition wastes will result from the planned recovery and reconstruction works in the Aceh Province. These demolition wastes include brick and concrete blocks that have been deposited around the buildings destroyed and damaged by the tsunami and wastes that will be generated immediately prior to reconstruction works. These demolition wastes include those derived from damaged buildings (domestic housing and commercial buildings) and infrastructure including roads and bridges.

The recycling of these wastes will have many benefits, including reduction of environmental risks, support and accelerate reconstruction works, sustainable employment generation, and demonstration and awareness-raising in waste recycling.

The nature and scale of disaster waste problem is also dependent on the event's intensity and duration, topography (coastal fringe, reclaimed land, highland), human settlements (sparse or densely populated area) and human activities (industry, farming, fishing).

The ability to respond to the disaster waste problem will be dependent on the residual status of the communities infrastructure (roads, landfills), equipment (wagons, compacter, collectors) manpower (trained operatives, waste planners) and funding.

2.2 Types of disaster waste and its implications

Vegetative debris is the largest portion of the debris produced during a disaster. These includes wastes such as trees, stumps, brush, and leaf litter that can easily be collected, stockpiled, land filled, used for firewood, as compost or as mulch. For example, the materials that remained after the recent Indian Ocean tsunami included aggregates, wood, metals, gypsum, plastics, bricks, tiles, and asbestos roofing. The materials from the construction and demolition (C&D) class of debris was largely recycled, but materials containing asbestos and other hazardous materials had to be carefully handled – but was not done so due to lack of awareness.

Two of the main classes of non-vegetative waste are aggregates, and construction and demolition debris. Aggregate debris, such as asphalt pavement and concrete, results from the destruction of roadways and other constructed land covers. These materials, if separated can be stockpiled and rescued after reprocessing them to the specifications used for road base aggregate or solid fill material.

The second class, C&D debris, is also a large component of disaster debris. This debris is the result of the destruction of homes, commercial and non-commercial buildings, and other structures. Most of the non-vegetative waste can also be reused or recycled. Any non-vegetative waste that cannot be reused or recycled is disposed in a dumpsite to avoid groundwater pollution and other problems.

Based on site-specific conditions of geology and hydrogeology, a debris disposal site could be strategically located above the groundwater table and over a layer of densely pack soil, such as clay, that would act as a barrier to leachate entering the groundwater supply.

Some debris components have specific storage and disposal requirements. For example, debris that consists of decomposing organic matter, chemicals, and fuels such as petrol, kerosene, and diesel could contaminate the groundwater for years to come unless a suitable location and dump site design is selected for disposal or burial.

These disaster wastes, as illustrated by the Tsunami disaster, can be a major barrier to quick recovery and reconstruction of affected communities and cities. Its careful handling is critical to ensure a minimum impact of the environment and its effective reuse and recycling in reconstruction processes.

3 Current Status of Disaster Waste

3 Current Status of Disaster Waste Management in Banda Aceh

A key starting point to the development of a disaster waste management plan is proper baseline data on the classification, quality, and quantity of wastes generated. The following section, presents a snapshot of the status of debris at the time of the survey in September 2007[1]. It is based on the DEBRI document, "Data Collection Guidelines"

3.1 Number of buildings destroyed

Comprehensive data on destroyed buildings/houses in Banda Aceh has not been identified and analyzed; however, the Dept of Urban Planning and Housing (Dinas Perkotaan dan Permukiman, DPP) Banda Aceh estimated that 17,286 new houses were required to be built to replace the destroyed houses. JICA URPP team and DKP (2006) estimated that Banda Aceh population in 2006 was 212.893, and the number of houses approximately 43,000 units. This means that more than 40 percent of the houses/building in Banda Aceh were destroyed during the tsunami disaster.

As a comparison, Banda Aceh's population in 2005 was 177.881, and comprised of 35.557 households. This dramatic increase was caused by urbanization and overall economic development. Furthermore DPP Banda Aceh also estimated that out of the required new houses, 3630 (8.4 percent) units were reserved for low-income households.

No comprehensive data or census information on type of the destroyed buildings is available so far. Based on aerial map representing the effect of Tsunami in Banda Aceh and field surveys, an estimation that 15 percent of the damaged building were commercial buildings (*Rukos* and other commercial buildings), and the remaining were residential

[1] The survey report was prepared by Dr. Suprihanto Notodarmojo, DEBRI Consultant

buildings, is quite reasonable. The residential houses along and near the coastal area were most severely damaged by the tsunami.

The following figures were developed based on aerial maps, field observations and discussion with local officials and experts (including BRR, BAPEDALDA, the Cleansing Department, and other agencies/organizations).

Housing (85%)

- Single storied wooden houses, estimated at 45 percent of the total destroyed housing (7,780 units), of which, 40 percent (3,112 units) were in poor condition (mixed houses in slum areas), with an average floor area of 36 m^2, and the remaining 4,668 units had average floor area of 65 m^2 per house.
- Single storied and concrete houses, estimated about 40 percent of the total destroyed housing (6,915 units). The average of floor area was 86 m^2.

Commercial establishments (15%)

- The number of single commercial establishments were estimated to be about 35 percent of the commercial establishments (908 units). Most of the commercial establishments were also being used as residences of the owner or their relatives. The average of floor area was 90 m^2
- Multi storied commercial establishments were estimated to be about 65 percent of all commercial establishments (1,685 units). The average of floor area of this type establishment was 165 m^2.

3.2 Estimating C&D waste generated by the tsunami and earthquake

The following section presents an estimation of the C&D waste generated during the disaster.

Most of the damaged and destroyed houses were either traditional wood houses (containing about 70 percent wood, 15 percent roof tiles and the remaining being mixed materials); or modern brick and concrete houses (containing 65 percent brick/concrete, 15 percent wood 10 percent roof tiles/sheets, and remaining being mixed materials).

These house characteristics were used to estimate the weight and volume of debris generated. For example for housing with roof tiles, the weight of the roof tile each square meter is between 30-40 kg, depending on the type of the roof tile used. For a modern brick house, the weight of wall per square meter is about 1,650 kg/m^3. If it is assumed that each square meter of floor has an average of 2 m^2 of wall, with a wall thickness of about 0.12 m, it generates 396 kg of rubbles per square meter of building.

The following calculations of potential C&D waste generated were used to estimate the volume of the potential C&D waste generated during the tsunami.

Box 2: Typical Wastes from Urban Structures

Wooden house

Roof	: 20-50 kg/m^2. (20 kg/m^2)
Wood structure and wall (including windows and doors).	: 30-50 kg/m^2. (40 kg/m^2)
Floor & mixed materials	: 20-55 kg/m^2. (20 kg/m^2)
Average C&D waste generated/m^2	: **80 kg/m^2**

The wood composition was assumed to be 70% of the total waste, roof tile estimated at 15% and the remains is mixed materials, including foundation.

Single modern brick house

Roof tile	: 40-50 kg/m^2.
Wood structure (incl. roof)	: 15-20 kg/m^2.
Brick wall (every square meter of floor area has an average 2 m^2 of brick wall*)	: 396 kg/m^2.
Concrete structure (5% of building area)	: 105 kg/m^2
Floor	: 165 kg/m^2
Mixed wastes	: 10 kg/m^2
Average C&D waste generated/m^2	**736 kg/m^2**

Single storied commercial establishment

Roof tile	: 50 kg/m^2.
Wood structure (incl. roof)	: 15-20 kg/m^2.
Brick wall (every square meter of floor area has an average 2 m^2*)	: 396 kg/m^2.
Concrete structure (5% of building area)	: 105 kg/m^2
Floor	: 165 kg/m^2
Mixed wastes	: 10 kg/m^2

Average C&D waste generated/m² **746 kg/m²**

Multi storied commercials establishment

An average of 2 stories were used in this calculation

Roof tile (kg/m² area of building) : 30 kg/m².
Wood structure (incl. roof) : 15-20 kg/m².
Brick wall (every square meter of
floor area has an average 2 m²*) : 396 kg/m².
Concrete structure
(7% of building area) : 115 kg/m²
Floor : 246 kg/m²
Mixed wastes : 10 kg/m²
Average C&D waste generated/m² **817 kg/m²**

Note

The following assumption is used in calculating the C&D waste to be generated by destroyed building.

* *Every square meter of floor has approximately 2 m² of brick wall or equivalent, with specific weight of 1,650 kg/m³.*

** *The specific weight of concrete used was 2100 kg/m³.*

*** *Every square meter of floor has 5 to 7% of concrete structure and foundation, which is comparable to 6.5 % for residential housing and 14 % for commercial building (of the total C&D waste). These figures are comparable to 1-8% and 10-20% of the total C&D waste estimated by Lauer et al., (1993).*

Using this figures, a modern brick house with 86 m² floor area is estimated to generate a total of 63,3 ton C&D waste, a figure that comparable to Oxfam GB (2005) estimation (50–75 ton/building).

Table 1 presents the summary of calculated C&D debris weight and volume generated during the tsunami disaster in Banda Aceh (2004).

Table1. Estimated C&D debris generated during earthquake and tsunami in Banda Aceh, 2004.

Source	Weight of C&D generated		Volume	
	Ton	%	M³	%
Single storied wooden house	29,503	4.85	95,722	13.2

Single storied brick and concrete house	290,492	47.77	315,005	43.4
Single storied commercial establishment	60,963	10.03	75,484	10.4
Multi storied commercial establishment	227,146	37.35	239,629	33.0
Total	**608,104**	**100**	**725,840**	**100**

The estimated volume of waste generated from C&D of buildings is **725,840** m^3. This amount is not including the foundation of the building. Estimating that the foundation volume is 15% of the total mass volume of the building, then the volume of the foundation is 128.090 m^3. The total volume of tsunami waste generated from destroyed building then **853,930** m^3.

The tsunami waves also scoured the bottom of the near shore, road, bridge, vegetation and soil/mud from land when it moved inward to the land, and swept away the debris when it moved backward. Oxfam GB estimated that approximately 50% of the tsunami waste consists of soil/mud/solids (30%) and vegetation (21%). This approximation was likely based on the estimate of waste already dumped in temporary dump site. Using this figure, the estimate volume of tsunami waste generated in Banda Aceh then becomes **1,742,714** m^3.

Parts of the tsunami waste were swept away by the backward wave or backward stream to the sea, leaving approximately 35 percent on the land, or **603.495** m^3 of mixed waste.

Table 2. Estimated C&D debris generated according to building type and building material

Type of structure	**Building material**	**Debris characteristic**		
		Weight [kg/m^3]	Percentage volume	Percentage weight
Single storied wooden-house	o Woods o Roof tiles o Mixed materials (including foundation	240 425 375	62.4 17.6 20.0	50.00 25.00 25.00

	and floor materials)			
Single storied brick and concrete houses	o Woods o Roof tiles o Brick o Concrete o Floor o Mixed materials	240 425 715- 1795* 950- 1800** 1100 375	7.7 13.2 45.1 12.0 18.8 3.2	2.0 6.1 53.8 14.3 22.4 1.4
Single storied commercial establishment	o Woods o Roof tiles o Brick o Concrete o floor o Mixed materials	240 425 715- 1795* 950- 1800** 1100 375	9.1 22.5 39.0 10.4 16.2 2.8	2.7 6.7 53.7 14.1 22.1 1.3
Multi storied commercial establishments	o Woods o Roof tiles o Brick o Concrete o floor o Mixed materials	240 450 715- 1795* 950- 1800** 1100 400	9.5 7.8 41.8 12.2 25.9 13.1	2.4 3.7 48.5 14.1 30.1 1.2

*. An average of 1000 kg/m^3 was used
** An average of 1100 kg/m^3 was used

Please note that the specific weight of C&D wastes is different compared to those used to calculate the previous C&D potential to be generated. The specific weight after the material becomes waste is lower than those still intact in the form of a building.

Table 3. Summary of Characteristics and material composition of C&D wastes generated by tsunami 2004 in Banda Aceh

Debris types	Details	Remarks
Wood	o Characteristics The wood debris consists of lumber and vegetation trunk and stems. The sizes	o Information and calculation are based on site survey and

	of lumber wastes are vary from normally lumber size 5x2 cm^2, 5x12 cm^2 to 9x 15 cm^2, with its length up to 3 m. Some of them already broken and in the form of small cut-off, and degraded. o Total lumber waste volume generated were 113106 m^3 or 15.6% o Total weight of lumber waste generated was 27657 tons. o Wooden houses were the major source of this type of debris.	visit, discussion with BRR staffs, UNDP staff, GTZ staff, CARE staffs, InSWA, documentation either photograph or television, Oxfam GB repots, DKP of Banda Aceh, DPP of Banda Aceh, MOE staffs, UNEP repot, local engineering consultants, and other repots.
Roof tile	o The most common roof tile used is clay - based roof tile. The size of broken roof tile is usually quite large from marble size up to 10x20 cm^2, in a form like a sheet with thickness of 0.7 to 1.0 cm. Some old houses used metal sheets (seng) as roof materials. Asbestos roof is also being used although it is not common, and quite rare. o Total volume this type of waste generated is about 271625 m^3. o Total weight of broken roof tile is approximately 37585 tons. o The sources of broken roof tile are single and modern	

	housing, since its use roof tile.	
brick	o Brick are one of the dominant C&D wastes generated during the disaster. Most housing built after 70s uses brick as the main materials, partly as a symbol of prosperity. Usually the bricks in the form of collapsed wall were to be broken down into smaller size such as rubbles, and 10 to 20 cm pieces to enable removal from the site. More than 40% of rubble and mortar were also broken into smaller nearly sand size and mixes with soil/mud. o Total volume of this type of waste generated is about 271655 m^3. o Total volume of this type of waste generated is about 298822 tons.	
Concrete	o Concrete has been used as column, ring balk and other structural components of the building, including floor for multi story buildings. Only in building more than 3 stories, the foundation may use concrete. Soon after the disaster, larger size of concrete column and concrete slabs were creating problem in removing and handling its. The sizes were varied from rubble size up to 2 m length of column and	

	more than 2.5 $m^2$of slab. Soon after the "metal scavenger" come into action, they broken down the size in order to enable the removal of valuable iron rod from the column and slabs. During the demolition of the building, the size of concrete wastes already smaller and separated from its iron rod. o The total volume of concrete waste including concrete floor (assuming 20% of floor are concrete) is 101.347 m^3. o The total weight of concrete waste generated is 111.547 tons.	
Foundation materials	o Approximately, 65% of building foundation still remains intact. The most common foundations used are stone mortared foundation. It containing about 45% of stone in a size 15 to 30 cm in diameter. The mortar use 3- 4 parts of sand and 1 parts of cement. Only small parts of foundation are removed by tsunami or by demolition. o The estimate volume of foundation waste is 128,090 m^3. o The estimate weight of foundation remains is 172,920 tons (assuming the specific weight of remains is 1350 kg/m^3).	
Mixed materials: o Plastic	o Mixed materials wastes consist of plastic, rugs,	

o Metals o Rugs and fabrics o Others	clothes, metal and other substances. Its size varies and usually not important except for metals. However some specific wastes such as medical waste and chemical waste needs serious attention due to the its potential to be hazard to human or environment. o The volume estimated is 38,766 m^3. o The weight of remains is estimated 11,330 tons.	

After being dumped to the disposal site, the C&D debris were mixed with soil/mud and vegetation debris. It is generally assumed that the mixed-waste then contains 30% of soil/mud and 21% of vegetation debris.

3.3 Current Status of debris

The estimated waste volume left after the tsunami was 603,495 m^3. This estimated volume was including the remains of building foundation. Until July 2007, the tsunami waste from Banda Aceh that was cleared and disposed to landfill sites was 461,614 m^3 (UNDP, 2007).

This leaves around 141,881 m^3 of wastes consists of un-demolished building and remains of building foundation that are still intact (covering 65 percent of the total foundation, or equivalent to 83,258 m^3).

By taking these statistics into account, it is estimated that the C&D waste still left in the form of un-demolished building or still left in temporary dumpsites in Banda Aceh is about 5,8622 m^3 (or equivalent to about 800 residential buildings). This figure matches field observations made at the end of August 2007.

3.4 Current Initiatives

3.4.1 United Nations Development Programme (UNDP)

UNDP is the institution to execute the Tsunami Recovery Waste Management Programme (TRWMP), funded by Multi Donor Fund (MDF) in a partnership with Badan Rehabilitasi dan Rekonstruksi (BRR), and is currently implemented through partnership with local government (in Banda Aceh with DKP). TRMWP was conceived to produce a coordinated pragmatic response to the public health/environmental concerns associated with both tsunami/earthquake debris and municipal solid waste (MSW) management during the rehabilitation and recovery of Aceh and Nias. TRWMP was initiated in January 2005, and effectively started in March 2005 untill now.

The expected outputs of UNDP-TRWMP are as follows:

- Capacity building in Local Government, recovery/collection & processing of MSW and tsunami waste
- Rehabilitation of existing dumpsites, provision of interim landfill, and detailed evaluation, design and construction supervision for regional & district landfills (including extend the capacity of Gampong Jawa by another 3-5 years).
- Livelihoods in waste management.

The longer term goals of the programme is to build capacity in government to implement TRWMP developed sustainable waste management systems that benefit the environment through the collection, recovery, recycling and/or safe disposal of waste materials, whilst incorporating cost recovery through the promotion of waste management related livelihoods.

3.4.2 Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ)

Under the program Support for Local Governance for Sustainable Reconstruction (SLGSR), GTZ prepared **Preliminary Design & Institutional Options for Waste Disposal** and selecting Regional Landfill site. GTZ was also initiated and developed waste bank concept. The recommended location for Regional landfill site according to GTZ is located at Montasik (desa Makmur), Aceh Besar. GTZ also initiated small scale community initiative by providing shredder and metal can compactor to be installed in Gampong Jawa landfill site.

3.4.3 Rotterdam Waste Management Plan

DKP under the auspices of Local government of Rotterdam, The Nederland, developed the Solid Waste Management (SWM) Plan. This plan is intended to be functioned as a planning document and a set of objectives, targets and related development measures, phased in short-term, medium-term and long-term activities for Banda Aceh City.

This plan covers a number of cross-cutting strategic issues and objectives, notably of a political, social, environmental, institutional, organizational, operational, technical, financial, economic and behavioural nature.

3.4.4 The Indonesian Waste Management Law

The Indonesian Parliament has reviewed and made into law a bill on waste management that includes post disaster generated waste that was enacted in May 2008.

The Law mandates a new legal framework for KLH, the line agencies and district governments in handling waste management as part of the broader environmental management process. This law is also clearly explains the government policy directions, roles and responsibilities of government at the national and district levels, as well as private organizations. It includes the adoption of 3R approach and clean technologies in reducing waste streams, incentives and disincentives as well as dispute resolution mechanisms.

The law itself classifies waste into three broad categories: domestic, similar to domestic wastes and specific wastes. The specific wastes includes hazardous waste (mixed with domestic wastes), post disaster wastes/debris, construction and demolition wastes, and other unmanaged wastes, if there is no technology available in place.

[See Annex 1 for a summary of the Law]

4 C&D Waste Management Practices

4 Review of Construction and Demolition Waste Management Practices

This section provides a general review of the construction and demolition waste management practices currently being practiced worldwide. While it does not focus specifically on disaster waste, it provides insights on how C&D wastes derived from disasters can be managed.[2]

4.1 Assessment of Existing Situation and Practices

Existing C&D management practices must be studied and understood to determine where improvements or changes are possible to be made in the overall waste management system. An organized set of steps or actions may be beneficial to better examine the existing situation, as follows:

- Review legal, regulatory, and existing policy frameworks
- Establish planning area demographics and physical characteristics
- Estimate C&D waste stream characteristics
- Identify current C&D collection practices
- Identify current C&D disposal practices
- Identify current C&D enforcement methods
- Estimate accumulated C&D wastes and disaster debris.

[2] The text of this chapter was contributed by the International Solid Waste Management Association (ISWA)

These steps are considered guidance and can be carried out to varying degrees of detail, depending on available resources, information, and waste sector data.

Review Legal, Regulatory, and Existing Policy Frameworks

As an initial step, waste planners need to review the overall solid waste regulatory and policy framework present for the planning area. This context is essential so as to determine lines of authority and responsibility, as well as the integration of programs for the management of C&D. A careful understanding of the laws, regulations, and sources of policy information is required as they pertain to C&D management and handling.

Planners should develop a listing and bibliography of the known laws and regulations related to C&D, including:

- Definitions of materials, including for disposal, processing, and reuse/resale
- Placement of C&D in unauthorized areas
- Storage and containment
- Transport and licensing of vehicles
- Permitting, location, design, operations, monitoring, and closure of disposal, transfer, and processing sites
- Collection of fees and fines.

Enforcement of laws and regulations is primarily a local government responsibility. Local governments typically are required to authorize disposal, transfer, and processing sites, to require clan-up of illegally-disposed C&D, and to enforce C&D collection and storage requirements. Local governments are also responsible for the permitting and regulation of C&D activities within their jurisdictions.

Establish Planning Area Demographics and Physical Characteristics

General planning area demographics and physical characteristics are typically readily available for most regions, either from government tracking and monitoring data or from previous studies in the region. Specific information related to C&D waste objectives may be desired in addition, including:

- Development activities and estimated growth rates within the planning area. It is important to understand whether an area is in an expansion, revitalization, or contraction/idle phase. If an area is undergoing expansion, it will be expecting significant construction activities. Similarly, if it is in a revitalization phase, significant demolition will occur, followed by construction.

- The type(s) of construction likely to occur in the planning area, and the type of contractors likely to perform these construction activities. This information will help assess the requirements for C&D regulations, collection service, and disposal facilities. For example, large contractors will have access to trucks and other equipment and will be more able to provide their own C&D collection services. These contractors may only need access to a disposal site. A small contractor or homeowner may not have access to equipment to transport heavy materials and thus, require both collection and disposal options.
- Road, highways, and other transportation limitations in the planning area. The C&D collection and disposal system will likely require that contractors, individuals, and/or specialized C&D contractors have access to authorized disposal sites. Criteria should be developed for use in evaluating potential C&D disposal, transfer, and/or processing facilities.
- Land use patterns to allow planners to understand where significant quantities of C&D materials are likely to be generated. Also, this analysis may provide preliminary indications where major C&D waste accumulations already exist (along particular roadways or in various waste piles). These will help in selecting locations for C&D disposal, transfer, and/or processing facilities.

Estimate C&D Waste Stream Characteristics

To evaluate C&D management alternatives it is necessary to know the physical characteristics and the composition of the C&D waste stream. To this end, planners should develop waste quantity and composition estimates that are as reliable as practical. In many cases, accurate information will simply not be available. If actual data are not available on existing C&D waste quantities generated and/or present, estimates can be made based on other geographic regions or jurisdictions with lesser degrees of accuracy. Alternatively, estimates can be made based on data categories, such as projected population growth rates, incomes, densities, and commercial sectors present.

Based on data from various publications, general C&D waste characteristics vary according to:

- Season and climate
- Extent of urbanization
- Income level
- Degree of industrial and commercial activities
- Degree of construction investment and urban renewal
- Frequency of disaster events (tsunamis, typhoons, earthquakes, floods, etc.).

While the composition of the C&D stream differs significantly from that of MSW, similar levels of information are generally used to make composition and generation/quantity estimates. In most cases, there is not a large existing body of data specifically detailing the compositions or quantities of C&D materials.

Types and Composition—
To evaluate C&D composition, the data for the total C&D waste stream should be separated into material types, and then types or categories. Example C&D material types are given in Table 4. Material types may vary significantly from region to region depending on typical construction practices. High levels of aggregate (concrete, soils) and masonry are to be expected in most urban centers because the primary method of construction is concrete and masonry. This type of construction typically requires significant excavations for foundations, with little room on site for regarding and/or using the excavated soils. The prevalence of plastic materials used in construction has risen significantly in the last 15 to 20 years.

Table 5 does not specifically address the presence of organic materials in C&D wastes. (Wood and plastic materials are considered non-organic in the waste management practice). In most areas C&D is composed of primarily non-organic materials such as dirt, rock, sand, masonry, concrete, metal, wood, and roofing materials. However, the level of decomposable organic materials can be significant in disaster debris as it is inadvertently mixed with the demolition/destroyed construction materials.

C&D waste stream categories/activities can be broken down as shown in Table 5. Planners should attempt to define the material types and sources/generators for all estimated quantities under each category noted. While these may be just estimates for a defined period of time, this process of categorizing allows for a better examination of the material challenges at hand. When quantity data are added (either by weights, volumes, or estimated blends of the two), calculated compositions for the C&D waste stream can be developed.

C&D Quantities—

Obtaining accurate data regarding the quantity of C&D can be a difficult task. It is common in many areas of the world for C&D to be the responsibility of the construction contractor or property owner. It is also common that the few regulations that do exist are not effectively enforced. This can lead to improper disposal and a resulting challenge to quantify and develop accurate data.

The technical literature is not replete with C&D generation estimates by country or per capita. Ranges vary from less than 0.05 kg of C&D per person per day to over 1.3 kg/person/day. These estimates are generally for ongoing C&D related to construction, remodeling, and demolition. They may not be useful for assessing the potential for reuse/recyclability of the materials present. With such a large ranges being reported international and a lack of rigorous studies, locally-based estimates are likely more accurate. Of course, literature estimates do not cover C&D from accumulated waste (roadsides, waste piles, etc.) on public and private properties, or from disaster debris.

Often the level of confidence in C&D quantity estimates is not very high, primarily due to both composition and weight/volume measurements (or estimates) used to develop the numerical values. This inherent weakness in describing the waste stream numerically should be recognized when evaluating alternatives. For example, proposed disposal sites and/or processing centers should have adequate capacity to handle the actual materials to be delivered. Planners developing the overall system to manage C&D need to take into account the variables associated with numerical quantity estimates, along with the levels of enforcement/compliance with C&D regulations and collection contract implementation.

Table 4: Construction and Demolition Example – Material Types

Material Type	**Examples**
Wood	Forming and framing lumber, stumps, plywood, laminates, scraps, flooring
Drywall	Sheetrock, drywall, gypsum,

	plaster
Metals	Pipes, rebar, flashing, steel, aluminum, copper, brass, stainless steel
Plastic	Vinyl siding, doors, windows, floor tiles, pipes, packaging, film plastic
Roofing	Asphalt and wood shingles, slate, tile, roofing felt
Aggregate	Asphalt, concrete, cinder blocks, rock, earth, soil
Masonry	Bricks and decorative blocks
Glass	Windows, mirrors, lights
Other	Carpeting, fixtures, insulation, ceramics

Identify Current C&D Collection Practices

Under some existing C&D management systems, it may be typical that much of the waste material is left as piles at project sites. If the materials are removed, it is often to an empty lot, dump site, or a roadside. Such practices do not conform with the goals of organized waste management systems nor with most existing laws and regulations. As a result, the waste collectors involved may not be forthcoming with accurate information regarding collection, possible reuse or recycling practices, and ultimate disposal. The intent of information gathering is not to identify current C&D generators and disposers who might be violators, but rather to generate sufficient information to evaluate and implement an improved C&D system.

C&D Categories/Activities	Source or Generator	Material Type (see Exhibit 2-1)	Estimated Quantity (weight/ volume)
New Construction	- Residential - Commercial - Industrial - Public Works		
Remodeling/Renewal Construction	- Residential - Commercial - Industrial - Public Works		
Demolition Projects	- Residential - Commercial - Industrial - Public Works		
Accumulated C&D	- Roadsides - Waste piles		
Disaster Events	- varies		

Table 5: Construction and Demolition Waste Stream Categories

C&D waste planners should identify information from numerous sources where practical. These sources may include:

- Solid waste system managers in various jurisdictions
- Waste collection system operators (or contractors)
- C&D contractors
- Transfer station and disposal site operators
- Building permit and development system managers
- Building contractors of all sizes
- Regulators for solid waste systems
- Property owners and leasing companies

Groups representing the construction industry, individual citizens, and property owners.

This identification step is more complex if the current collection system serves a wide range of users and is serviced by a wide range of providers. In addition to larger, well-equipped contractors, C&D collection system users may include:

- Property owners repairing, remodeling, or building their own properties
- Small contractors that do not have access to vehicles to provide transportation to disposal sites, or the medium to large equipment that would be used to store and transport C&D to disposal locations.

Where the current system includes significant amounts of improper disposal, it can be assumed that there are contractors available that could provide C&D collection services. Often it is the case, however, that many such contractors are not licensed and do not transport the material to an approved disposal site. This may be due to the unavailability of disposal sites, difficult access, or the fees/costs associated with disposal.

Identify Current C&D Disposal Practices

Current C&D disposal sites may have to be inventoried. To identify current disposal sites, the waste planner should first have discussions with and review the records of local government officials who have the authority to designate and control those sites. If authorized sites are available, then they should be documented as to location, capacity, etc. Another source of information on potential C&D disposal is from the managers of the municipal solid waste disposal system in place. Some C&D is probably allowed to be disposed of at the MSW sites, and policies regarding the acceptance of C&D at MSW sites should be reviewed.

Where established and authorized sites are not present, planners should attempt to locate the commonly used sites (whether they are authorized or not) and begin the process to document site characteristics and development of a site inventory. From the inventory may arise sites that are suitable for future permitted and managed C&D disposal.

For any current disposal site identified, the planer should obtain the following information:

- Site owner/operator contact information
- Status of permits or past authorizations, and authorizing entity

- Volume or tonnage capacities of the site, and possible areas of expansion
- Policies towards acceptance of C&D waste
- List of materials accepted
- Separation practices employed (if any)
- List of largest site users (generators and/or collectors)
- List of potential user types, large contractors, public agencies, individuals, etc.
- Fees charged for disposal.

For those sites identified that are not permitted or authorized, the planner should attempt to determine if the owner intends to allow disposal activities in the future. That is, part of the inventory process is to establish where there might be potential for siting new disposal locations, or adding existing locations to the new C&D management system. Potential cleanup efforts and control actions may need to be incorporated as well. Similarly, significant disposal activities on vacant lots and roadsides also should be documented for future consideration. However, an extensive search for these sites and dumping locations may be considered a future task.

The current disposal system for residential, commercial, and industrial wastes should be reviewed and documented in the context of C&D wastes. That is, identify the current policies regarding acceptance and record-keeping of C&D-type materials. This review should consider the different types of C&D such as general construction debris, excavation waste materials, demolition debris, and natural disaster debris. Planners should also document where a site simply disposes of these materials or if any separation practices are employed, perhaps for purposes of daily waste cover, road building, or other useful purposes.

Identify Current C&D Enforcement Methods

The planner should identify current enforcement programs that are applicable to C&D waste management. Enforcement or control authorization may be sanctioned in various agencies, such as:

- Construction and permitting
- Building construction or inspection
- Health monitoring
- Environmental monitoring
- Solid waste management
- Law enforcement, including police.

Potential enforcement agencies should be identified and interviewed, and the information documented for later consideration and use. The interviews should document current activities related to waste management, actual or perceived limitations on enforcement (such as resources, legal or regulatory obstacles) and suggestions for program changes.

Estimate Accumulated C&D Wastes and Disaster Debris

One of the most difficult challenges facing the planner is to estimate accumulated C&D waste and separately, disaster debris. Such inventories are complex due to the potential number of waste piles, lack of accurate measuring techniques (volumes, weights, and compositions), mapping approaches, resources to cover large geographic areas, and determination of responsibilities for cleanups. Decision-makers must choose whether or not to include both waste types in the waste management planning process, or whether to have accumulated waste piles left to be part of enforcement programs. However, unless the accumulated waste piles are removed or managed in a satisfactory manner, the incentives for system improvements and new program implementations may be impacted.

Conducting detailed surveys of accumulated C&D and disaster debris throughout the designated planning area, while difficult, need to be considered. Some sort of reliable information must be obtained in order to plan for its management and for future programs. One option is to conduct a survey of one or more representative areas and use that information to estimate quantities and conditions throughout a planning area.

Such surveys can be visual, handpicking, manual waste sorts, collection vehicle counts, or combinations thereof. The size of the sample area and the level of effort required should be used to establish the reliability of the resulting estimates. Such a survey might include:

- Type of waste materials and relative composition (percent by volume or weight)
- Quantity of waste materials
- Location of waste materials
- Whether materials are on public or private properties.

The level and accuracy of information collected during this stage will be beneficial when considering options to improve the C&D management system. The quantity and composition of the wastes to be managed drive the budgetary and scheduling efforts that are associated with program and construction designs.

4.2 Options to Improve C&D Waste Management

This section discusses the need to identify and assess options for C&D management and service improvements. Once collection practices are in place, the principal management methods for C&D materials are processing for reuse and recycling, and landfilling. The primary issues are who will be responsible for collection, recycling, and disposal, and who will pay for it, and which materials are best suited for recovery.

Survey Stakeholders

The collection and disposal of C&D typically involves a range of stakeholders not necessarily participating in the solid waste management system at hand. Contractors, waste collectors, and other stakeholders involved with C&D materials should be identified as part of the effort to improve C&D management and services. For example, an important group to be considered is the landowners, private and public, upon whose land much of the existing C&D has accumulated or been stored or disposed.

Involving various stakeholders is intended to draw out the key issues to be dealt with, to enhance the opportunity for cooperation within a common market or service regime, to identify economics of scale for similar work efforts and responsibilities, and to add to the quality of available information. A listing of stakeholders might include: land owners, regulators, building contractors, MSW system managers, building permit system managers, waste collection and processing system operators (or contractors), transfer station and disposal site operators, reuse/recycling groups and buyers, and various citizen groups. Waste planners should seek the below information from these stakeholder groups:

- Opinion of existing services and service provider performance
- Their ability and willingness to cooperate in the planning and implementation of improved service
- Their ability and willingness to pay for more expanded or improved C&D system

- Their ability and willingness to pay for the recycled/rcovered C&D products
- The expectations they have for quantity and quality of C&D materials
- Their attitudes and behavior in participating in experimental or pilot projects, particularly relating to use of new collection services
- Their attitudes and behavior in participating in experimental or pilot projects, particularly relating to the use of new disposal sites.

Gathering of such information can be through face-to-face meetings, telephone discussions, or written instruments for surveys. Waste planners need to allow for adequate time at the onset to gather this information, particularly on multi-year project implementation schedules.

Identify Options for Improving C&D Collection

Collection of C&D offers some challenges due to the variable characteristics of the materials and the unpredictability of their generation. In some instances, the collection methods used for C&D are similar to or the same as those used for MSW collection systems for commercial and industrial wastes. Often the same trucks and loaders employed in the construction industry are seen for C&D materials management.

Where collection most often becomes a challenge is to get generators and contractors to transport the C&D wastes to an approved transfer or disposal location, rather than leaving the waste material on-site or dumping it at a convenience location, legal or not. Secondly, such approved sites must be available. Thus, key elements to finding an effective management option for C&D is to determine how to provide a system and having incentives in place for proper transport and disposal.

To identify workable collection options for C&D, separate alternatives for different C&D materials make sense. The following are examples of the variety of collection and disposal options for the different waste categories.

- Excavation Soils. Collection and transport of excavation soils typically are managed as a subcategory of a construction project.

These materials are mostly inert and may be moved to another location on site, or they may need to be removed. When these materials remain onsite they do not become part of the C&D system.

If the soil materials are to be removed from the site, minimal processing (e.g., screening) may be beneficial for secondary markets, re-grading at other construction sites, or similar usages. Alternatively, the off-site location should be an authorized disposal site. The collection and transport of excavation materials is usually accomplished with a truck and other specialized earth-moving equipment.

Collection and transport of excavation materials and demolition waste may be more effective if left up to construction and demolition contractors. They have the specialized equipment necessary to move large volumes over short periods of time. In this instance, the C&D system needs to have existing legal and convenient disposal sites, and an adequate enforcement program in place to make sure the material is taken to the proper sites.

- General Construction and Demolition Debris. Collection of general construction debris may include a wide variety of materials such as wood, plastic, concrete, masonry, and other materials. Even though these materials generally do not contain a significant amount of putresible (organic) components, they should be disposed of at an authorized disposal site and not used as 'fill' in a re-grading activity. Collection can be done with general construction equipment, such as dual-axle dump trucks, stakebed-type trucks, or open-top container vehicles. Containers that are used to store and collect regular solid waste from larger locations (such as for commercial or industrial wastes) may also be used for C&D.

  Demolition waste can be a mixture of any material that is used in the construction of buildings and structures. It can also be material that is left behind from previous activities at the site. Demolition materials are usually removed from a site during the demolition process. However, they are sometimes stored on site for an indefinite period. Typically, demolition debris is collected and transported using trucks or solid waste containers

as described for construction debris. Small quantities are sometimes collected in the normal solid waste system.
C&D from medium to large projects usually is best managed with the same equipment used for industrial waste. One C&D option may be to consider managing this waste separately from other C&D materials. This could include making it a responsibility of an available industrial waste contractor. Similarly, locally-based commercial and industrial solid waste contractors may be well-suited for handling the C&D from small to medium-sized generators.

- Roofing Materials. Roofing materials differ by geographical region, and may contain asphalt or other sealant and insulation materials, tiles, wood, metal sheeting (e.g., corrugated), concrete, etc. Roofing material can be collected and transported in a manner similar to demolition waste.

One alternative for managing the C&D stream is to continue to rely on the property owners and contractors to deliver waste materials to proper disposal sites. While this reliance has not provided acceptable results in the past in many locations, several management practices can be implemented to enhance and improve C&D collection systems.

A significant measure is to provide convenient, authorized disposal sites. Whether these sites are landfills, transfer stations, or processing/recycling facilities, they must be available, convenient to use, well-known by potential users, and reasonably priced. Once proper disposal sites are available, an effective enforcement program needs to be implemented. Such programs would make sure that waste materials are removed from a project site and delivered to a proper disposal site.

Another management alternative is for the responsible local government to contract with a private contractor to provide C&D collection services to property owners and building contractors. In such a privatization scheme, the government could contract with one or several contractors to provide collection services for all C&D materials generated. Collection specifications could be designed for all or portions of the waste stream. Specifications would make it the private C&D contractor's responsibility to work with construction contractors and property owners for materials collection, processing and/or removal. The contractor would be responsible to transport the waste materials to the site(s) designated by the government. Such an approach may improve legal disposal and quantification of the C&D waste stream.

There are several forms of privatization for waste collection to gain improvements in proper disposal practices. For example, C&D materials can be added to the duties of a municipal solid waste contractor. Alternatively, the governmental entity could designate one or more areas in its jurisdiction and issue franchises or licenses to C&D collection contractors. A franchise, or license, to collect and transport C&D might be an exclusive arrangement that allows only one C&D collection contractor to provide services in an area. There could also be non-exclusive franchises that allow the C&D contractors to compete for business.

The waste planner needs to examine the number and kinds of operating private contractors that might offer C&D collection and disposal services, as well as the different needs of the range of users that will constitute the C&D system. Where practical, small, medium, and large users (generators) should be matched with service providers that have the proper equipment to handle such quantities.

- Container Delivery and Pick-up. Choice of the proper containers for waste material storage can lead to an effective collection system. For small-to-medium-sized commercial and institutional generators, metal or plastic rigid containers are useful alternatives. These containers range in size from approximately one cubic meter to six cubic meters. These containers are ideal for handling small to medium amounts of C&D waste materials. They have the advantage that they can be collected on the same route as the commercial and institutional customers. Also, because C&D uses are often temporary, container can be delivered and placed easily for use during the scheduled project and then subsequently removed.

- Use of Bulky Waste Collection Program. Small-to-medium amounts of C&D can be handled within the bulky waste collection procedures developed for normal solid waste collection programs. This option assumes that the existing solid waste system is flexible enough to allow users to dispose of extra, bulky wastes, and that a collection system has been matched to this subset of the waste stream. Bulky materials combined with small C&D materials can be workable because they are typically limited in quantity, can be collected with similar equipment and collection crews, and can be easily understood by the public and generators.

- Industrial Roll-Off Containers. Many industrial customers are served by large metal bins known as roll-of or drop box containers. These roll-off containers generally range in size from eight to 40 cubic meters. They are delivered to a construction site and generally are left to be filled by a construction or demolition contractor. They can also be loaded while the delivery truck is waiting. The advantage of the roll-off containers is that they allow contractors to store waste materials on an as-needed basis, saving a reloading step. The roll-off containers can be transported directly to a disposal site and then reused at another location.

- Construction Dump Trucks. Dual-axle dump trucks are commonly used in the construction industry for purposes of material deliveries and hauling away C&D and other waste components. Other trucks are used of varying size and box-type configurations. Generally, trucks are used exclusively for transport rather than for intermediate or long-term storage.

Identify Options for C&D Waste Processing

C&D waste processing can occur at a construction or demolition site, at a disposal site such as a transfer station or a landfill, or at a separate facility designed to process the waste materials into components for reuse or resale. Using estimates for the quantities and composition of materials available, the waste planner can evaluate the potential for C&D recycling. Options for C&D processing range from low technology operations to the use of high technology equipment for purposes of material separation.

- Salvaging. Depending on the common practice in the region, salvaging of C&D materials (particularly wood and metals) may already be taking place as part of efforts by the informal sector. Such activities lead to some materials not being present in the C&D waste stream to be managed. In some regions, the informal sector is not a significant player in the C&D waste management system.

  Organized salvaging means the removal of reusable items from buildings and structures prior to demolition or remodeling. Through cooperation with permit agencies and construction/demolition contractors, organized groups often are in the business of enter buildings during a specific window of time to conduct salvaging activities. Such groups may seek materials of architectural quality, functional items (such as doors, windows, marble, lumber, lights, etc.), or items of value (such as copper pipes and other metals). Waste planners may be able to identify such groups and assist in the cooperative effort to reduce the volume of materials entering the C&D waste stream through this reuse approach.

- Source Separation. Source separation practices are growing in use at new construction and major remodeling sites. Through cooperation and agreements with construction contractors, organized groups supply containers at the construction sites to make it easy for the contractor's employees to separate the C&D waste materials during the construction phases. Such containers (typically roll-off or open box containers) are meant to capture mostly homogeneous materials (e.g., scrap lumber, scrap metal, extra bricks or masonry, plastic sheeting) as a means to avoid commingling of materials at the front end, and to save the contractor the expense of removing extra materials from the construction site at the conclusion of the project.

- Concrete/Asphalt Crushing and Screening. C&D waste materials may provide the opportunity for use of rock crushing and size-reduction equipment. The equipment is typically used globally at concrete crushing plants and has been adopted to the C&D waste industry. Incoming materials may be old highway sections, sidewalks, reinforced concrete, and other concrete-like slabs of varying thicknesses, shapes, and compositions. Downsizing of the incoming materials may be by the jaw crushers, impactors, cone crushers, use of excavators with concrete pulverizer attachments, jackhammers, and other variants of these. Secondary separation and sizing may be accomplished with magnetic separators and vibrating screens (depending on the material sizing desired).

- Mixed C&D Processing. Where C&D waste materials are commingled in containers, various operators have developed sorting and separation processes to capture at least a portion of the C&D materials prior to sending the residuals on to disposal sites. In this manner, the mixed C&D waste delivered may be mechanically processed as well as manually sorted, depending on the composition of each incoming C&D load. Typically, processing begins with mechanical separation using trammel screens or disc screens, followed by magnetic separators, handpicking stations, wood shredders, and vibratory screens. Material products would include concrete, rock, dirt, sand, lumber wood, wire, and ferrous materials.

- C&D Wood Waste Processing. Wood may be a significant portion of the C&D waste stream, from both new construction sites and from land-clearing sites. Wood wastes can be processed into mulch-like products for landscaping activities. Wood chips can be used for ground covers or as fuel for boilers. Contamination from painted or treated lumber can be a problem. Acceptable materials normally include clean (non-painted/treated) lumber, trees, stumps, and other woody wastes. Ferrous materials are also present as attached to the wood. Typically, processing equipment includes with wood shredders, magnetic separators, and disc screens for material sizing.

The above C&D processing options have the capability to provide reasonable proficiency in capturing certain products from the waste stream as well as preventing a greater quantity of materials being disposed of at landfill sites.

Identify Options for Improving C&D Disposal

The potential sites for C&D disposal include dedicated C&D landfills, quarries, other land areas where fill material is desired, and sanitary landfills for municipal solid waste. These options may or may not be available due to existing laws and regulatory standards, and/or the existence of such facilities and sites. Landfills for MSW materials are designed, constructed, and operated to minimize contaminated releases to surface and ground water resources, as well as to reduce/prevent other environmental impacts such as subsurface landfill gas migration, odors, dust, and litter. Guidelines and regulations for the siting and design of MSW landfills are commonly in place for jurisdictions.

Where the C&D materials are composed of inert, non-putresible components (such as soil, rock, concrete, and masonry), environmental threats to surface and ground water resources, are significantly reduced. Where other components are present in the C&D waste stream, such as plastics, metals, sheetrock, a decision needs to be made whether it is appropriate or allowed these waste types into an inert fill area, or if it should be directed to an MSW landfill. Similarly, where putresible wastes are present such as woody plant materials (often the case with natural disaster debris and other accumulated waste piles), a decision needs to be made by the jurisdiction as to where these materials must be disposed. The decision should be based on the site characteristics, environmental contamination potential and risks, and regulatory allowances.

There may be no specific regulations for C&D disposal sites, or more often, the process to permit such a site is similar to that for the MSW landfills. To develop a C&D disposal site, a common practice is to conduct a detailed site assessment to examine the potential for environmental impacts. Site assessments follow local, state/provincial, or Federal standards and typically include full descriptions of the proposed site land uses (present and past), hydrogeological conditions (if known, or if not, then based on new field studies), and anticipated measures that the new facility will take to prevent environmental impacts. Such measures typically include construction and operational techniques, closure and post-closure designs and performance standards, monitoring, reporting, compliance activities, and in the event of a contaminant release, corrective action programs.

Where most of the materials that will be placed into a C&D disposal site are inert, non-putresible, and generally not subject to significant decomposition and settlement, the engineering and environmental standards are often significantly different than those for MSW landfills. The following standards are typical for a C&D disposal facility:

- A synthetic (plastic) liner may not be required
- Daily covering of the disposed waste materials may not be required
- A control system for subsurface landfill gas may not be required
- Leachate collection system should be in place, but a on-site treatment system may not be required
- Control of odors, dust, and litter is required
- Control of site access and disposal is required
- Leveling and compaction of disposed waste materials is required.

For example, soil materials from the C&D waste stream may be appropriate for re-grading of sites, filling of low-lying areas, or for daily cover at MSW landfills. These uses may be limited in the volume of C&D that can be used. However, filling of larger areas, such as pits and quarries, will use significant, large-scale amounts of C&D materials.

Identify Options for Accumulated Waste Materials

One of the most significant challenges facing waste managers is to determine an effective C&D collection, processing, and disposal system for accumulated wastes. Often times, vast quantities already exist on public and private lands, in part, as a result of improper disposal. Also, the occurrence of a natural disaster causes an unpredictable strain on these planned systems as the amount of material to be handled rises immediately and normal programmatic processes become difficult to implement. Both scenarios (ongoing improper disposal practices and natural disasters) result in accumulated wastes on empty lots and roadsides, widely scattered or spread out over an entire jurisdiction.
As discussed previously, waste planners need to assess the potential quantities to be managed and to what degree this accumulated waste will be included in any future waste management system and how it will be handled. Secondly and related to this issue is who will pay for the collection, processing, and disposal services of this accumulated material.

The collection, processing, and disposal of accumulated C&D materials can be managed as part of a new overall system, or as an independent approach for general clean-up purposes. Selection of either approach will affect the resources required, schedule of performance, and associated budgetary costs. With the exception of C&D materials resulting from natural disasters, most planners appear to integrate the accumulated C&D materials from improper disposal into the planned overall C&D system, allowing for additional time and resources to capture this portion of the waste stream. For C&D wastes from natural disasters, often independent approaches are required to deal with the vast quantities that require movement and transport on a more immediate level.

Where jurisdictions use (or will use) public personnel and resources for at least part of the residential and commercial MSW collection, waste planners may be able to integrate existing (where available) equipment from past clean-up projects and experienced personnel and drivers. These resources may be used to clean up the accumulated wastes in targeted zones of a municipal jurisdiction. The primary resources are:

dump trucks, front-end loaders, bulldozers, drivers, supervisors, and laborers. If these resources are to be used, then a survey of the jurisdiction should be performed to identify and inventory the areas that need to be cleared and cleaned up. This survey should be tied into a performance schedule to systematically clean up the high priority areas first, then the lower priorities. Such an approach is workable for both public and private lands, provided that access can be gained for conducting operations.

Similarly, a municipality may prefer to use one or more private contractors to clean up accumulated C&D wastes. If a private contractor is desired, the options include hiring a separate contractor for accumulated wastes only, adding the accumulated waste clean-up responsibilities to an MSW contractor, or including the responsibilities in a C&D collection and disposal contract. In any option for contracting, the scope of work must reflect the details of the responsibilities, particularly for the quantities and locations of waste materials to be handled. Also, adequate time to perform the clean-up activities is necessary. Many such projects in urban zones can take one to three years to properly collect and disposal accumulated wastes.

Coupled with the planning steps to physically remove accumulated C&D materials should be an effective enforcement program. This program could include enforcement of clean-up regulations on private or public lands, or both. Typically, enforcement programs require the implementation of new laws and regulations (or revisions thereof), and dedicated funding for enforcement. In addition, enforcement probably needs to include public or contractor services to clean up areas where the landowners refuse to do it themselves. Recovery of costs for these services is often difficult and needs to be budgeted accordingly. For public land areas requiring clean ups, the responsible jurisdiction would likely be required to clean up their properties.

Identify Options for Improving C&D Enforcement

Enforcement programs to improve C&D management can be challenging where little to no enforcement was employed in the past. It is usually cheaper for a generator to leave C&D wastes at the project site location or to dump it nearby if there is little enforcement to prohibit such actions. Effective rules, clearly written and applied based on existing regulations can lead to successful enforcement. Also, provision of incentives for performance improvements is a proven technique. Even if a jurisdiction chooses to provide all collection and disposal services to C&D generators (individuals, construction contractors, etc.), enforcement programs should be in place to ensure compliance. The more a jurisdiction relies on the C&D generators to provide their own C&D waste collection, more enforcement generally will be required. Enforcement programs to assure proper collection and disposal of C&D can be the responsibility of several agencies within a local government or jurisdiction.

- Building Permit Agencies. Permit writers often have a keen knowledge of local construction activities (both planned and underway) and of the contractors. Building inspectors may have site access, construction plans and schedules, and can make on-site observations of C&D waste handling practices (particularly storage, processing, and transport). On the other hand, not all builders obtain proper permits. Once the C&D is transported off-site, the building inspector has little control over the C&D materials.
- Solid Waste Management Agencies. Because many local governments provide their own MSW collection and street sweeping services, their employees can observe wide areas of the jurisdiction to monitor and report on illegal C&D disposal practices. With proper training in this regard, the employees can provide an important and cost-effective function on behalf of the C&D system. Alternatively, specific employees can be trained as stand-alone inspectors because they have familiarity with solid waste and general waste handling practices. Inspectors need to be aware of active construction taking place, as well as likely areas for illegal disposal. A counter argument to the use of regular solid waste collection forces is that these personnel have a priority to provide services rather than enforcement. Collection schedules and pick-up performance are the key priorities. In their positions, they will likely have limited authority apply to enforcement and thus have only limited problem-solving capabilities.
- Environmental Management Agencies. In some cases, governmental environmental agencies can be used to enforce the C&D regulations, particularly for illegal disposal events. Inspection agents must be trained in enforcement techniques, knowledgeable about C&D waste streams and practices, and familiar with C&D disposal locations.
- Special C&D Inspectors. A new agency or department could be created to monitor, inspect, report, and enforce C&D regulations. Trained inspectors could be provided with the

resources and authority to carry out the performance standards desired. This option would add additional costs and might overlap with other jurisdictional programs. In some ways, special inspectors as a department or unit may constitute an advantage to a jurisdiction for purposes of budgeting and performance. That is, staffing of the unit can be increased or reduced as a function of the scope of the problem.
The focus of such units would be primarily on solid waste management (and possibly, more broadly, environmental) programs. Their activities could be linked to monitoring of contractor performance and contract scopes of work where privatization of waste management services is a portion of the overall system. Thus, their duties could be structured to perform field inspections of all areas of solid waste management, particularly where illegal storage or disposal is most prevalent. Specialized training could be provided to include MSW, C&D, hazardous, and/or medical wastes so that multiple programs would receive effective monitoring for the same or similar geographic areas.

- Police Departments. Police departments should be aware of waste management rules and regulations so as to be able to identify illegal practices when they occur. Their personnel have the authority to enforce the laws. However, there are many different specialties within law enforcement (e.g., traffic, crimes, anti-littering, etc.) and as a result, C&D wastes may be a low priority.

Typically, any of the above agencies (or combinations thereof) could be used to enforce a C&D program. Waste planners need to look at the historical success of similar enforcement approaches and take into account practical approaches to improving disposal performance. For C&D programs in many countries, enforcement generally is assigned to building permit agencies, local building inspectors, nuisance/littering inspectors, or solid waste program managers. Few governments use police departments exclusively to enforce waste disposal violations.

Enforcement agencies and personnel need to have adequate resources. These include sufficient staffing and the right tools to be effective (such as for communications, transportation, monitoring equipment, and recordkeeping). C&D waste enforcement should be a primary responsibility rather than simply another assigned duty.

5 Lessons Learnt in Managing Disaster Wastes

5 Lessons Learnt in Managing Disaster Wastes

Preparing a disaster debris management plan in advance can pay off in the event of a natural disaster. Such planning can help a city or community identify its debris collection, recycling, and disposal options. Although the recovery process can take a long time, perhaps even years, careful planning will prevent costly mistakes, speed recovery, and avoid creation of more waste.

A plan also can save money by identifying cost-effective debris management options and sources of help, increasing control over debris management in the city or community, and improving administrative efficiency.

The following suggestions[3] for disaster debris planning are based on insights from city and community officials who have experienced natural disasters.

5.1 Make a Long-term Debris Management Plan

Every city or community consulted suggested increasing existing emergency planning to include long-term debris management. Because natural disasters can generate tremendous quantities of debris, cities and communities should plan for the worst case. Any plan should include a detailed strategy for debris collection, temporary storage and staging areas, recycling, disposal, hazardous waste identification and handling, administration, and dissemination of information to the public.

The plan and work involved, needs to be distributed to personnel from all concerned local agencies to ensure that it is implemented quickly and smoothly. The plan is also reviewed and revised at least once a year as needed.

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[3] Adapted and expanded from California Disaster Waste Management Planning, 2006.

5.2 Consider Mutual Aid Arrangements

Mutual aid arrangements between cities and between communities, allow quick access to specialized personnel or equipment on a short-term basis. Usually the host city pays the expenses for the personnel as well as any maintenance or repair costs for equipment. These agreements can be developed for a local geographic area or can extend to cities in other states. The agreements can be formal or informal.

5.3 Implement Recycling Programmes

Implementing a plan for recycling disaster debris is much easier if a city or community already has a recycling program in place. As a result, permits, enforcement, collection, processing, and marketing issues will already have been largely resolved. After a disaster, the community will be faced with expanding current recycling practices rather than designing and implementing new practices. It is much easier to expand existing capacities and markets than to start these endeavors in the wake of a disaster.

5.4 Update the City's Solid Waste Management Plan

It is important that a city's solid waste management plan reflect current practices and policies, especially those that apply in disaster situations. The plan is an official document that often is filed with the city office, and when regional solid waste services or facilities are involved, a copy often is provided to neighboring cities as well.

It can also be beneficial to share the plan with private contractors and other community agencies (e.g., fire and police) that in the event of a disaster would be involved with solid waste management services. Should a disaster occur, supporting agencies would find the plan useful because it describes established practices and policies, as well as the types, locations, and capacities of existing solid waste recycling and disposal facilities.

5.5 Develop a Communication Strategy

A communication strategy needs to be prepared ahead of time. Government officials will need to tell the community when, where, and how trash collection will resume, as well as provide special instructions for reporting and sorting disaster debris. Many cities and communities have prepared radio announcements and flyers as part of their emergency plan.

Depending on the type and severity of the natural disaster, however, a city or community may lose electricity, telephone service, radio broadcasting capability, or newspaper service. Therefore, there should be more than one method of communication. Local media also need to be involved in the use of free advertising time and space to communicate instructions in the event of a disaster.

5.6 Prepare for Increased Outreach and Enforce Staffing Needs

In the aftermath of a natural disaster, waste management staff must handle an increased number of telephone calls and requests concerning waste removal. Communities need more staff to train and monitor debris collection contractors, enforce disposal restrictions, and help solve implementation problems. The use of members of the community itself as a temporary source of labour should be considered, especially for low-income households.

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Box 3: Disaster Waste Planning Issues

Based on the experiences of local and national government agencies that face natural disasters, proper planning and management of waste during both the pre-disaster and post-disaster stages is very critical to speed up recovery and to avoid long term environmental problems. A number of issues need to be taken into account for this purpose.

Planning issues to be considered

The following issues can be incorporated into disaster waste management planning process:

1. The disaster waste planning process can be used to estimate the magnitude and composition of likely wastes from a range of disaster scenarios. Attention should be given to components with potential health and environmental impacts such as chemical contamination from commercial premises, wastes from health care institutions, asbestos and other substances commonly included in buildings, spilt fuels and oils, agricultural chemicals from stores and farms. Also included is any residues generated by damage to waste disposal facilities themselves, such as floods sweeping away a garbage dump. Wastes arising from chemical or fuel transport accidents should also be considered.

2. Vulnerability of municipal and commercial waste facilities, including landfills and dump istes, to natural disasters. Landfills on low-lying ground, transfer stations on the shoreline, wastewater treatment plants at the base of steep hillsides are just some examples.

3. Identification of potential temporary storage or disposal areas for large volumes of inert solid debris close to where such waste might be generated – i.e. towns and industrial zones. It is unlikely that debris will be carried very far during a time of crisis.

4. Identification of additional removal, transport and handling personnel and equipment that might be called upon (and that would not already be employed in other aspects of humanitarian crisis relief). In effect, emergency services should have a stand-by list of resources able to address immediately the waste management functions, and know the land areas available for storage/disposal.

5. Identification of how possible separation and recovery of potentially valuable waste components might be carried out. As well as providing secondary materials for reconstruction, such operations provide some employment relief for victims who have otherwise lost their livelihood. Ownership, resale or donation conditions of such recovered waste should also ideally be pre-determined during the planning process to avoid unpleasant situations during the crisis.

6. Training of non-waste personnel to assume waste management functions during a crisis.

7. Identifying wastes that might arise from a large-scale disaster relief operation, especially medical, health-care wastes and any equipment that will eventually be discarded.

8. Large industrial sites in areas struck by disasters cause especially difficult circumstances as regular municipal authorities have little experience in handling the debris from industrial plants or transport accidents. While the expertise in the industry can assist, there remain legal liability questions, and a lack of facilities that can accommodate such special wastes. These circumstances need to be explicitly planned for.

9. Integration of the normal waste generated during the emergency period into the waste management plan. This has to be managed at the same time as the debris.

In particular, the following need to be incorporated in plans for disaster waste management

- maintaining close links with disaster management agencies, and ensuring that waste management is incorporated into overall emergency plans
- nominating stand-by waste personnel and equipment and ensuring training and practice, as in normal emergency management
- identifying temporary waste handling locations
- incorporating disaster mitigation measures in the design and operation of waste management facilities
- elaborating special emergency waste systems for sensitive installations such as hospitals
- incorporating disaster wastes into the scenario for overall waste planning at national & local level

5.7 Obtain Equipment and Supplies

Identify in advance the types of equipment and supplies that waste teams will need to implement the plan. Quick procurement of these items through mutual aid agreements or standing contracts, or stockpiling such equipment should be considered and planned for. If stockpiling is too expensive for one city alone, perhaps a group of neghbouring cities could stockpile the equipment.

Types of equipment that a community might need include chain saws, portable generators, cellular phones, flashlights, batteries, vehicle repair equipment (flat tires occur more often because of glass and metal debris in roads), and extra work clothing. For example, A local government that routinely stores drinking water (e.g., for its solid waste collection crews) might want to make sure that water supplies are well-stocked during the hurricane or flood season.

5.8 Select Collection and Storage Sites

The most common suggestion from communities that have experienced natural disasters is to pre-select debris staging sites that will be used for temporary storage and processing of debris. Convenient local sites allow collection crews to reduce travel time when transferring debris to processing or disposal facilities and result in faster street clearing.

Site operators can sort debris for recycling or disposal, as well as answer questions from the public. These sites can be used to store green waste before transferring it to another facility, or they can be used to chip and mulch green waste on site. Cities can also use these sites to distribute recycled materials to the public.

Sites are selected based on planned activities, such as staging, collection, storage, sorting, recycling, landfilling, and burning of debris. Pre-selection of sites speeds the implementation of the debris management plan. Also access to heavy equipment, lack of impact on environmentally sensitive areas, and convenience to collection routes, need to be considered. Possible impacts on adjacent housing need to be investigated, since the sites could produce noise at levels deemed unacceptable by residents or attract rodents that may carry disease. Evaluate and document the condition of these sites prior to use.

The government agencies involved will be responsible for returning these sites to their original condition. An agreement on the schedule for return of the property to the owners and the degree of rehabilitation to the property should be established.

If residents are to be asked to bring disaster debris to collection sites, the city should include these locations in its disaster communication strategy, so that information is immediately available to the public in the event of a disaster. Schedules and staffing plans for these sites should take into account that the busiest times for residents dropping off home-related debris are likely to be evenings and weekends.

5.9 Determine Management Options and Goals

Any disaster debris management plan should include a disposal strategy. Communities need to set priorities for recycling wastes and determine the desired disposal options for the remaining waste.

5.10 Segregate Hazardous Waste

Segregation of hazardous from non-hazardous disaster debris should be carried out in order to avoid disposal of combined waste as hazardous waste. Collected business waste should be monitored to be certain it does not meet the definition of hazardous waste. Waste handlers need to understand these requirements as well as have a plan for controlling and diverting hazardous waste from the debris stream.

Taken together, these lessons learnt present important building blocks for an effective waste management mechanism that is able to respond to and manage disaster wastes effectively and efficiently.

6 Technologies for Disaster Waste Processing

6 Technology Systems for Disaster Waste Processing

The core of the DEBRI project lies in demonstrating environmentally sound technologies (ESTs) for the management of disaster debris. ESTs encompass technologies that have the potential for significantly improved environmental performance. These technologies protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way.

Furthermore, ESTs are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures.

6.1 Understanding C&D Wastes to develop Technology Systems

A key crosscutting aspect of a good waste management mechanism is the technologies for waste handling. This is particularly the case for large pieces of waste such as concrete blocks and other C&D wastes[4].

But the management and disposal of C&D are beset with numerous problems, most of which relate to handling, storage, transport, and disposition either by recycling or by final disposal. These problems are largely due to the nature of the wastes themselves.

A characteristic that frequently magnifies the problems is bulkiness. The bulk density of C&D is a function of that of its components. The bulk density of major components of C&D is indicated by the data listed in Table 6. Bulkiness and heaviness, along with resistance to compaction, seriously constrain the landfill option to handle C&D wastes. High costs also rule out particle size reduction (shredding,

[4] Source: UNEP-IETC, *Solid Waste Management.* UNEP-IETC, 2005

grinding) merely as a means of compensating for bulkiness. Disposal by incineration is impractical since the material is mostly inert.

One solution to disposal difficulties is to avoid them through recycling. Although C&D may be difficult to handle and to move, it potentially is rich in terms of inorganics that compare favourably with those of virgin materials.

Concrete debris comes from the razing of buildings and the demolition of other structures, roads, and highways, and may represent 10% to 40% of C&D. A significant fraction of the concrete debris was and still is recycled after only a minimum of processing that consists of reducing the concrete chunks to a size required by their intended use. The uses are many and varied. For example, they may be used in dike construction, or may provide an "all-weather" temporary roadbed in a waste disposal site.

The physical characteristics of C&D are such as to need the use of relatively expensive equipment for processing it into its marketable components. A promising means of lowering the resulting unit cost of processing is to rely upon portable equipment that can be moved from one demolition operation to another. Equipment cost has not deterred some contractors from designing and operating C&D processing facilities. The facilities usually incorporate some or all of the following operations to produce marketable materials: screening, size reduction, magnetic separation, density separation, and manual sorting.

The following table presents an overview of different types of materials generated during a disaster and the required on-site processing and market value of the processed wastes.

Table 6: Technology Policy options for C&D Wastes

Material	**Onsite Processing**	**Market**
Concrete	Crushed to 10 cm maximum particle size	Blend and sub-grade preparation; stockpile for future use
Structural steel	Cut with hydraulic shears	Local scrap metal processor
Asphalt	Ground on-site and crushed to 10 cm maximum particle size	Reused as aggregate

Brick from the oldest fireplace	Hand recovered; mortar taken off, palletised; shrink-wrapped	Stockpiled for reuse in the new building
Brick, other (5,200 Mg)	Crushed to 10 cm maximum particle size	Blend and sub-grade preparation; compact in 30 cm lifts; stockpile remainder for future use
Wood (frames, floors, etc.)	None	Local processing as chips for use as fuel or planned for furniture
Electrical (copper) and plumbing (iron, copper, and brass)	None	Local scrap salvager
Old iron fence	Stockpiled	Future reuse onsite
Other, mixed wastes	Collected for disposal	Transport to landfill

Although technologies for the overall processing of C&D may be loosely grouped into manual (i.e., labour-intensive) and fairly mechanized, concrete debris processing generally does not lend itself to such a grouping in that its processing is, as a whole, both labour-intensive and mechanized.

However, there may be some advantages in designing the technology to be either predominantly manual or mainly mechanized. Advantages in predominantly manual processing are lower capital expenditure, and a labour force that is available for other activities during the intervals between process operations. Advantages attributed to largely mechanized approaches are greater efficiency and processing rates, and lower labour requirements.

"Sorting" exemplifies the "dual nature" of debris processing. Sorting is two-fold: 1) separation of concrete debris from other C&D, and 2) classification of the separated concrete debris. Separation from other debris usually is one of the demolition activities and, thereby, begins at the demolition site. At this point, segregation may be performed manually, mechanically, or both. The role of sorting in this stage is to retrieve recyclable materials. It is exemplified in the demolition of a building that has one or all of the following: concrete walls, floors (slabs), and columns. Steel and/or wire present in the structures is removed manually as the demolition progresses.

Concrete recycling process system

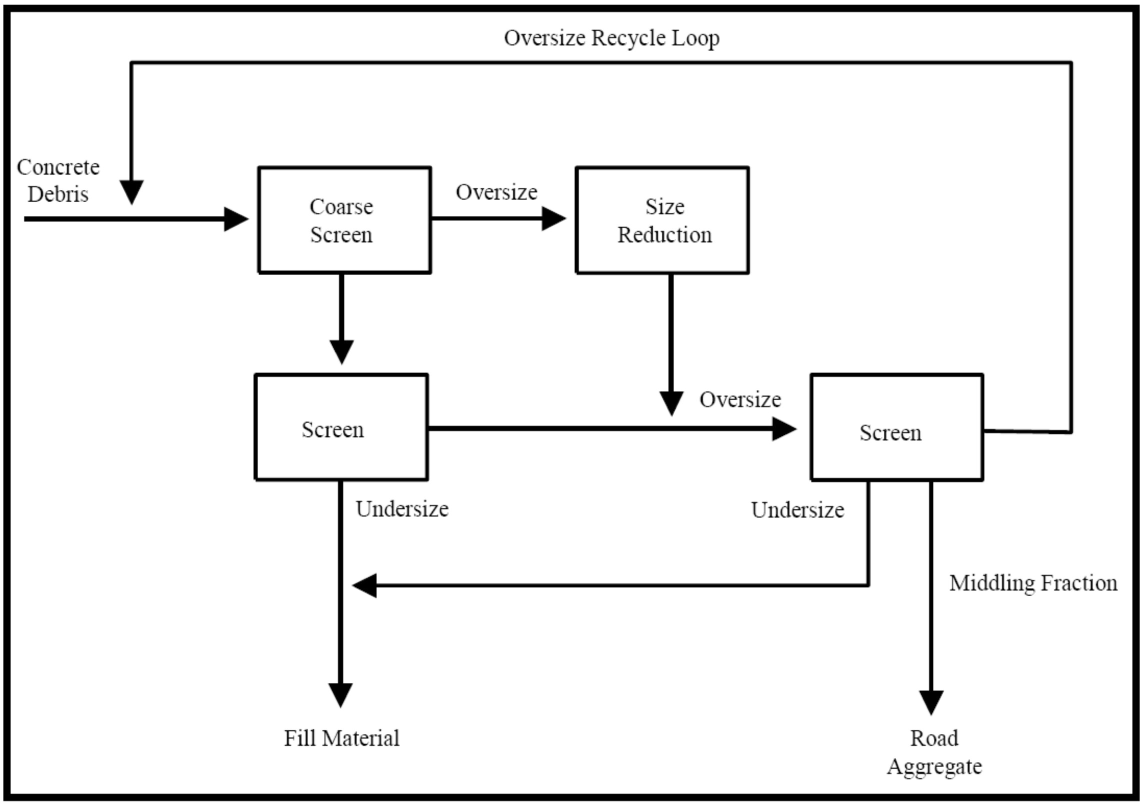


Figure 2: Concrete Recycling Process System

The other aspect of sorting is the separation and classification done in the processing sequence. This sorting usually is mechanized and largely consists of screening. The screening may be preceded by size reduction and be augmented by: 1) magnetic removal of ferrous material, and 2) flotation to separate wood and plastics. These processing operations may be performed onsite, with the use of portable equipment, or at a central facility.

Size reduction is one of the more important of the processing steps. It usually is carried out by a specially designed crushing machine ("shredder") or by a grinder. Discharge from the machines is screened and further processed. As stated earlier, the discharge may serve as an aggregate for use in roadbed construction or may be further processed (refined) to the extent required for a particular use. A likely use would be for making concrete. Careful analyses of the concrete must be performed to ensure that it meets national standards.

Construction and demolition debris recycling process system

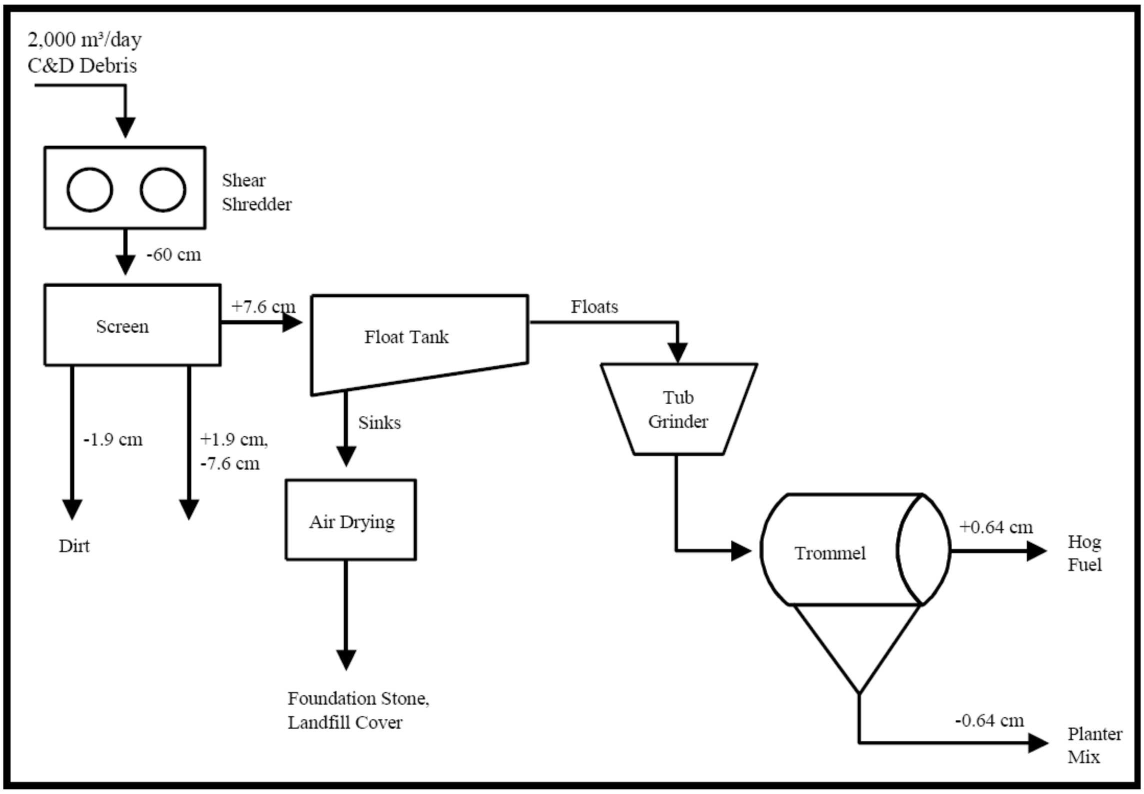


Figure 3: Construction and demolition debris recycling process system

6.2 Assessing and evaluating technologies for their environmental and sustainability soundness

In the face of growing concerns regarding sustainability, a need for promotion of ESTs aiding sustainable development was recognized in the early 1990s. The Local Agenda 21 under the United Nations Conference on Environment and Development (UNCED) in particular, highlighted this issue. Further, a number of national and regional initiatives across the world focused on the incorporation of what have come to be known as Environmentally Sound Technologies or "ESTs" in the development process.

ESTs encompass technologies that have the potential for significantly improved environmental performance relative to other technologies. Broadly speaking, these technologies -

- protect the environment
- are less polluting
- use resources in a sustainable manner
- recycle more of their wastes and products
- handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes

Furthermore, as argued in Chapter 34 of Agenda 21, ESTs are not just "individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures". This requires both the human resource development and local capacity building aspects of technology choices. There is also the need to ensure that ESTs are compatible with nationally determined socio-economic, cultural and environmental priorities and development goals.

In the complex relationship between disasters and the environment, technology provides a link between human action and the natural resource base. As a result, the application of new, resource efficient ESTs has become crucial for both disaster management and the environment.

The availability of ESTs for disaster risk reduction and mitigation will largely depend on willingness to pursue an environmental agenda and proper decision-making processes put in place at the national and local levels.

In order for developing countries to make the best use of ESTs, however, they must increase their ability to assess, analyze and choose technologies based on their own needs and disaster management priorities, and adapt these technologies to specific local conditions. Of particular importance will be the building of capacitates to integrate economic, social and environmental considerations in order to ensure resource efficiency and social acceptability.

It is with the above thinking that an activity on the development of a systematic process and methodology of technology identification and selection was included in the DEBRI project.

The criteria for technology identification and selection presented in this document is based on earlier work of UNEP on ESTs. Among them, of particular interest is the list of core criteria and indicators for EST evaluation and assessment, summarized in the table below.

Table 7: Core Criteria and Indicators for EST Evaluation and Assessment

Technological Suitability	
1	Compliance with fundamental science and engineering principle
2	Appropriateness of service and efficiency
3	Certainty for forecast of service and environmental load
4	Sustainability of technical performance
5	Speed of service development
Protects the Environment	
1	Compliance with local, national and regional environmental standards or internationally recognized standards (e.g. ISO)
2	Compliance with Multilateral Environmental Agreements (MEAs)
3	Environmental impact relative to the product or service provided (Eco efficiency)
4	Ecological footprint
5	Overall impact on ecosystem health and integrity
6	Compatibility with immediate and adjoining facilities and systems
7	Potential for geomorphological, landscape and eco-hydrological impacts
8	Potential for long-range transport of pollutants
Less polluting and handles wastes in a more acceptable manner	
1	Total quantities of wastes (air, water and gaseous) generated
2	Cumulative air, water and waste emissions
3	Quantities of toxic waste produced
4	Potential for generation of secondary pollutants/ by products
5	Noise/ vibrations/ odour generation
6	Thermal emissions
7	Radiation emissions
8	Potential for climate change impacts
9	Potential for soil contamination
10	Appropriateness of waste (air, water and solid) treatment and disposal
Uses all resources in a more sustainable manner	
1	Efficiency of energy, water and material use, relative to the product of service provided
2	Useful life of technology, and of products/ services

3	Relative use of renewable/ non-renewable sources
4	Conservation of water, including portion of recycled water used
5	Use of 'environmentally friendly' materials
6	Sustainable use of local resources
7	Use of sparse resources
8	Space required for the technology investment
Recycles more of its products and wastes	
1	Use of recycled, reused and waste material and by products
2	Life cycle performance

The above criteria have been used as a guide to develop the key factors in technology identification and selection[5].

Key Factors for Technology Assessment

At a broad level, in identifying, assessing and selecting technologies, it is important for us to consider[6] what the *inputs* are in terms of the costs, raw materials and other resources; the *outputs* in terms of items produced (including other issues such as pollution or emissions); the *outcomes* in terms of goals and objectives achieved; and the overall *impacts* of the technology within its lifecycle.

Further, in any decision-making process, special attention needs to be given to the risks and restrictions associated with each choice, since these become crucial deciding factors in many instances.

Typically, risks and restrictions that need to be considered in making the technology choice include stability, flexibility, hazard, size/scale of operation, adaptability, skill levels needed, and other pre-requisites such as availability of space, etc.

These issues have been consolidated into four sets of factors to be used for identification and selection of technologies, summarized in the table below:

Table 8: Key Factors for Technology Assessment

Category		**Description**
1	Strategic factors	Strategic factors are based on situational analyses, expert opinion and existing baseline

[5] These and other resources are available with UNEP-IETC for reference during the technology identification and selection process

[6] Collectively called the "IOOI Framework", developed by the World Bank.

		data, and are used to assess the technology's conformity and compliance with policies, programmes and legislation.
2	Operational factors	Operational factors are based on a thorough technical analysis of the technology options that includes its potential environmental impacts.
3	Financial factors	Financial factors are based the costs incurred in procuring, installing, operating and maintaining the technology. Additional factors related to the potential of jobs created or incomes generated are also taken into consideration.
4	Socio-cultural factors	Socio-cultural factors cover issues related to the local community where the technology will be installed, and includes health and safety issues, acceptability of the technology and other related issues.

Each of these factors are described in more detail in the following sections.

1 Strategic factors

The key objective of the set of factors related to strategic assessment is to ensure compatibility and conformity of the technology options with governmental policies and programmes related to environmental and sustainability, waste management, technology and related issues[7].

It specifically looks at the compliance of the technology with relevant laws and legislation related to environment and sustainability, waste management and disaster preparedness. The assessment is broad-based, at the macro level, and provides descriptive explanation of the issues involved.

For the assessment, descriptions and data values as applicable for each factor, and reasons for each factor's rank (low, medium or high) need to be mentioned.

[7] For example, the new National Waste Management Law of the Government of Indonesia, that will come into effect in late 2007.

Table 9: Technology Identification and Selection – Strategic Factors

Issue	Factor	Explanation
Compliance	*Compliance with local and national environmental laws, legislation, regulations etc., including multilateral environmental agreements (MEAs) if applicable.*	YES/NO The technology options should be compliant with local environmental legislation and rules/regulations. Information from technology fact sheets, technology vendors and expert opinion if necessary is used for decisions on this factor.
Environmental policies	*Meeting environmental policy objectives such as 3Rs, disaster preparedness and management planning etc.*	YES/NO The technology options should meet stated government policies and objectives on related issues: environment, disasters, health et al. Information from technology fact sheets, expert opinions and information from vendors is used for decisions on this factor.

2 Operational factors

Operational factors are based on a thorough technical analysis of the technology options that includes its potential environmental impacts.

The operational factors included for assessment include its technical suitability, environment/health/safety and installation issues. The assessment is specific to the issues/factors outlined below and is evaluated based on a ranked scoring for each item.

For the assessment, descriptions and data values for each factor, and reasons for each factor's rank (low, medium or high) need to be mentioned.

Table 10: Technology Identification and Selection – Operational Factors

Issue	Factor	Explanation
Technical suitability	*Energy/resource consumption:* • *Fuel* • *Electricity* • *Steam* • *Water* • *Other resources*	LOW/MEDIUM/HIGH (Note: Low consumption = high score) Quantity per hour The technology's need for various resources is assessed here. Information from vendors, technology fact sheets and expert opinions can be used to take decisions on this factor.

	Mobility	LOW/MEDIUM/HIGH Depending on the location of the disaster or need for C&D waste processing, the technologies will have to be mobile, transported as self-mobile equipment, or on trucks. Information from vendors, technology fact sheets and expert opinions can be used to take decisions on this factor.
	Compatibility with local natural conditions (topographical, climate etc.)	LOW/MEDIUM/HIGH For the optimal performance of the technology, it is necessary to check compatibility with local natural conditions and climate (including contamination, topographical suitability etc.) Information from technology fact sheets, expert opinions and information from vendors is used to take decisions on this factor.

	Extent of usage of local parts and components	LOW/MEDIUM/HIGH Preference should be given to use of local parts and components for both cost as well as social reasons Information from vendors and technology fact sheets is used to take decisions on this factor.
	Availability of local skills and capacities	LOW/MEDIUM/HIGH Preference is to be given to the availability of local skills and capacities for operation and management of the technology option. Information from vendors and technology fact sheets is used to take decisions on this factor.
	Track record of performance and reliability	LOW/MEDIUM/HIGH Track records of the technology and the vendor need to be checked to facilitate endorsement. Technology fact sheets, market intelligence, site visits to similar installations can help in deciding on this aspect.

	Compatibility with existing situations	LOW/MEDIUM/HIGH It is essential that the new system is compatible with the existing infrastructure (roads, electricity supply etc.) and technology systems as well as the local government's waste management systems. Expert opinions supplemented by the technology fact sheets and vendor information is used to take decisions on this factor.
	Other technical factors: • *Adaptability to future situations (potential for scale-up/expansion, upgrading, etc.)* • *Process stability (perform in a stable manner in various situations)* • *Ease of maintenance* • *Expected technology lifespan* • *Calibration requirements, if any*	LOW/MEDIUM/HIGH Vendor information, technology fact sheets, expert opinions and case studies can be used to take decisions on this factor.

Environ-ment, health and safety	*Risk level for:* • *Workers* • *Local community* • *Environment* • *Noise* • *Odours*	LOW/MEDIUM/HIGH (Note: Low risk = high score) The technology's potential environmental, health and safety risks to the workers, communities as well as to the environment need to be assessed. Information from expert opinions and technology fact sheets, supplemented by risk assessment exercises where needed, can be used to take decisions on this factor.
Installation	*Requirements for installation:* • Amount of space required for installing and operating the technology • Storage of technology components when not in use • Other requirements such as support structures, covered building etc.	LOW/MEDIUM/HIGH (Note: Low need = high score) Depending on the technology, its installation requirements may vary. Information from expert opinions and technology fact sheets, case studies, and vendor information can be used to take decisions on this factor.

3 Financial factors

Financial factors are based on the capital investment incurred in procuring, installing, operating and maintaining the technology. While detailed costs may be difficult to obtain at this stage, estimates can be used for this purpose.

Estimates for operation and maintenance of technologies are also used to assess viability. Additional factors related to the potential of jobs created or incomes generated are also taken into consideration.

For the assessment, descriptions and data values for each factor, and reasons for each factor's rank (low, medium or high) need to be mentioned.

Table 11: Technology Identification and Selection – Financial Factors

Issue	Factor	Explanation
Economic / financial factors	*Capital investment*	LOW/MEDIUM/HIGH (Note: Low investment = high score) This is a standard cost-benefit analysis that also looks into returns on investment. Vendor information and queries with vendors can be used to take decisions on this factor.
Long-term factors	*Operation and maintenance costs*	LOW/MEDIUM/HIGH (Note: Low cost = high score)

4 Socio-cultural factors

Socio-cultural factors cover issues related to the local community where the technology will be installed, and includes issues such as job creation and income generation potential, acceptability of the technology by the community, and other related issues.

For the assessment, descriptions and data values (if applicable) for each factor, and reasons for each factor's rank (low, medium or high) need to be mentioned.

Table 12: Technology Identification and Selection – Socio-cultural Factors

Issue	Factor	Explanation
Socio-cultural aspects	*Income generation and job creation potential*	LOW/MEDIUM/HIGH A key aspect of a technology is its ability to generate income and create jobs for the local community – (a) in operating and maintaining the technology, and (b) in using the technology's outputs for further processing and product development. Information from expert opinions and technology fact sheets, case studies, and vendor information can be used to take decisions on this factor.

	Acceptability	LOW/MEDIUM/HIGH Overall potential attitudes, views and impressions of the local community are determined here. Examples include: • Impacts/affects on daily life, if any • Impacts/affects on community areas • Community perceptions on health, safety, noise odour etc. • Trust in information provided Information is gathered from interviews with local political leaders, community leaders (Bupatis) and expert opinions.

6.3 **Application to DEBRI Project**

The above four key factors for technology assessment (Strategic factors, Operational factors, Financial factors, and Socio-cultural factors) were used to assess a range of technologies necessary for managing of disaster debris.

Using a series of interactions with project partners, local stakeholders and experts, organized in Jakarta and Banda Aceh in 2007 and early 2008, each of the criteria listed in Section 6.2 was provided with a score, and technologies required (and options available) for the DEBRI project were ranked and weighted, in order to select the best technology package available[8].

The technologies covered in the assessment are illustrated in the figure below:

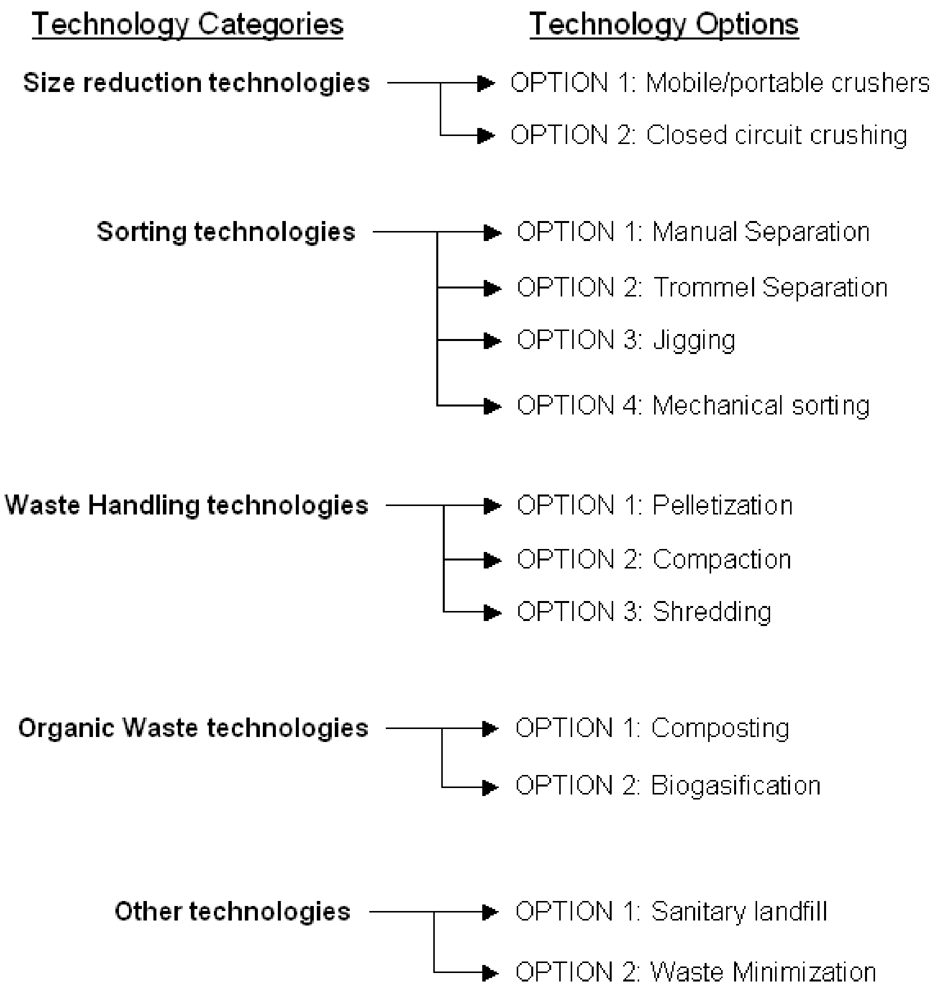


Figure 4: Technology Categories and Options

[8] Details of the assessment is explained in the DEBRI Report, "The DEBRI Project: Technology Identification and Selection" November 2007.

Some of the key observations that were raised in meetings between partners and other stakeholders, and guided the technology selection included the following:

- C&D wastes, arising from disasters are predominantly a mix of different types of wastes, but can be separated more easily than municipal solid wastes (MSW). However, due to the unpredictability of disaster events, the chances of contamination of C&D wastes are also high.

- Demand for recycled C&D wastes is usually high, including and particularly aggregates of different sizes, due to the urgency of recovery needs

- Technology choice should consider sudden peak in volume of debris that has to be balanced with lower volume of MSW generation. Priority for local agencies on a day-to-day basis is MSW anyway.

- Use of technologies need to be tempered by human capacities to handle them, and by its job creation potentials

- Need for a clear waste management plan of action –

    - within which the procured technology will have to fit in
    - that includes capacity building
    - linked to the larger disaster management plans for Banda Aceh
    - scalable to handle different kinds of wastes from different disaster types
- Highly localized nature of disaster events mean that mobility of waste equipment is important –
    - to process debris and wastes where it is generated, or where it will be used
    - to assist neighbouring cities, towns and villages in time of need

6.4 Technology Components

Based on the outcomes of meetings and discussions held in Jakarta and Banda Aceh among the project partners, consultants, and other local stakeholders, and after a detailed review of the outputs from DEBRI activities, it was recommended that the following technologies be procured under the DEBRI Project.

Table 13: Selected Technology Components

1. Solid waste crushing machine	
Basic purpose	• For size reduction of solids
Description	• This machine is used to reduce the size of solids such as concrete, bricks or asphalt to manageable sizes so that it can be easily transported or reused.
Essential characteristics of equipment	• Mobile – either self propelled or can be transported on a flat-bed truck • Jaw crusher that can handle a variety of C&D wastes • Can include a sorter that separates the solids into different aggregate sizes
Type of waste processed	• concrete (including blocks), stone (marble, granite, rock etc.), brick, etc.
Capacity of machine	• Size of materials produced: about 0.2in. to 3in. • Capacity: 15-20 tonnes per hour • Mobility: Mobile - self propelled or truck mounted
Power needs	• Diesel operated
2. Waste sorting machine	
Basic purpose	• Separation of solids to different sizes
Description	• This machine is used to sort C&D and municipal waste into different types and/or sizes so that it can be reused/recycled
Essential characteristics of equipment	• The machine uses a manual sorting process to separate C&D wastes according to their size and weight. • The machine can also be used for MSW waste, when not in use for debris or C&D wastes
Type of waste processed	• Mixed C&D waste, MSW wastes
Elements required	• Belt conveyor: 50-75 cm wide, 7-10 m long • Hopper (loading ramp)
Capacity of machine	• 5-8 tons per hour

Power needs	• Electrical or diesel powered
3. Waste Shredding machine	
Basic purpose	• For shredding of plant and vegetative matter • For shredding plastic waste
Description	• This machine is used to shred plant and vegetative matter into smaller manageable pieces so that the resulting organic waste can be used more effectively as a fuel or as mulch for composting. • This machine is used to shred plastic waste into smaller manageable pieces so that the resulting plastic waste can be used more effectively as recycling materials
Essential characteristics of equipment	• Essentially handles organic waste and plastic waste (excludes solid C&D wastes such as concrete, brick or stone). • The machine can also be used for MSW waste, when not in use for debris or C&D wastes
Type of waste processed	• plants and other vegetative matter • plastic waste
Capacity of machine	• 3000 to 5000 kgs per hour. Max. size of plant trunks: 15-20 cm for vegetative matter • 500 to 1000 kgs per hour for plastic waste
Power needs	• Diesel powered
4. Composting Facility	
Basic purpose	• For treating and processing organic waste
Description	• This facility is used to process organic waste through open windrow process to produce compost
Essential characteristics of equipment	• Essentially handles organic wastes, and composts them using a windrow turner.
Type of waste processed	• plants and other vegetative matter (organic waste)
Capacity of facility	• 5 – 10 tons of organic waste per day
Elements required	• Processing area of 500 m^2 (20 x 25 m^2) • Building and its facilities (including office, drainage system, pumping station, mechanical electrical, water supply, leachate

	collection) • Machine for turning over compost pile – 50-80 horsepower tow-behind windrow turners/aeraters; 500-1000 m^3 per hour throughput; • Thermometer (multi) • Nutrition test kit (compost quality test). Test kits (and procedure manuals) to measure pH, soluble salts/salinity, nutrient content, (nitrogen, phosphorus and potassium), moisture content, percentage of organic matter, particle size and bulk density.
Power needs	• Electrical or diesel powered

7 Disaster Waste Planning and Management

7 Disaster Waste Planning and Management Components

The management of disaster wastes is a complex process that requires careful integration into not only the overall day-to-day waste management of a city or community, but also into the emergency response planning process of the area.

A number of components need to be considered in planning for disaster waste management. These include:

1. Organizational Coordination
2. Waste Assessment
3. Development of a Plan
4. Debris Processing and Separation/Segregation
5. Recycling and Disposal

7.1 Organizational Coordination

In the event of a disaster, local government officials must know whom to contact for assistance and must understand the roles and responsibilities of the other governmental agencies involved in order to effectively coordinate recovery efforts. This chapter outlines the roles and responsibilities of the local, state, and federal agencies with respect to disaster debris management.

In addition, it is critical that a jurisdiction establish effective coordination within its own organization. Organizational coordination includes a description of an emergency organization in terms of who is responsible for what; identification of departmental relationships; designation of a debris manager and team; identification of a management structure; identification of available resources (staff and equipment); and description of mutual aid agreements.

To facilitate organizational coordination, the following steps should be taken:

- Define intradepartmental relationships, designate a debris manager and establish a debris "team."
- Outline and evaluate potential for specific disaster events and develop functional checklists by disaster for debris manager and team.
- Become familiar with emergency plans, procedures, and the Standardized Emergency Management System.
- Identify local, state, and federal agencies involved in disaster debris management.

7.2 Waste Assessment

Assessing the quantity and quality of disaster waste is a critical first step in mounting a response to a disaster event. The assessment needs to be done in two stages – one, a pre-disaster exercise, as a part of the preparedness and mitigation processes, and two, a post-disaster assessment as a part of the recovery and reconstruction processes.

7.2.1 Pre-disaster Assessment

Each city community needs to conduct a survey to determine the quantity and types of materials likely to be generated in a particular disaster. This is important because development of particular waste programs will depend on the type and amount of debris generated, as well as the end-uses identified for the materials.

Further, by conducting a pre-disaster assessment, a jurisdiction will have identified the specific areas that must be developed in a debris management plan.

Brief descriptions of the other types of information to be included in this assessment are identification of type of disaster likely to occur in a particular locality; identification of transportation corridors and development of alternate routes; identification of recyclers, haulers, and processors in the area available to handle the debris; contingency plans for waste disposal; identification of temporary storage or staging areas for debris; facilities to handle/process debris and the amount that can be handled; and markets for the generated materials.

Pre-planning is the most effective way to ensure waste activities are carried out after a disaster. By having local policies in place to require that recycling or other diversion programs be implemented after a disaster, a quick recovery can be ensured to enable reconstruction to begin.

To facilitate pre-disaster waste assessments, the following steps should be taken:

- Develop local checklists of available resources.
- Conduct a disaster event analysis and waste
- characterization analysis.
- Identify temporary storage sites.
- Identify end-uses and markets.
- Identify facilities and processing operations.
- Identify processing techniques and barriers.
- Identify processing equipment needs.
- Determine contract needs.
- Review mutual aid agreements with neighbouring districts and cities.
- Identify labor needs.
- Review local ordinances.

7.2.2 Post-Disaster Assessment

Like the waste characterization and assessments carried out in the aftermath of the tsunami disaster, a post-disaster assessment is more focused on the particular disaster and locality. In addition to the issues mentioned above under pre-disaster assessment, post-disaster assessments include:

- Waste Identification; geographic presence of the wastes through governmental sources, GIS, news, local sources and implementing agencies, as well as selection of geographic area to be included in the waste plan.
- Waste Characterisation; quantification, composition and quality of the identified waste streams and dumps/landfills through site visits and wastes sampling/analysis, and collated on 'waste maps'.
- Capacity Assessment; evaluation of institutional and operational capacity including personnel, machinery, recycling and lifetime of disposal facilities as well as in-country waste management expertise. Local community interest in waste management

issues to be included in this assessment as well as issues surrounding livelihoods.

- Risk Assessment; in accordance an assessment of the risks associated with each waste stream and/or dump/landfill site in order to allow for proper handling, processing and disposal.
- Prioritisation; each of the identified waste streams and/or waste dumps/landfills is given a ranking (for example, emergency, medium-term, long-term) based on the hazard risk assessment, and taking into account the reconstruction plans as well as general sustainability of the proposed interventions.

7.3 Development of Plan

A waste plan consolidates the "how-to" information that a local government would need to establish a debris management program. The plan can include the setting up of temporary storage sites, curbside collection, building demolition, debris processing and separation/segregation and recycling/disposal components. The primary issues and the minimum requirements that should be considered in establishing such programs include guidelines for establishing the above components; end-uses for materials generated; and type and quantity of equipment needed for debris removal; labor, facility, and processing requirements.

To facilitate the development of a plan, the following steps need be taken:

- Make disaster waste management programs a priority.
- Become familiar with national and local federal debris removal criteria and guidelines.
- Develop a debris removal strategy.
- Identify project scope, set program goals and identify labour needs.
- Identify processing equipment needs and determine method of operation.
- Adapt program length, and review funding options.
- Establish a public information program.
- Develop monitoring and enforcement program.
- Pursue regional coordination, and set up a simulation and training program.

7.3.1 Temporary storage sites

Local governments have identified temporary storage sites as the primary obstacle in establishing a debris management program. Without the ability to stockpile or store the disaster debris until such time as a local government can turn its attention to processing and marketing the materials, the debris present an obstacle to effective recovery and reconstruction.

Securing storage sites is best done before a disaster so that arrangements, such as leases and permits for the land, can be accomplished quickly. Given that the immediate response is for lifesaving activities, recycling and diversion programs often become secondary in importance. Having storage sites available in advance gives a local government additional time to develop strategies and programs to handle the disaster debris.

To facilitate the identification and designation of temporary storage sites for disaster wastes, the following steps need to be taken:

- Determine need for facilities.
- Develop criteria to evaluate potential sites.
- Identify temporary storage sites.
- Consult with local solid waste facility operators and local cleansing departments regarding establishment of temporary storage or processing areas.
- Identify permits or variances if needed.
- Perform environmental review of site.
- Prepare a site development and operation plan.
- Prepare inspection and site management guidelines.
- Prepare a site restoration plan, to return it to its original state.

7.3.2 Curbside Pick-up Programme

One of the primary methods used by local governments to remove material after a disaster is a curbside waste pickup program. Cities and communities implement curbside pickup programs to remove debris from the street after businesses and residents have placed the materials in front of their properties.

In any curbside pickup program, there are some basic requirements that need to be addressed and implemented. A partial list of issues includes, processing and facility needs; waste separation (by the business/household or by volunteers); labour and equipment needs; funding requirements; method of implementation; temporary storage requirements; public information strategy; and market requirements.

To facilitate an effective curbside pick programme, the following steps need to be taken:

- Identify/estimate the quality and quantify of material to be picked up.
- Determine processing and facility needs.
- Identify labor and equipment needs.
- Secure program funding in advance.
- Select method to locate curbside waste.
- Determine method of implementation, particularly in the use of every day waste collection systems for the purpose.
- Identify temporary storage areas.
- Identify/establish markets for collected materials.
- Develop public information program/strategy, including the time period for collection, waste categories to be collected etc.
- Develop monitoring and enforcement program.

7.3.3 Building Demolition

Besides buildings that have actually collapsed, a number of standing, but damaged buildings deemed unfit for habitation and use will have to be demolished and cleared before reconstruction can commence.

The system of building demolition is well established in most cities, with active participation of the private sector firms. This system needs to be trained and activated in order to be able to serve the specific needs of the aftermath of a disaster.

Issues such as preparation of demolition plans, expert inspections, demolition designation system for damaged buildings; establishment of haul routes; identification of potential hazardous materials in damaged buildings and plans to handle them; recycling of demolition debris where feasible and disposal of remaining wastes.

7.3.4 Debris processing and Separation / Segregation

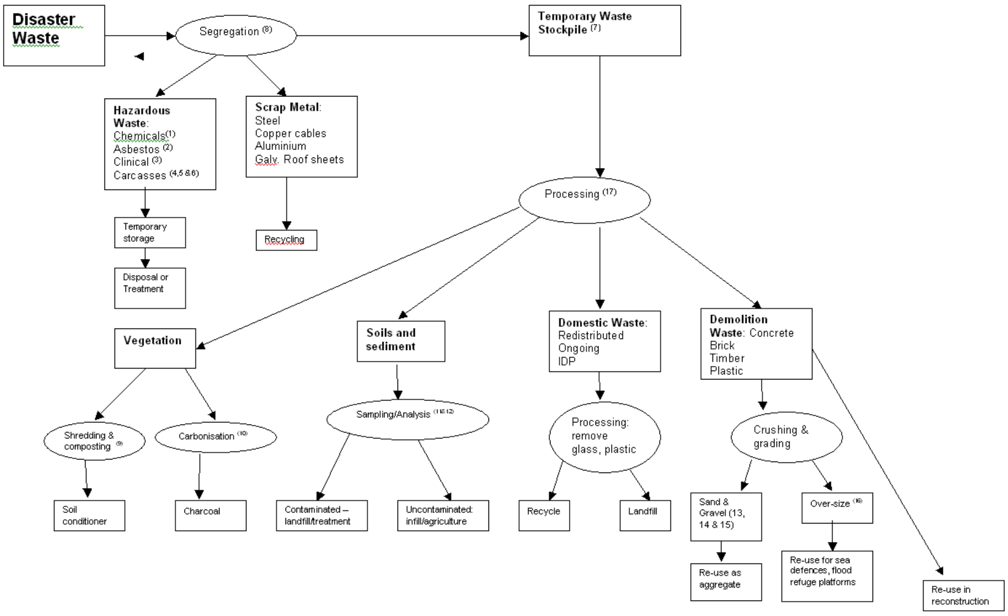


Figure 5: Options for Debris Separation / Segregation

Lessons learnt from managing of disaster debris illustrates two key actions that need to be take – as shown in Figure 5 above.

The first key action relates to the segregation of wastes to remove potential hazardous wastes, particularly those that are chemical, asbestos, clinical or carcasses wastes. These will have to be temporarily stored before it can be disposed or properly treated. Similarly, scrap metal such as steel, copper, aluminum etc. need to be segregated so that it can be effectively recycled.

Other types of wastes need to be stockpiled temporarily, before it can be effectively and properly processed. For example, vegetative matter can be either shredded and composted (for soil conditioning), or can be carbonized (for use as charcoal). Other wastes have to be similarly processed so that it can be converted into a state that makes them useful and saleable. As illustrated in Figure 5, much of the wastes can be processed for resources that can be recycled and reused, or disposed in a proper manner in a landfill.

7.3.5 Recycling and disposal

After the disaster recovery is well underway, residents and businesses will begin rebuilding. Rebuilding includes two aspects that are important for disaster planning selecting recycled-content products (RCPs) for building, and separating materials at the construction jobsite to maximize recovery.

The key to diverting construction and demolition (C&D) debris is to promote products using the debris as feedstock. Recycled-content construction products are categorized in two categories inerts, and general building products.

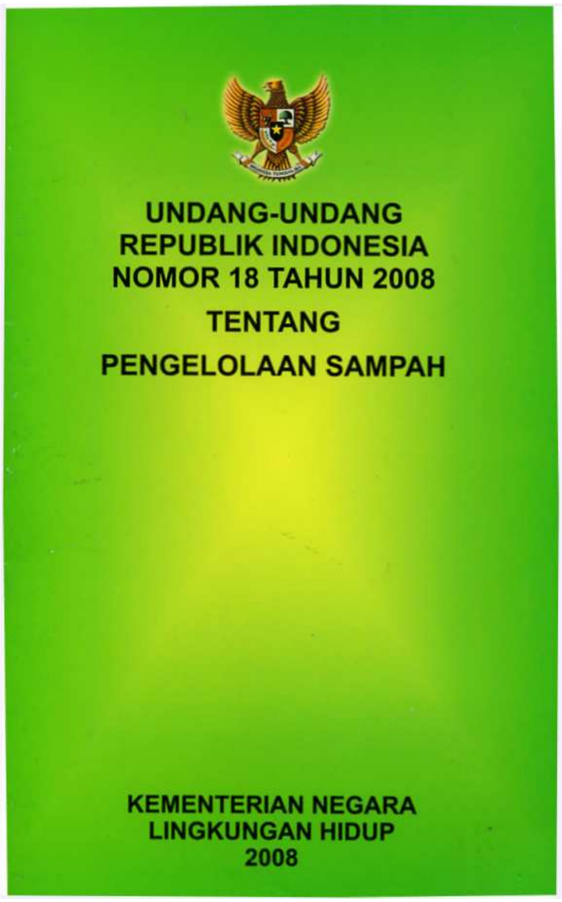
To facilitate proper recycling and disposal the following lists of actions need to be taken:

- promote recycled-content products with public works personnel;
- encourage RCP selection;
- assist manufacturers with financing or assistance with permits if they are expanding or in start-up phase; and
- encourage separation and recycling of construction waste at new construction sites.

8 Annexes

Annex 1

Summary of Waste Management Law No 18/2008



Scope and Principles

A comprehensive Municipal Waste Management Act (*UU Pengelolaan Sampah), UU 18/2008*, was passed by the National House of Representative (DPR) and became effective on May 2008. The UU 18/2008 is a major piece of environmental legislation which became a new arrangement of municipal waste legislation nationwide. The UU essentially amends Industrial Waste Management Act that is specifically regulates industrial waste handling for industries that applies '*polluter pay principles*'.

The UU 18/2008, comprises a total of 49 sections, provides the framework for the future management of municipal waste nationwide. A fundamental provision of the Act is the establishment of clear mandate among government agencies at national, provincial and district level. It also clearly stipulates the role and responsibility of individuals and community to participate in municipal waste management.
FIGURE &

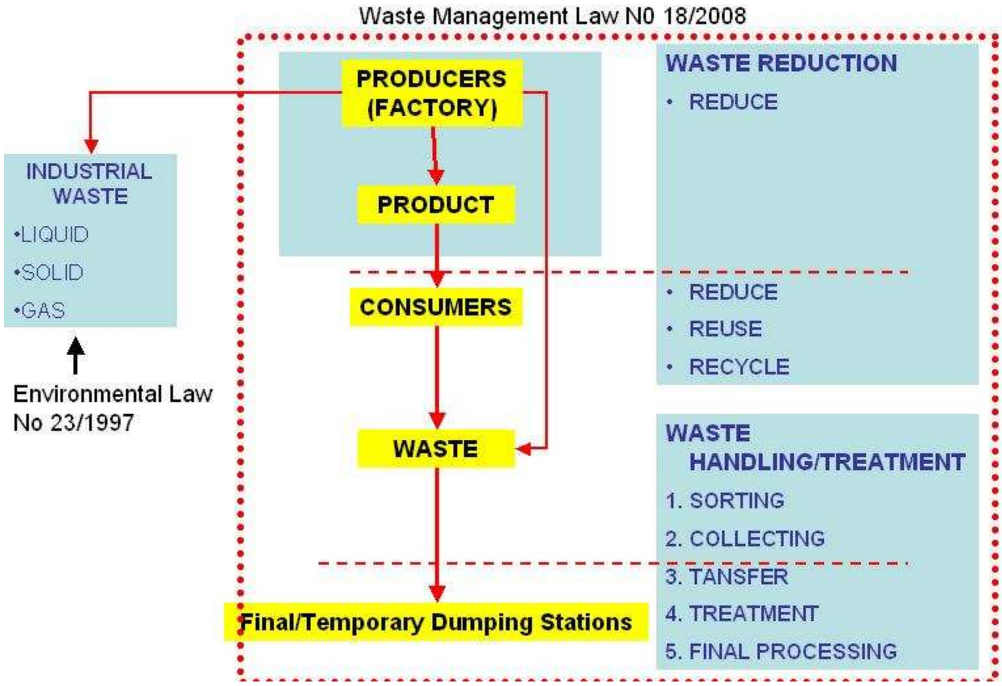


Figure 6: Scope of New Waste Management Law

The municipal waste management activities are divided in two broad categories: waste reduction and handling/treatment. Waste reduction includes the activities to limit waste production, reduce waste production at producer level as well as reduce, reuse and recycle at consumer levels. Waste handling includes the activities of sorting, collection, transferring, treatment and final waste processing. Except for other waste types, the handling of the specific waste types is undertaken by the government.

Government Role and Responsibility

At national level, Ministry of Environment (KLH) as the agency with primary responsibility to:

- develop national policy and strategy
- develop norm, standard, procedure and criteria
- facilitate and develop partnership among region, partner and networks, coordinate, guide and monitor provincial/district government performance
- facilitate conflict resolution among region

At provincial level, the provincial government has responsibility to:

- develop policy and strategy at provincial level
- facilitate partnership among districts/municipal governments in one province, partner and networks
- coordinate, guide and monitor district/municipal government performance
- to facilitate conflict resolution among district/municipal governments in the province

At district level, district/city government has responsibility to:

- develop policy and strategy based on national and provincial government rule/regulation
- implement waste management at district/municipal level in accordance with norms, standard, procedure and criteria developed by national government
- guide and monitor waste management performance implemented by third party organization
- decide the locations of temporary dumping sites, integrated waste management and/or final processing sites.
- monitor and evaluate regularly every 6(six) months over the period of 20(twenty) years to the final waste processing locations in open dumping site that already closed.
- develop and implement emergency response system

Implementation Timetable

In an effort to achieve stated goals, UU 18/2008 sets up the following time table:

- National Government must establish government rules and Ministerial decrees by 2009. About 11(eleven) government rules have to be delivered by the Ministry of Environment/KLH.
- Each district obliged to develop district government rule by by 2011
- Each district required to submit a a plan for closing the open dumping stations by 2009
- Each district must close open dumping stations by 2013.

Specific Arrangement of Debris Waste Management

Article 2(4) and 2(5) of UU 18/2008 provide general principle of specific waste that cover debries and disaster waste. Government has been identified by this law as having primary responsibility for debries/disaster waste management and handling. Specific provisions relating to this waste will be outlined under Ministerial decree being developed.

Annex 2

Brief Description of DEBRI Partners

The **United Nations Environment Programme (UNEP)** was set up to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. With six divisions and a worldwide network of offices, UNEP works on six priority areas - climate change, ecosystem management, hazardous materials,resource efficiency, natural disasters and conflicts, and environmental governance.

UNEP Division of Technology, Industry and Economics (DTIE) implements programmes to encourage decision markers to integrate environment into their decision making and to promote policies, business models and practices that demonstrate concern for humans and the environment.

Keeping this DTIE mission in mind, the International Environmental Technology Center (IETC), located in Osaka and Shiga in Japan, pursues programmes and projects that (a) facilitate the implementation of environmentally sound technologies and practices for water and wastewater management that are suitable for developing countries, (b) facilitate implementation of systems and associated technologies for Integrated Waste Management to enhance efficiency of resource use in developing countries, and (c) to promote urban disaster risk reduction mechanisms for disaster prevention and preparedness in developing countries, focusing on environmental issues.

More information on IETC can be obtained from http://www.unep.or.jp/

Ministry of Environment, MOE, is a national government agency with the primary responsibility to:

- regulate and develops national policy, allocation of natural resources and management and the reuse of natural resources, including genetic resources;
- regulate legal actions and legal relations between persons and/or other legal subjects as well as legal actions regarding natural resources and artificial resources, including genetic resources;
- control activities which have social impact; and
- develop a funding system for efforts to preserve environmental functions.

MOE has been involved and joined environmental activities both at multi lateral and bilateral cooperation as well as activities at national and local levels. MOE and UNEP have been signed Letter of Intent (LOI) on March 2005 used as a basis of any joint activities in the areas of disaster mitigation, capacity building and eco-design for environmental recovery in Tsunami impacted areas.

MOE has also actively collaborated with UNEP in preparing Rapid Environmental Assessments (REAs) of the tsunami damage during January – March 2005. As a follow-up to the REAs, MOE (and its local BAPPEDALDA office in Banda Aceh) and UNEP organized a Waste Management Workshop, targeting local government officials and other ministries in discussing environmentally friendly ways of processing and recycling construction and demolition waste. This workshop took place on 29-30 June 2005 in Banda Aceh. The DEBRI Project is a continuation of the collaboration with UNEP on the Indian Ocean Tsunami tragedy and related activities.

More information on KLH can be obtained from the following website: *http://* www.menlh.go.id/

ISWA – The International Solid Waste Association - is an international, independent and non-profit making association, working in the public interest to promote and develop sustainable waste management worldwide. ISWA has members around the world and is the only worldwide association promoting sustainable and professional waste management. The Association is open to individuals and organisations from the scientific community, public institutions and public and private companies from all over the world working in the field of and interested in waste management. Its mission is to promote sustainable waste management Worldwide by protecting human health, natural resources and the environment , providing information, promoting research and development, education and training, influencing policies by providing advice and serving the membership.

ISWA since 2001 has been acting as a partner of The United Nations Environmental Programme (UNEP) and has signed a Memorandum of Understanding (MOU) with UNEP. Since then ISWA carried out several projects in-co-operation with UNEP directed towards implementing the targets set in Agenda 21 as well as preparing the latest review of the world-wide situation delivered at the Johannesburg World Summit.

More information on ISWA can be obtained from the following website: http://www.iswa.org/

Annex 3 Contextualizing Economic Instruments in the DEBRI Project

The DEBRI project's three key pillars are (a) technology support, (b) capacity building and (c) economic instruments. As a part of the project, innovative and appropriate Environmentally Sound Technologies (ESTs) for management of debris are identified and demonstration projects on reuse and recycling are carried out, along with training programmes for local and national stakeholders.

The economic instruments component forms an important part of the project. The project identifies economic barriers to active participation of target communities and local government agencies, and ensure broader local ownership. This component is carried out in close collaboration with local and national authorities.

This section provides a brief introduction to economic instruments in order to contextualize them in the DEBRI Project.

Taxonomy of Economic Instruments for Solid Waste Management

In order to streamline the choice of economic instruments for specific solid waste management targets, a properly laid out menu is also important. Although there is general agreement on the key subcategories of economic instruments, there are still notable differences. A taxonomy of economic instruments for waste management categorizes them into three groups: revenue raising instruments, revenue providing instruments and non-revenue instruments.

Revenue raising instruments

Revenue raising instruments include various kinds of user charges (levies or taxes) for the provision of collection, transportation and final disposal services. These are directed at "internalizing" the externalities associated with the production, transportation and disposal of wastes.

The revenue raised from such charges could then be earmarked for solving specific problems for which the charge was levied. There are many examples of charges and taxes that fall under the category of revenue raising economic instruments:

- pollution charges, based on pollutant loading;
- waste generation charges, based on waste quantities and degree of waste hazard;
- waste user charges, based on collection and disposal services received;
- waste tipping charges, to unload at transfer or disposal facilities;
- product charges or fees to handle disposal of problem products, such as batteries, tyres and refrigerators;
- disposal taxes, added to disposal charges to influence disposal choices;
- pollution taxes, added to user charges to influence choices for pollution reduction;
- eco-taxes, added to non-renewable energy production or fuels to influence energy demand and fuel choices;
- presumptive taxes, based on presumed levels of pollution; and
- renewable resource taxes, on virgin materials to influence demand for their use and motivate recycling of secondary materials.

Under this category are also subsidies and subsidy removal schemes which are meant to compensate for the cost of solid waste collection, transportation and disposal. In as much as subsidies find vast applications, they are especially desirable in situations where polluters cannot be easily identified. On the other hand, subsidy removal is aimed at discouraging production and consumption behaviour that is harmful to the environment.

Revenue providing instruments

Revenue providing instruments include subsidies of different kinds that seek to directly reward desired behaviour (waste reduction, improved management, or recycling) rather than penalize the behaviour to be discouraged. Subsidies can be direct payments, reductions in taxes or other charges, preferential access to credit, or in-kind transfers like the provision of land or other resources.

These instruments however, tend to reduce revenues available to the authorities. Examples of revenue providing economic instruments used in solid waste management are presented below:

- tax credits and tax relief, allowances on property taxes, customs duties, or sales taxes to motivate investment in waste management improvements;
- charge reduction, based on proof of recycling or reuse in reducing wastes requiring collection or disposal;
- tax rebates, for pollution savings or energy efficiencies;
- environmental improvement funds, established to support pollution reduction, resource protection, energy efficiency;
- research grants, to stimulate technology development;
- carbon sequestration funds, to encourage purchase of lands that rejuvenate air quality, sometimes as a trade-off by polluters;
- host community compensation, incentives given by host communities to accommodate waste transfer or disposal facilities;
- development rights, long-term leases of land and development rights provided to private companies building waste treatment and disposal facilities, or to those finding remedy to and reclaiming old disposal sites.

Non-revenue instruments

Non-revenue instruments, which include deposit-refund programmes, combine the incentive effects of charges (when a good is purchased and the deposit is made) and subsidies (when the good is returned or otherwise handled properly and the deposit is refunded) for the management of solid waste. Other incentive-creating policies can include property rights based instruments a well as legal-/information based instruments.

Under this sub-category are found liability laws and performance bonds (which increase the financial cost of irresponsible waste handling or disposal); performance disclosure (in which information about the performance of a waste producer or handler affects its financial condition by affecting public standing); and general public education (to alter the demand for environmentally- improved waste management).

Creation or facilitation of markets is a measure relevant to all parts of the product and waste cycle. Policies to promote more competitive markets in waste management services, instead of the usual direct public administration of waste management, can alter the incentives for participation in the provision of the services; the incentives of the public to rely upon the services, and the fiscal condition of public authorities. Experience with tendering long-term contracts to private service providers illustrates this type of economic instrument. Specific examples of non-revenue economic instruments used in solid waste management are provided below:

- Product life cycle assessment, which predicts overall environmental burden of products and can be used in certification programmes;
- Deposit-refund, deposit paid and refund given upon product return for reuse;
- Take-back systems, where manufacturers take back used products or packaging; Procurement preferences, evaluation criteria adding points for products with recycled content or reduced resource demand;
- Eco-labelling, which notes product's recyclable content and whether product is recyclable;
- Recycled content requirements, laws and procurement specifications noting the precise recycled content required;
- Product stewardship, which encourages product designs that reduce pollution, include the full cost of solid waste recycling and disposal, reduce wastes and encourage recycling;
- Disclosure requirement, in which waste generators are required to disclose their pollution;
- Manifest systems, precise cradle-to-grave tracking of hazardous wastes;
- Blacklists of polluters, published lists enable consumers to consider whether to buy from polluting companies;
- Liability insurance, liability assurances by contractors and private operators;
- Bonds and sureties, guarantees for performance by contractors and private operators;
- Performance-based management contracting where oversight contractors commit to overall service improvements; and
- Clean City competitions that reward neighbourhoods and cities that have improved cleanliness.

Lessons learnt from Economic Instruments in Solid Waste Management

Based on projects implemented by UNEP and its partners in south east Asian countries on solid waste management, a number of lessons have been emerging.

Most of these lessons deal with solid waste management in general, and there is a need to adopt these lessons specifically to the management of disaster debris.

Table 14: Lessons learnt from Economic Instruments in Solid Waste Management

Lessons learnt	*Implications for C&D Debris*
First, a policy on the development and use of economic instruments and empowerment of government staff to seek opportunities for implementing new economic instruments are critical. National policy guidelines on cost recovery measures, moreover, reduce political risk for local officials.	*National and local policies on waste management need to take into account the potential debris that will be generated by a disaster event, such as a typhoon, earthquake or tsunami*
Second, building on what already exists (through review and improvement) should be the priority.	*A clear documentation of the situation and action taken to clear and process disaster debris should be recorded and good practices enhanced to facilitate replication in other situations, and incorporation in policies*
Third, learning by doing is the way forward since many instruments will not be perfectly designed. An imperfectly designed instrument may be subject to amendment, based on stakeholder feedback.	*Proper and inclusive stakeholder consultation and participation will help in identifying and implementing the appropriate economic instrument for C&D disaster debris*
Fourth, a national committee may be necessary to study and implement economic instruments. The committee can include diverse professionals including economists, engineers, lawyers, and environmental scientists (from ministries responsible for	*Inclusion of disaster and rapid response professionals in the committee will ensure that issues related to C&D disaster debris are incorporated in the deliberations of such a committee.*

environment, land, finance, and others, and from the private sector) and can apply multi-disciplinary approaches to carry out the economic analysis and environmental assessment of each economic instrument option before choice is made.	
Fifth, in principle, user charges can encourage waste minimization and proper waste management throughout the product and waste cycle.	*For C&D disaster debris, experience has shown that proper waste separation and recycling will greatly benefit environmentally sound waste management. Potential earmarking of user charges to handle C&D disaster debris will have to be explored.* *Experience has also shown that proper planning and designation of land area for processing of C&D disaster debris will have a positive impact on reducing illegal dumping of such wastes (as was observed in Banda Aceh).*
Sixth, the use of taxes at the disposal stage to internalize the air, water and soil pollution effects of disposal has great potential but this requires that the municipalities have sufficient financial strength (which can be improved via better management of user charges) and stringent control of illegal dumping.	
Seventh, revenue providing economic instruments such as tax credits, low-interest credit lines, accelerated depreciation, and relief from custom duties can provide financial incentives for the private sector to invest in production changes that reduce hazardous substances, increase recyclability, generate less waste, and to participate in solid waste service delivery, including resource recovery.	*The potential benefits of such action to reduce the risk/hazard risk of contamination and/or industrial accidents during a disaster event, such as a typhoon, earthquake or tsunami, will also have to be highlighted, in order to encourage wider participation and involvement.*
Eighth, instruments that target areas of significant pollution loading and environmental consequences should receive priority.	*Besides the points mentioned above, the potential threat of environmental degradation leading to disasters themselves*

	will also have to be considered in identifying and using appropriate economic instruments.

Other design considerations include:

- Instruments that focus on long-term behaviour modification should be implemented.
- New instruments should be introduced in steps, gradually.
- Instruments should be in tune with broader economic development objectives in terms of use of labour, energy and capital.
- Consideration should be given to how revenues from economic instruments will be used.

Comparisons of Economic Instruments for Waste Management

Table 15: Comparisons of Economic Instruments for Waste Management

Economic Instruemnt	*Impact*	*Supporting Regulatory instruments*
Direct Charging	Promotes waste minimization, composting & recycling by penalizing alternatives	Mandatory recycling targets Mandatory provision of schemes Mandatory participation in recycling schemes Landfill Bans for specific waste streams Ban or charging for goods that produce the wastes
Landfill Tax	Promotes diversion from landfill via any other option	Mandatory Recycling targets to encourage diversion to

		recycling rather than treatment and energy recovery Landfill bans for specific waste streams
Tradable landfill permits	Promotes minimization, recycling or energy recovery of the component or waste stream targeted by the permit	Landfill Bans for certain materials
Raw Materials (or Aggregates) Tax	Promotes waste prevention and waste recycling	Recovery targets/packaging regulations
Peat Tax	Promotes composting	Compost targets/mandatory collection of biodegradable waste
Product tax	Promotes waste prevention and minimization	Landfill bans Diversion targets
Deposit refund schemes	Promotes waste minimization, reuse and recycling	National Targets for waste diversion Landfill bans
Incineration tax	Promotes waste minimization, reuse and recycling	Recycling targets Mandatory collection/schemes /participation
Waste Tax	Promotes diversion to options with lowest tax	Recycling targets Packaging Regulations
Voluntary agreements	Participation of concerned stakeholders in voluntarily reducing (or setting targets for)	Information campaigns Stakeholder consultations

	waste generated	
Public information campaigns	Educating public in waste separation and disposal	Education programmes Stakeholder consultations
Cleaner Alternatives (including technologies)	Providing alternatives for activities that generate waste	National and local laws providing for alternatives

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

> **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
> **Production and Consumption** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
> **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
> **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
> **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information,
see **www.unep.fr**

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UNEP

This publication is a practical guide to assist decision makers in national and local government agencies in Indonesia to understand the issue of disaster wastes management. It outlines the development of a waste management mechanism that facilitates the development of local strategies on waste issues, bringing together knowledge and experience on existing and ongoing work on waste and debris clean-up. It specifically looks at the issue of construction and demolition waste, and addresses the following issues:

- *How demolition wastes can be collected, including clearing of debris, buildings slated for demolition, and foundations of buildings that need to be cleared before reconstruction can begin.*
- *How demolition and building/construction debris can be treated in order to make it reusable – in what form and for what purposes.*

This publication is part of the EU funded Asia Pro Eco II B Project entitled "Tsunami Waste Management: Demonstrating ESTs for Building waste Reduction in Indonesia" – The DEBRI Project.

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