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Demonstrating ESTs for Building waste Reduction in Indonesia

The DEBRI Project

Report on Tsunami-generated Debris
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EXECUTIVE SUMMARY

This report on the tsunami-generated debris is intended to adjust existing basic data that will to help identify technology components to be procured under the DEBRI project, and develop a comprehensive waste management mechanism for construction and demolition (C&D) disaster wastes.

The collation of data presented here is from secondary sources – project documents and reports of a number of organizations funding or working on issues related to waste debris, as well as field visits to verify and reassess their validity.

This report consist of four parts. Part 1 provides an overview of the quantification and classification of debris (C&D wastes), including the number of buildings destroyed and estimation of C&D waste generated by the tsunami and earthquake. Part 2 outlines the current status of debris, including debris remaining, municipal solid wastes. Part 3 summarizes completed/ongoing waste projects on debris management in Banda Aceh, and Part 4 reviews prevailing waste management systems. A list of references used is also provided in the end.

Key Findings and Observation

The current waste composition in Banda Aceh is mainly composed of organic wastes. However, C&D wastes arising from the tsunami disaster still remains intact. These C&D wastes are mixed, consisting of stone/brick, timber, vegetation, metals, soil/mud, and other types, but can be separated more easily than municipal solid wastes (MSW). However, due to unpredictability of disasters events, the chances of contamination of C&D wastes are also high.

The adjusted total volume of C&D waste generated from destroyed building has been estimated to be around **853,930** m^3 comprising of building super-structures (above ground) at **725,840** m^3 and sub-structures/foundations at **128.090 m^3**.

There were no special technologies used to treat C&D wastes. The institutional capacity of local authorities in handling C&D wastes was quite limited. However, the existing infrastructure and experience of Banda Aceh's DKP (Cleansing Department) in handling MSW and post tsunami wastes may be a potential modality to develop integrated waste processing and reuse/recycling.

Waste Characteristics and Volume

The characteristics and material composition of C&D wastes generated by Tsunami 2004. in Banda Aceh can be summarized as follows:

Waste type	**Status**	***Technology implications***
Wood.	The wood debris consists of lumber, vegetation and other matter. The sizes of lumber wastes varied from normal lumber size of 5x2 cm^2, 5x12 cm^2 to 9x 15 cm^2, with its length up to 3 m. Some of these wastes were already broken and in a degraded state, unsuitable for direct reuse. Total volume of lumber waste generated was 113,106 m^3 or 15.6 percent. Total weight of lumber waste generated was about 27,657 tons. Wooden houses were the major source of this type of debris.	*In processing wastes still remaining from the tsunami disaster, and in preparing for future disasters in the region, there is a need to explore the potential for technologies and technologies to reuse and process wood wastes, including shredders and compactors.*

Roof-tiles	The most common roof tile used in Banda Aceh was clay-based roof tiles. The size of broken roof tile is usually quite large, from small pieces up to 10x20 cm^2, with thickness of 0.7 to 1.0 cm. Some old houses used metal sheets (zinc) as roof materials. Asbestos roof was also being used although it is not common, and quite rare. Total volume this type of waste generated was estimated to be about 271,625 m^3. Total weight of broken roof tile was approximately 37,585 tons.	*In processing wastes still remaining from the tsunami disaster, and in preparing for future disasters in the region, there is a need to explore the potential for technologies and technologies to prepare such wastes for recycling, including crushers that reduce the size of the tiles to a uniform size, and sorters that sort out the different sizes of crushed wastes.*
Brick	Brick were one of the most predominant C&D wastes generated during the disaster. More than 40 percent of rubble and mortar were also broken into smaller nearly sand size and mixes with soil/mud. Total volume of this type of waste generated is about 271,655 m^3. Total volume of this type of waste generated is about 298,822 tons.	*As with roof tiles above, there is a need to explore the potential for technologies and technologies to prepare such wastes for recycling, including crushers that reduce the size of bricks to a uniform size, and sorters that sort out the different sizes of crushed wastes. The potential of reusing bricks as-is when they can be recovered intact also needs to be explored. Due to the fact that some of the brick waste may be mixed with mortar or concrete, its potential use after recycling/processing as filler and non-structural aggregates (for example, for road*

		building, grading etc.) can also be explored.
Concrete	Concrete was predominantly used for reinforced columns, horizontal beams and other structural components of the building, including floors for multi story buildings. Only in building with more than three stories, foundations also used concrete. The size of concrete waste generated from the tsunami varied from small rubble size, up to 2 m length of column or more than 2.5 m^2 of slab. The total volume of concrete waste including concrete floors (assuming 20 percent of floors were concrete) has been estimated at 101.347 m^3. The total weight of concrete waste generated was about 111,547 tons.	*As with roof tiles above, there is a need to explore the potential for technologies and technologies to prepare such wastes for recycling, including crushers that reduce the size of the tiles to a uniform size, and sorters that sort out the different sizes of crushed wastes.*
Foundation Materials	Approximately, 65 percent of building foundation still remains intact. The most common foundations used are stone mortared foundation. It contains about 45 percent of stone of size 15 to 30 cm in diameter. The mortar predominantly used is 3- 4 parts of sand and 1 part	*As with the above types of C&D wastes, there is a need to explore the potential for technologies and technologies to prepare such wastes for recycling, including crushers that reduce the size of the concrete/stone to a uniform size, and sorters that sort out the different sizes or types of crushed wastes. Due to the*

	cement. Only small parts of foundation were destroyed by the tsunami or by demolition. The estimated volume of foundation waste is therefore about 128,090 m^3. The estimate weight of foundation is 172,920 tons (assuming the specific weight of remains is 1350 kg/m^3).	*mixed nature of foundation wastes, the predominant use of recycled/processed wastes is as filler and non-structural aggregates (for example, for road building, grading etc.)*
Mixed materials	Mixed wastes consists of plastic, rugs, clothes, metal and other household goods. Its size varies greatly, and usually not important except for potential extraction of recyclable materials, including plastics, metals and glass. The estimated volume was about 38,766 m^3. The weight of the waste was estimated to be 11,330 tons.	*Due to the mixed nature of such wastes, there is a need to explore the potential for technologies and techniques to prepare such wastes for reuse or for disposal, including their proper manual sorting, shredding for extraction of recyclable materials, and compacting for disposal/landfilling.*

Current Status of C&D and Municipal Solid Waste

- **Current status of debris in Banda Aceh.** Current tsunamis debris remaining in the city is approximately 58,622 m^3 in the form of un-demolished building, solids and mud in low lying area, or wastes remaining in temporary dumpsites, such as in Gano (near Syah Kuala) and in blocks of former rice fields (*sawah*) in Ulee lhee. Building foundations that are still intact is estimated to be around 83,258 m^3 (65 percent).
- **Current status of solid waste in Banda Aceh.** Banda Aceh has a per capita waste generation of about 0.6 kg/day (GTZ), and the

estimated volume generated per capita is 1.2 L/day (BPPT as cited by PT Demensi Ronakon). It is estimated that DKP collected about 96 tons per day (35,000 tons/year) of MSW in 2006, with covered rate of 60-80 percent of the city (GTZ and DKP). This represents a total volume of about 600-700 m^3/day. The volume of MSW currently (2007) collected daily by DKP on average is 540-600 m^3.

- **DKP Institutional Capacity**. The Cleansing Department of Banda Aceh (DKP) hires about 300 people to handle municipal waste. The operational infrastructure consists of dump trucks,(20 units), roll on/roll off Trucks (11 units), pick up trucks (9 units), compactor trucks (2 units), heavy equipments(15 units), cesspit trucks (9 units), water tankers (6 units) and 6 m^3 waste containers (62 units).
- **DKP Budget Capacity**. The operational budget for waste management in 2006 was Rp. 8 billion (about USD 800,000). In 2007 the budget was increased to Rp. 13 billion. Proposed budget for 2008 is expected to be Rp. 23.8 billion. The increasing budget expresses the serious commitment of the local government to manage MSW.

The current status of C&D debris and MSW illustrates a need, as outlined by the DEBRI project, for a comprehensive waste management mechanism that builds capacity and demonstrates specific technologies that can handle a variety of C&D wastes arising both from disaster events as well as from everyday activities.

Collection of baseline data on Debris resulting from the 2004 Indian Ocean Tsunami in Banda Aceh, Indonesia

INTRODUCTION

The Indian Ocean Tsunami occurred on 26 December 2004, followed by a series of earthquakes on 28 March 2005 and floods at the end of April 2005 - devastating approximately 187,784 building units in NAD Province. The amount of buildings (mostly houses) destroyed were 110,986 units, and 76,798 units were damaged or slightly damaged (BRR, as cited by Dept. of Urban Planning and Housing, Kota Banda Aceh, 2006).

PART 1: QUANTIFICATION AND CLASSIFICATION OF DEBRIS (C&D wastes)

A. Number of buildings destroyed

Comprehensive data on destroyed buildings/houses in Banda Aceh has not been collected 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, 3,630 (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 maps 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 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 (for example, 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.

B. Estimating C&D waste generated by tsunami and earthquake.

The following section present an estimation of C&D waste generated during the tsunami disaster. The estimation was carried out by multiplying the floor area with the following ratio (estimated by Indonesian Architect Y Hardjono).

- Traditional wooden house: 10-15 kgs debris per square meter of floor area, consists of:
  - 70% wood,
  - 15% roof tile or sheeting (seng or asbestos), and
  - The remaining is mixed materials, including concrete foundation and floor (15%).
- Modern brick and concrete house: 20-25 kgs of C&D debris per square meter of floor area, consists of:
  - 65% brick/concrete,
  - 15% wood,
  - 10% is roof tiles or sheeting, and
  - The remaining is other materials, including concrete foundation and floor (10%).

However, it is considered that the figures of the ratio and weight of C&D waste generated for each type building proposed by Y Hardjono were too small. 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 modern brick house, the weight of wall per square meter is about 0.12x1650 kg/m^3. If it is assumed that each square meter of floor has an average of 2 m^2 of wall, with the thickness of wall about 0.12 m, it contributes about 396 kg of rubbles per square meter of building.

Normal C&D waste

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

Wooden house

Roof : 20-50 kg/m^2. (20 kg/m^2)
Wood structure and wall : 30-50 kg/m^2. (40 kg/m^2)
(Including windows and doors)

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/m^2 **746 kg/m^2**

Multi storied commercials establishment

An average of 2 stories were used in this calculation

Roof tile (kg/m^2 area of building) : 30 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 (7% of building area) : 115 kg/m^2

Floor : 246 kg/m^2
Mixed wastes : 10 kg/m^2
Average C&D waste generated/m^2 **817 kg/m^2**

Note
The following assumption is used in calculating the C&D waste to be generated by destroyed building.
* A square meter of floor has approximately 2 m^2 of brick wall or equivalent, with specific weight of 1,650 kg/m^3.
** The specific weight of concrete used was 2,100 kg/m^3.
*** A 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 these figures, a modern brick house with 86 m^2 floor area is estimated to generate 63.3 ton C&D waste, a figure that comparable to Oxfam GB (2005) estimation (50–75 ton/building).

Table 1 presents a summary of calculated C&D debris weight and volume generated during tsunamis 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	%	M^3	%
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 building is **725,840** m^3. This amount does not include foundations of buildings. Estimating that the foundation volume is 15% of the total mass volume of a building, then the volume of foundations is 128,090 m^3. The total volume of C&D waste generated from destroyed building then be **853,930** m^3.

Tsunami Waste

The tsunami waves also scoured the bottom of nearby shores, roads, bridges, vegetation and soil/mud from the land when it moved inland, and swept away debris when it moved backward. Oxfam GB estimated that approximately 50% of the tsunami waste consisted of soil/mud/solids (30%) and vegetation (21%). This approximation was likely based on the estimate of waste already dumped in the temporary dumpsite. 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 was swept away by the backward wave to the sea, leaving approximately 35% on the land, or **603,495** m^3 of mixed waste.

Table 2. Estimated C&D debris generated and its characteristic 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 and floor materials)	240 425 375	62.4 17.6 20.0	50.00 25.00 25.00
Single storied brick and concrete houses	o Woods o Roof tiles o Brick	240 425 715-	7.7 13.2 45.1	2.0 6.1 53.8

	o Concrete o Floor o Mixed materials	1795* 950-1800** 1100 375	12.0 18.8 3.2	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 potential C&D waste generated. The specific weight may be 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 Wood debris consists of lumber and vegetation trunk and stems. The sizes of lumber wastes varied 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 were	o Information and calculation are based on site survey and visit, discussion with staff from BRR, UNDP, GTZ,

	already broken and in the form of small pieces, and degraded. o Total lumber waste volume generated was 113,106 m^3 or 15.6% o Total weight of lumber waste generated was 27,657 tons. o Wooden houses were the major source of this type of debris.	CARE, ISWA, documentation (photograph or television), Oxfam GB reports, DKP of Banda Aceh, DPP of Banda Aceh, MOE staff, UNEP report, local engineering consultants, and other reports.
Roof tiles	o The most common roof tiles used is clay - based roof tile. The size of broken roof tile was usually quite large from pebble size up to 10x20 cm^2, in the form of a sheet with thickness of 0.7 to 1.0 cm. Some old houses used metal sheets (seng) as roof materials. Asbestos roof was also being used although this was not common, and quite rare. o Estimated total volume of this type of waste generated was about 271,625 m^3. o Estimated total weight of broken roof tile was approximately 37,585 tons. o The main sources of broken roof tiles were single and modern housing.	o Obtained mostly from field surveys.
Brick	o Brick was a dominant C&D waste generated during the	o Obtained mostly from

	disaster. Most housing built after the 70s used brick as the main material, partly as a symbol of "prosperity". Usually the bricks in the form of collapsed wall were broken down into smaller sizes of 10 to 20 cm pieces to enable removal from the site. More than 40% of rubble and mortar was also broken into smaller nearly sand size and mixed with soil/mud. o Estimated total volume of this type of waste generated was about 271,655 m^3. o Estimated total weight of this type of waste generated is about 298,822 tons.	field surveys.
Concrete	o Concrete was used as column, ring balk and other structural components of buildings, including floors for multi story buildings. Foundations of buildings more than three stories also used concrete. Soon after the disaster, larger size concrete columns and concrete slabs created problems in removing and handling. The sizes varied from rubble size up to 2 m length of column and more than 2.5 m^2 of slab. A "metal scavenger" was used to break it down in size in order to enable the removal	Currently, most of the concrete rubble has been used for land filling or road reclamation.

	of valuable iron rod from the column and slabs. During the demolition of the building, the size of concrete wastes was smaller and separated from its iron rod. o Estimated total volume of concrete waste including concrete floor (assuming 20% of floor are concrete) was 101,347 m^3. o Estimated total weight of concrete waste generated was 111,547 tons.	
Foundation materials	o Approximately, 65% of building foundation still remains intact. The most common foundations used were stone mortared foundation. Such foundations contain about 45% of stone of size 15 to 30 cm in diameter. The mortar used 3- 4 parts of sand and 1 part of cement. Only small parts of the foundations were removed by tsunami or by demolition. o Estimated volume of foundation waste is 128,090 m^3. o The estimate weight of foundation remaining is 172,920 tons (assuming the specific weight of remains is 1,350 kg/m^3).	Most of bridge foundations are still intact, especially those near Ulhee lee.
Mixed materials: • Plastic	o Mixed materials wastes consists of plastic, rugs,	o Metal metals such as copper,

• Metals • Rugs and fabrics • Others	clothes, metal and other substances. Its size varies and usually not important except for metals and other recyclable materials. However some specific wastes such as medical waste and chemical waste needs serious attention due to its potential to be a hazard to humans or the environment. o The volume estimated was 38,766 m^3. o The weight of the remains is estimated at 11,330 tons.	aluminum, iron steel are being collected by scavengers or informal scrap dealers from the site itself or from temporary dumpsites and landfill site. This includes iron rods used in reinforced concrete buildings.

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

Part 2: CURRENT STATUS OF DEBRIS:

A. Debris remaining

The estimated waste volume left after the tsunami was **603,495** m^3. This estimated volume was including the remains of building foundations. Until July 2007, the tsunami waste from Banda Aceh that has been cleared to disposal 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 still intact (covering 65% of the total foundation, or equivalent to 83,258 m^3). By taking this into account, it is estimated that the tsunami waste still left in the form of un-demolished building or still left in temporary dumpsites in Banda Aceh is **58,622** m^3 in the form of undemolished/destroyed buildings, soil/mud swept away by runoff after heavy rain, or left in temporary dump site, or elsewhere in the Banda Aceh area. (NOTE: This figure should *be reduced* by excluding the concrete elevated PDAM reservoir and PLN building recently demolished, sorted and dumped.)

Figure 1. Remains of PLN Building under demolition (28 August 2007)

A portion of the tsunami waste that was dumped into a rice field (sawah) still remain there, since the owner let the tsunami waste debris fill his low lying land.

B. Current status of debris in Banda Aceh

The following sections present the summary of current status of debris

- Current tsunamis debris remaining is approximately 58,622 m^3 in the form of un-demolished buildings, solids and mud in low lying area, or still left in small amounts at temporary dumpsites, such as in Gano (near Syah Kuala) and in a block of former rice fields in Ulee lhee.
- Building foundations that are still intact is estimated around 83,258 m^3 (65%).
- Field survey indicates that destroyed buildings not been demolished are:
    - About 12 double storied commercial buildings at Meuraxa, Ulee lhee (near a tsunamis survival mosque), and 100-120 buildings (around 30 buildings are two storied commercial buildings) at Pasar Aceh, commercial buildings near Grand Mosque Baiturrahman, Kutaraja), and housing/residential buildings in Kuta Alam.
    - There are also some destroyed buildings that are being kept intact, as a "reminder" (monuments), such as in mass cemeteries (Meuraxa), and a two-stories building that was used to take videos of the tsunami moment.
    - Bridge foundations in adjacent area of Syah Kuala

a. Two storied commercial establishment at Meuraxa

b. Commercial establishment near Pasar Aceh

c. Commercial building at Kutaraja, next to Grand Mosque

Figure 3. Tsunamis destroyed buildings still remains intact. Some of them (middle) are inhabited illegally.

Figure 4. Destroyed buildings that are being kept intact as a memorial (as monuments). Top: buildings in a mass cemetery in Meuraxa, and above, the house that had been used to take amateur videos during the tsunami moment (Meuraxa).

Figure 5. Remain of a destroyed bridge at Syah Kuala

- Until July 2007, the tsunami waste cleared in Banda Aceh alone was 461,614 m^3, while for NAD the figure was 1,107,389 m^3 (UNDP, 2007). UNDP and DKP of Banda Aceh are the institutions that played a major role and was responsible in waste clearing.
- Heavy equipments such as back hoe loader, bulldozer and dump truck were used for waste clearing. No special equipment such as concrete crusher or shredder was used. The average heavy equipment leased for waste clearing throughout NAD was 123 per day. However in July 2007 the number was decreased to 40 units per day. For Banda Aceh alone, the average heavy equipment leased was 34.5 units per day.
- Until July 2007, the sawah/tambak rehabilitated was 101 ha (UNDP 2007), DKP staff indicate that there will be no more sawah rehabilitated in Banda Aceh.
- Until July 2007, the number of tsunami/earthquake buildings demolished were 101 units (UNDP 2007). Since August 2006, the number of building demolished is less than 10 units. It is likely that no more building will be demolished by UNDP or DKP. Last important buildings to be demolished were PDAM elevated reservoir and PLN Regional Office buildings (August 2007). The PLN building demolition was carried out by independent contractor under PLN supervision.
- Recovered wood processed into condition suitable for recycling was 1,527 m^3 (UNDP, 2007), and 13,185 m^3 was stockpiled or provided to NGOs for reconstruction. For Province of Aceh, the figures are 2,744 m^3 and 17,713 m^3 respectively. Some of the recovered woods was used for making furniture (table, cupboard, etc.).
- The rubble derived from debris has been used to recover roads and filling up low lying land. For Banda Aceh alone, the length of road rehabilitated/reclaimed was 19 km, and throughout NAD the length of rehabilitated roads were 79.1 km (UNDP 2007). The volume of rubble being used for road rehabilitation was 14,560 m^3 (DKP).
- Most of the cleared wastes are now in the main Banda Aceh landfill site of Gampong Jawa.

- More than 85% of all metals such as copper, aluminum, iron steel are being collected by informal scrap dealers from the site itself or from temporary dumpsites and landfill site to be sold on the market (mostly in nearby city of Medan). This includes iron rods used in reinforced concrete buildings.
- The remaining foundations are largely structurally intact and in some cases can also be reused in situ.
- The dumped C&D waste which is mixed with soil/mud after sorted out from organic, glass and woods has the potential to be used for land filling, while rubbles and demolished concretes can be used for road reclamation.

C. Municipal Solid Wastes

Municipal solid waste in Banda Aceh is managed by Cleansing Department (DKP). DKP of Banda Aceh was established according to the Local Government Regulation (Perda or Qanun) No. 5/1976, followed by Perda No.09/2001 describing the organization structure and working description of DKP. The existence and operation of the DKP is supported by Perda No: 5/2003, regarding city cleanliness, the authority and responsibility of the DKP to carry out the job, and Perda (Qanun) no. 13/2007 which is dealing with contribution of the community to the institution and government (retribution). This Perda is being updated, giving more control to communities, companies and institutions. Soon, after the Draft of National Legislation on Solid Wastes 2007 (RUU-Sampah) has been ratified by the Parliament, the existence and function of Department such as DKP will be stronger and more powerful.

The following section describes the current status of municipal waste in Banda Aceh.

- Banda Aceh has a per capita waste generation of about 0.6 kg/day (GTZ), and the estimated volume generated per capita is 1.2 L/day (BPPT as cited by PT Demensi Ronakon).
- The municipal solid waste (MSW) that has been collected by DKP also has a significant role in the tsunami waste reduction. This is shown by the significant volume of MSW disposed in the early operation of the TRWM Project (DKP and UNDP). In April 2005, the total volume of MSW disposed was 29,222 m^3 per month, and

gradually decreased to 2,669 m^3 per month, a year later (April 2007).

- It is estimated that DKP collected 96 tons per day (35,000 tons/year) of MSW in 2006, with 60-80% of the city covered (GTZ and DKP). This represents a total volume of about 600-700 m^3/day. BPPT, in a report prepared by PT Demensi Ronakon (2007), estimated that the daily MSW production is about 637 m^3.
- The volume of MSW currently (2007) collected daily by DKP on average is 540-600 m^3.

- The Cleansing Department of Banda Aceh (DKP) hires about 300 people to handle municipal waste. They possess the following vehicles and equipments:
    - Dump truck, 20 units
    - Roll on/roll off Trucks, 11 units
    - Pick up Trucks, 9 units
    - Compactor Trucks, 2 units
    - Heavy equipments, 15 units
    - Cesspit trucks, 9 units
    - Water tankers, 6 units
    - Waste containers (6 m^3), 62 units
- The operational budget for waste management in 2006 was Rp. 8 billion (about USD 800,000). In 2007 the budget was increased to Rp. 13 billion. Proposed budget for 2008 is expected to be Rp. 23.8 billion. The increased budget demonstrates the serious commitment of the local government to manage the MSW.
- The composition of MSW collected in Banda Aceh is as follow:

Table 4. Municipal Waste Composition Data

Waste type	Domestic		Commercial			Market	Landfill
	Permanent	Temporary	Grocery	Photocopy center & Printing	Food shop		
Organics	69%	38%	17%	9%	50%	58%	34%
Plastics	17%	23%	25%	27%	25%	17%	16%
Paper	5%	15%	42%	64%	17%	8%	13%
Metal	2%	8%	0%	0%	0%	8%	13%
Textile	7%	0%	0%	0%	0%	0%	8%
Glass	0%	0%	0%	0%	0%	0%	8%
Rubber	0%	15%	17%	0%	8%	8%	8%

Source: DKP 2006.

It is worth noticing that the organic content of the MSW, especially coming from permanent domestic residential, market and food shop is quite high (50% - 69%). This composition has potential for composting application to reduce the volume of dumped MSW.

PART 3. COMPLETED/ONGOING WASTE PROJECT

Until now, there have been many ongoing waste-related projects in Banda Aceh. The following Figure 6 shows involvement of some important institutions in tsunami wastes collection, handling and management of MSW. Among the institutions or organizations involved in the tsunami waste clearing and management, UNDP played an important role.

Institutions currently involved in the waste management in Banda Aceh are:

a. UNDP UNDP is the institution executing the Tsunami Recovery Waste Management Programme (TRWMP), funded by Multi Donor Fund (MDF) in partnership with Badan Rehabilitasi dan Rekonstruksi (BRR), and is currently implemented through a partnership with the 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.

The outputs of UNDP-TRWMP were:

- 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.

b. CAL GAP Introducing small scale composting technique for organic municipal waste reduction.

c. VNG Preparing a MSW management master plan for Banda Aceh. The service is expected to complete during the end of 2007.

d. GTZ Through Support for Local Governance for Sustainable Reconstruction (SLGSR), preparing a Preliminary Design & Institutional Options for Waste Disposal and selecting Regional Landfill site. GTZ 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.

e. PT Demensi Ronakon

Preparing the Feasibility of Regional Landfill at Desa Makmur (Montasik). Service expected until the end of 2007.

f. AUSTCARE Execute consulting services in livelihood programme that supports the following kinds of activities:

- recycling of plastics, metals, food and drink cans, rubbles
- composting,
- develope energy from waste, and
- use wastes as raw materials in small business such as brick/lime kiln.

The project started in January 2007.

g. OXFAM Initiating "waste bank" concept together with GTZ and Pro-LH to purchase recycleable materials by opening Oxfam Lampaya shop. This initiative is still ongoing.

h.SOGREAH Provide technical assistant to BRR on solid waste collection, and disposal, and drainege maintenance in Banda Aceh. The service is expected to complete in 2007.

i. ISWM Integrated Solid Waste Management (ISWM) set up by UNDP-TRWMP and DKP with its aim to help the establishment of regional solid waste landfill.

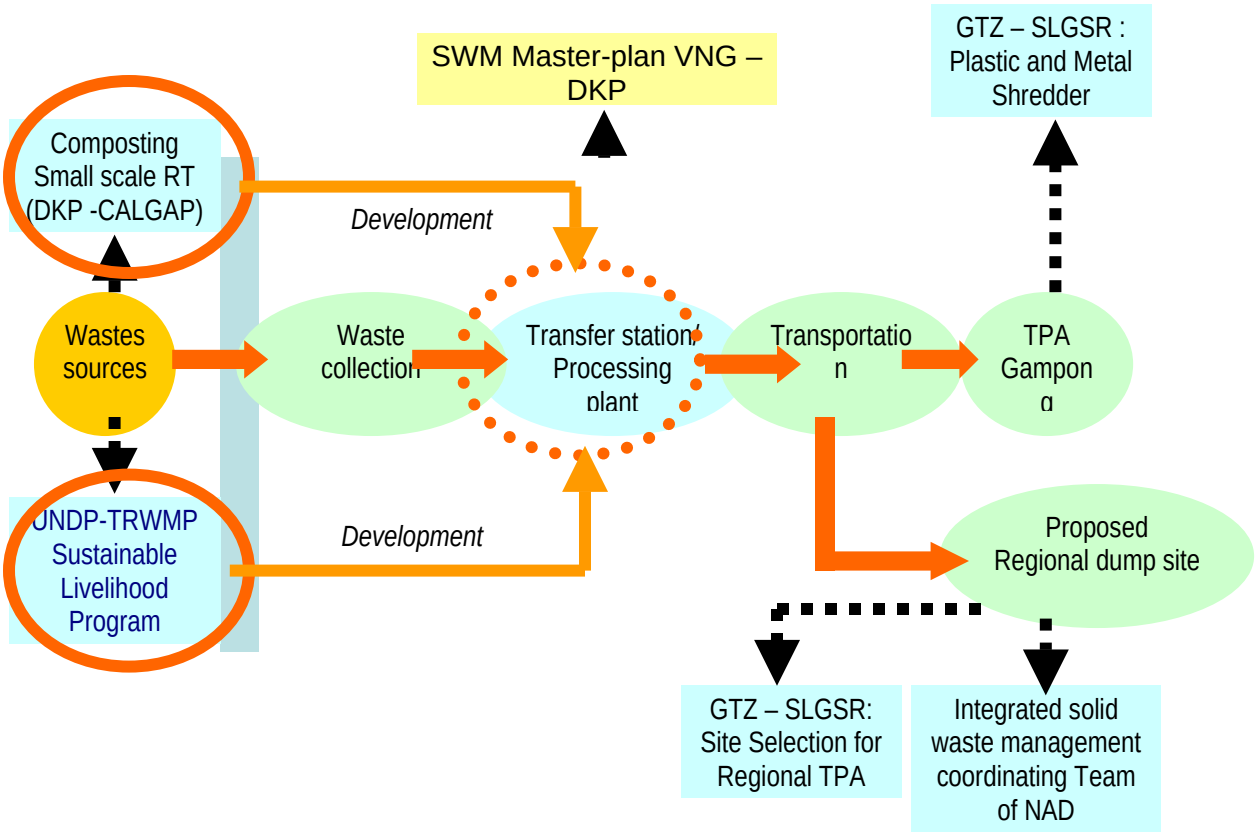

Figure 6. Involvement of some institutions in Banda Aceh MSW management

PART 4. REVIEW OF PREVAILING WASTE MANAGEMENT SYSTEM

Concerning tsunami debris and municipal solid waste, the following section discusses a quick assessment of the current situation.

- Tsunami waste has been effectively cleared by participation of the community, local and international institutions/organizations. The recorded volume of tsunami waste cleared (461,614 m^3) has significantly reduced the existing debris. The remaining debris in the form of building remains, building or bridge foundation so far has no significant effect to the daily activities of Banda Aceh community or local government. The remaining destroyed buildings that are still intact may be due to legal problems (such as, inhabited illegally, or the owner is not known) or the owner is happy with the current situation. However, it is necessary to clear some big or clusters of buildings, in spite of the non-technical problems, since these buildings are not safe to be inhabited.

- With such issues as enormous volume of debris, any effort to recycle or reuse the debris must be a very valuable option. Information on the characteristic of the debris is minimum, however some recycle and reuse practices has been applied successfully. Although the character of debris will be different for each location, characterization of tsunami debris is an important step in the effort to recycle and reuse of the debris.

- The current practices in organization/institutional recycling and reuse emphasize on the use of wood for rebuilding homes (just after the tsunami) and to make furniture, and rubbles for road rehabilitation and land reclamation. With the current volume of timber stockpiled being 13,185 m^3, the reuse and recycle of this timber needs a detailed plan and organization.

- Some metals, iron bars and plastic have been collected and recycled or reused by informal scrap dealers. In case of soil and mud, which is major part of the debris, it has been used to cover MSW at the Gampong Jawa dump site. Another opportunity to recycle and reuse of tsunami debris is the use of rubbles and slabs of concrete in dumpsite or C&D waste from buildings to be demolished. By shredding the concrete waste from C&D waste, a good quality of rubles may be obtained and used.

In the case of MSW, Banda Aceh has been actively promoting composting of organic rich MSW. A composting facility with a capacity of approximately 50 tons/month has been able to operate in a location near Gampung Jawa landfill site. The problem encountered is the sustainability of the project, since the use of compost is still very limited. It is necessary to understand that composting will reduce the volume of dumped waste, and it means reduction of collection and transport costs, and extended life of the dumping site.

- Currently, and in the future, DKP will play a very important role in waste management. The structure of DKP has been rearranged based on Perda 09/2001. The structure of DKP regarding the execution of waste collection, disposal and processing has been well developed to suit needs of Banda Aceh. Supported by strong commitment from local government, the MSW management of Banda Aceh has shown a very good performance. An important aspect to note is that DKP is also the organization collecting MSW. This method is also practiced by DKP throughout Indonesia. By setting up collection of domestic waste conducted by the smallest community structure (RT and RW), communities have responsibility to manage their own waste.

- Aceh population is approximately 3.9 million. It consists of many ethnic groups. Aceh was once a meeting point for many nations, and among the present day Acehnese can be found some individuals of Arab, Turkish and Indian descent. Chinese can also be found in Aceh especially in Banda Aceh. The dominant ethnic group in Aceh is Acehnese (70%), followed by Gayo Lut (7%), Gayo Luwes (5%), Alas (4%), Singkil (3%), Javanese (3%), and Simeulu (2%). At the moment there is no indication of exclusive residential or kampongs for a specific ethnic group, especially after the tsunami. The majority religion in Aceh is Islam (98.6%), other religion followers are as follows: Cristianity (0.7%), Hindu (0.08%), and Buddhism (0.55%).

- The disaster also created psychological trauma to the people. A report cited by a leading national newspaper (Kompas, September 2007) indicated that patients who recently visited psychological hospital increased by 25 % compared to the year 2003. Although the figure may be questionable, however the

tragedy is believed to have created a deep traumatic feeling to the people who experienced the moment.

In terms of waste management, the role of women is very important. It has been found during the field visit and interviews with local people, that when dealing with domestic waste, women or housewives take responsibility. This situation may be typical for Sumatran people. Therefore, any effort in improving MSW collection and disposal should take this situation into account.

- Rapid risk assessment on the tsunami debris recommended that remains of destroyed buildings must be demolished as soon as possible to avoid further complicated problems. The main concern was the safety of the people who inhabited or lived near the building.

The capacity of the DKP in handling the waste problem is currently good, however the capacity of Gampong Jawa dump site is obviously limited. A project to extend the lifetime of this landfill by another 3-5 years is now being conducted. A new landfill site proposed in Montasik (at desa Makmur), is planned to operate in 2-3 years.

As an emergency measure, recycling and reuse of debris and MSW waste as an effort to reduce the dumped waste is a preferred option. In this case, a demonstration will give significant example on how recycling and reuse of disaster debris (including C&D waste) and MSW will benefit local community and their environment. A package of technologies properly designed to process C&D waste and MSW as a demonstration, which will be complementary, is a recommended option.

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