

# Disaster Waste Management and Environmental Sanitation Status in Developing Countries: Case of Indonesian Major Disasters 1990-2012

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## Abstract

In this paper, two aspects of disaster waste management were described for assessing the status and the problem of disaster waste management in Indonesia. First one is the concern of the management process and second concern is management system. Then the estimation of disaster waste generation especially for construction and demolish disaster waste, proposed by UNEP on Aceh Tsunami Waste, could be developed for baseline formula on other events, however it needs a continued statistical record due to environmental-sanitation sector on as part of disaster management. Simple recycling already establish in line with a conventional method process-collect-transport-discharge-in disaster waste treatment, informal sector on disaster waste recycling with waste picker, scavenger should be enhanced in line with cash work-livelihood program. Use of a vacant land as a temporary storage was mostly uncontrolled. Although Basic legal framework and coordination among institution including International NGO/Agency were already established, the low-level management status in normal condition became a constraint for action in disaster event. Enhancement of mitigation planning including master plan for sanitation sector, enhancement of contingency plan together with stakeholder concern in disaster management were proposed in this paper for fostering resilience on disaster waste management in Indonesia.

**Key Word:** Disaster Waste, Management, Developing Countries, Indonesia

## 1. INTRODUCTION

Indonesia is one of the disaster-prone countries in the world. In the middle of 2013, Indonesia agency for disaster management recorded more than 18,837 disasters hit in Indonesia. Around 337,905 people died due the calamities<sup>1)</sup>. There are 13 disaster types attacked in Indonesia, Earthquake-Tsunami is the highest in number of victims and flood is the highest in number of events. With the high potential of natural hazard, enhancement of prospered and environmentally sound disaster waste management in Indonesia is significantly important.

This paper assesses major factors of disaster waste management in Indonesia. Firstly, assessment of disaster waste management process was conducted considering how management takes into account with kind of technologies in collection, transportation, intermediate treatment and final treatment setup in Indonesia. Secondly, disaster waste management system such as legal framework, institutional framework and coordination including budgeting

system for running disaster management as of environmental sanitation sector managed of disaster waste management were explored.

Moreover, this paper attempted to describe disaster waste management process considering how disaster waste treatment flow was applied to control negative impact of disaster waste and environmental pollution<sup>2)</sup>. Then disaster waste management system was also assessed considering planning system, setting of process operation, framework of regulations, organization arrangement and financial mechanism.

## 2. DISASTER WASTE MANAGEMENT SYSTEM

### (1) Estimation of Disaster Waste Generation and Characteristics

In Banda Aceh, disaster management method for tsunami waste such as estimation method of construction and demolition waste (CDW) generation and treatment process were well documented.

The following formula (1) was developed by Tsunami waste program of UNEP <sup>3)</sup>:

$$\text{CDW} = 80\text{WH} + 736\text{SMH} + 746\text{SCE} + 817\text{MCE} \dots(1)$$

Where:

CDW: Generation amount of construction and demolition disaster waste (t)

WH : Area of wooden house damaged (m<sup>2</sup>)

SMH : Area of single modern brick house damaged (m<sup>2</sup>)

SCE : Area of single storied commercial establishment damaged (m<sup>2</sup>)

MCE : Area of multiple storied establishment damaged (m<sup>2</sup>)

The formula can estimate CDW generation from any kind of housing and building. It took into account of detail components of housing and building such as roof, wall, foundation and other part component of house and building including, social facility, commercial building in each city.

In this study, the formula was applied to past earthquake and tsunami in Indonesia in order to estimate CDW generation. For the estimation of disaster waste, the aerial map and GIS map were used as basic information of disaster event regarding building and housing damage. While using this method, determination of building in each category were also crosschecked by the information provided from the interviews to stakeholders. Statistical data from documented report in each city were also used for improvement of accuracy .

Table 1 shows the results of estimation of CDW generation from earthquake - tsunami in Flores 1992 until earthquake -tsunami in Mentawai 2010. The listed disasters in the table are regarded as major disasters that the central government is dominantly responsible for. According to the estimated CDW in series of major disasters in Indonesia, the earthquake

in Padang west Sumatra generated around 3.5 Million Ton as the highest among others, while earthquake-tsunami in Mentawai Island in 2010 generated around 24,000 ton of CDW as the lowest for disaster event in Indonesia

Flood is one of the ordinary disaster events occur mostly in rainy season in Indonesian cities. According to some grey documents and interview to government officers conducted in this research, it was found that Jakarta flood 2007 generated around 32,000 ton of flood waste and Bengawan Solo flood 1998 generated around 100,000 ton of flood waste. Volcano eruption in Merapi in 2010 exhausted more than 140 Million m<sup>3</sup> of sand, gravel, and disaster waste due to damaged housing and facilities in all affected area.

## (2) Disaster Waste Treatment Process

Banda Aceh tsunami waste management program 2004 is the significant experience for disaster waste management in Indonesia. It introduces a holistic environmental sound mechanism for disaster waste management and treatment. Totally 8 processes for Banda Aceh Tsunami waste management were demonstrated, namely ; i) land clearance from tsunami waste, ii) support of MSW collection; iii) building demolition, iv) payment for compensation, v) waste reduction-recycling of CDW for land cover and road material in rehabilitation and reconstruction; tsunami wood recycling for furniture, vi) dumpsite rehabilitation, vii) capacity building for government and community for enhancement of governance performance, and viii) regional landfill site construction.

Tsunami waste management program in Banda Aceh city, treated around 1.7 million m<sup>3</sup> of disaster waste. Disaster waste consist of CDW, vegetation, soil/mud/solid. 608,104 ton of CDW consisted of single storied wooden house (13.2%), single storied brick and concrete house (43.4%), single storied

**Table 1.** Estimation for Construction and Demolition Disaster Waste in Indonesian Major Disaster

NO	Earthquake and Tsunami Events	Damage and loses (Billion IDR)	City most severely affected	Estimation of C&D Disaster Waste in all affected area (tons)	Estimation of C&D Disaster Waste in City most severely affected (tons)
1	Earthquake-Tsunami Flores 1992	200	Maumere	180,000	90,000
2	Indian Tsunami 2004 <sup>3)</sup>	39000	Banda Aceh	4,700,000	608,000
3	Tsunami-Earthquake Nias 2004	900	Gunung Sitoli	1,100,000	200,000
4	Yogya Earthquake 2006	29100	Bantul	4,900,000	2,400,000
5	Java Earthquake-Tsunami 2006	534.8	Ciamis	120,000	110,000
6	Bengkulu Earthquake 2007	3218	Nort Bengkulu	780,000	190,000
7	West Sumatra Earthquake 2009	21000	Padang	7,500,000	3,500,000
8	Mentawai Tsunami 2010	348.92	Mentawai	NA	24,000

commercial establishment (10.4%), and multi storied commercial establishment (33.0%)<sup>4)</sup>.

Disaster waste management in Banda Aceh has treated more than 1 Million m<sup>3</sup> of disaster waste and that was utilized for recycled and reuse materials for buildings and 100 km of road, and 12,000 furniture from Tsunami wood<sup>5)</sup>.

A process of the disaster waste treatment and technologies used from 2005 until 2012 were introduced. And setting of final disposal in landfill sites also demonstrated in this program. It also says that disaster waste management process needs a comprehensive thinking considering local condition. As shown in figure 1 disaster waste treatment process in Indonesian major disaster conducted as of solid waste management in disaster condition. Final treatment conducted in landfill site. Compared to a disaster waste treatment flow in Great East Japan Earthquake<sup>6)</sup>, there is no incineration process in Indonesian case.

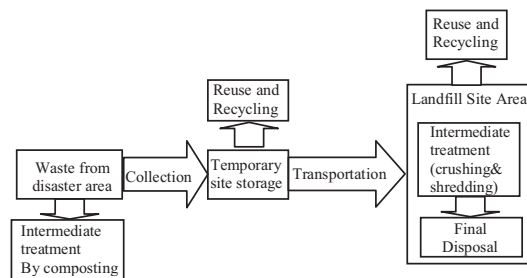
Only in Banda Aceh disaster waste management process well documented. Interview with stakeholder, mostly disaster waste management running with conventional approach. Collect-transfer-discharge. Sorting and recycling mostly by scavenger, waste picker, survivor and volunteers in informal condition. Vacant land and farm land usually chose as temporary site, and some time become permanent site.

For flooding waste process, Jakarta flood 2007 recorded that the process as of normal condition which no formal reduction and recycling program setting. Conventional treatment applied in collection-transport and discharge in Bantar Gebang landfill site. Several actors and stakeholders, such as government officials, NGPs and even scavengers were involved in cleanup work then local government's clean service section collected waste.

Around 59,227 m<sup>3</sup> of flood waste was collected with 130 trucks and 70 fire-trucks. Ministry of public work supported 10 backhoe and 50 trucks. National State agency, Kadin, helped 327 of many type heavy machines for cleanup of flood waste 27,490 m<sup>3</sup>, local government contracted 200 private trucks for cleanup of 45,000 m<sup>3</sup> of flood waste<sup>7)</sup>. Special treatment facilities were installed in three landfill sections in Bantargebang landfill site. One of the section, around 2.1 ha, was called Kepala Burung which had treatment capacity of 500 – 1000 ton per day. This place was already closed.

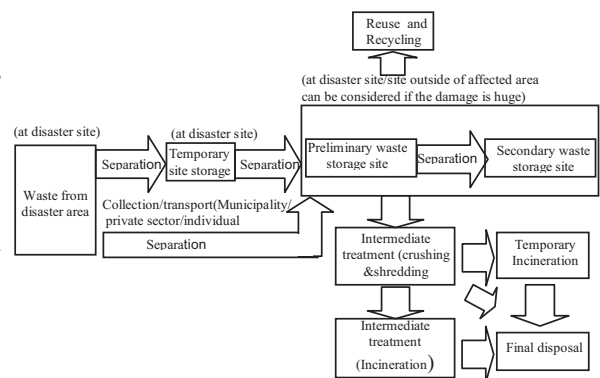
### (3) Legal framework

There are four sub-systems of basic regulation for development of environmental sound and sustainability of disaster waste management in Indonesia. Figure 3 describes the correlation of legal framework system of disaster waste management in Indonesia. Indonesian law no.24 year 2007 manage



**Figure 1.** Disaster waste management process in Banda Aceh Indonesia, 2004, <sup>modified 6)</sup>

the building, access road, public facility and all physical infrastructure, including solid waste management facility for normal condition. From this guide line, disaster waste generation and estimation can be built. Side selection for intermediate (temporary) and final disposal also could be set using this guideline.



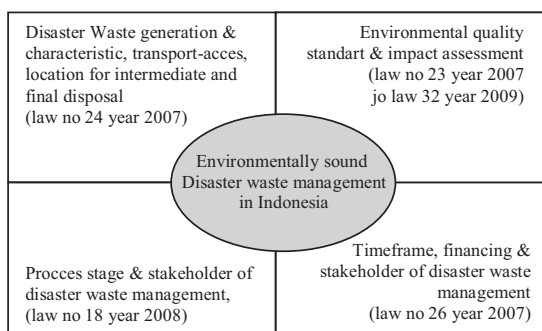
**Figure 2.** Disaster waste management process in Great earthquake Japan, 2011<sup>6)</sup>

Indonesia law no 18 year 2008 is the basic line for disaster waste management as of normal condition for waste management. Indonesia law number 26 year 2007 concerning disaster management. In this law, time frame due to emergency respond, rehabilitation reconstruction state clearly including budgeting and stakeholder coordination.

### (4) Institutional framework

Possibility institutional involvement on Indonesian huge disaster waste management can be described as figure 4. Disaster waste management agency as a leader for disaster management. Department of environmental cleansing responsible for debris clean up. The department can mobilize all resource needed, however this department give a mandatory to department of public work for operation.

Public participation and private participation is a significant issue on institutional framework due to disaster waste management in Indonesia.



**Figure 3.** architecture of Legal framework system for disaster waste management in Indonesia

“gotong royong” is the traditional model for environmental cleanup both normal condition and disaster event. Mostly disaster waste was managed by this concept for involve public private participation, since the government face some difficulties.

### (5) Budgeting

Aceh tsunami waste program issued budget – \$39,4 million for debris clean up and improving city solid waste management in Banda Aceh <sup>8)</sup>. Detail Tsunami waste budgeting, in emergency respond IDR 138,5 billion expensed ( 1 \$ = 9600 IDR) for year 2005-2007, In the intermediate treatment, IDR 246, 3 billion expensed for year 2009 – 2010. For final treatment IDR 119,6 billion expensed for year 2009-2010 and finally, IDR 125,9 billion expensed for install new landfill site for year 2010-2012.

Furthermore, Yogyakarta-central java earthquake 2006 expensed 109,6 Billions for debris clean up and disaster waste management. Those budgeting for disaster waste management with resource mobilization come from any institution coordination. Hard tools be coming from other cities, Jakarta, Semarang such as 22 Excavator, 7 Loader , 38 Dump truck ,1 Trailer , 1 Tandem Roller and 1 Gen-set <sup>9)</sup>

New system for budgeting and financial mechanism construct under “On call budget”, financing system for Indonesia’s disaster management <sup>10)</sup>. Especially for emergency respond, continued by rehabilitation-reconstruction. This is not a regular-annual budgeting. However, no clearly stated.

## 3. PROBLEM IN DISASTER WASTE MANAGEMENT

### (1) Disaster waste estimation

Actually no formula for estimation disaster waste management in Indonesia. No formula proposed for general disaster management beyond to tsunami waste in Banda Aceh and other disaster after. So no comparison value due to detail for housing and building composition. For illustration, material of roof, which part of Indonesia has several types for material. For other problem due to housing

classification which one as permanent housing and which one for non -permanent housing. It is also very hard to identification type of building due to government building and private company building.

### (2) Disaster waste management process

Formal guideline not yet issued for operation in disaster waste management. Debris clean-up mostly very slowly in line with disaster management. No temporary site selected in collecting and transferring for early treatment. Debris discharged to the landfill directly. In some situation, disaster debris discharge to the farm land or vacant land or marginal land in urban area or rural area. More than 60% debris generate from private goods such as damage housing and the furniture. An informal recycling done by waste survivors, waste picker and scavenger and survivors directly in line with other disaster waste management. Final treatment for disaster waste management mostly using landfill site method and no incineration for intermediate treatment.

### (3) Legal framework system

Detail technical for disaster waste management treatment have not yet established. Law number 18 year 2008 concerning waste management not yet detail in disaster waste management. It just state general condition concerning disaster waste management. The other problem is how to setting the coordination among stakeholder due to equipment and tools.

Legal framework due to disaster waste management was very complex, since there are many guidelines as of waste management in normal situation. Part of them issued by ministry of environmental, several type especially for house hold issued by ministry of home affair, while industrial waste issued by ministry of environment and ministry of industry. Disaster waste guideline must accommodate due to waste guidelines for managed disaster waste as household material and hazardous waste from industrial estate and other land use area.

### (4) Institutional coordination

Department of Environmental Clean up as one of the department in Agency for National Disaster Management take a main actor/leader for debris management in emergency respond for disaster waste management process. However the department not yet issued a command and control for disaster waste management. Other problem is transfers from emergency respond to rehabilitation and recovery which so complicated due to administrative procedure. Some time no process transfer for emergency respond to recovery process. Recovery Facility establishment mostly done by international NGO and international agency which also support in emergency respond.

## (5) Budgeting and financial system

No clearly financing mechanism for disaster waste management, and no statistical cost data recorded due to expenses for debris treatment. No basic price issued for running hard equipment such as excavator, and heavy truck. Mostly debris management allocated as a “small part” and concentrated in reconstruction, in line water and sanitation as part of main program of housing permanent recovery. For Banda Aceh Tsunami waste, in emergency respond IDR 138,5 billion expensed ( 1 \$ = 9600 IDR) for year 2005-2007, In the intermediate treatment, IDR 246, 3 billion expensed for year 2009 – 2010. For final treatment IDR 119,6 billion expensed for year 2009-2010 and finally, IDR 125,9 Billion expensed for install new landfill site for year 2010-2012.

On call budget, financing system for Indonesia disaster management, especially for emergency respond, continued by rehabilitation-reconstruction. This is not a

regular-annual budgeting. However, no clearly state how much on call budget issued for waste management and sanitation program. For illustration, National Agency rejected IDR 168 Million for Ambon flood waste cleanup 2012. For other example National Disaster Management Agency allocated IDR 4.5 Trillion for West Sumatra earthquake 2009, only 20 %, compare with IDR 21 Trillion needed for all rehabilitation-reconstruction. Yogyakarta-Sleman Local state issued IDR 4 Billion for Merapi eruption 2010, very limited budget compared with IDR 3.54 trillion needed for rehabilitation and reconstruction.

## 4. CONCLUSION AND PROPOSAL FOR FOSTERING DISASTER WASTE MANAGEMENT IN INDONESIA

As of prone countries which a lot of hazard, Indonesia have set disaster waste management model including disaster waste management. Disaster management already accommodated sustainable

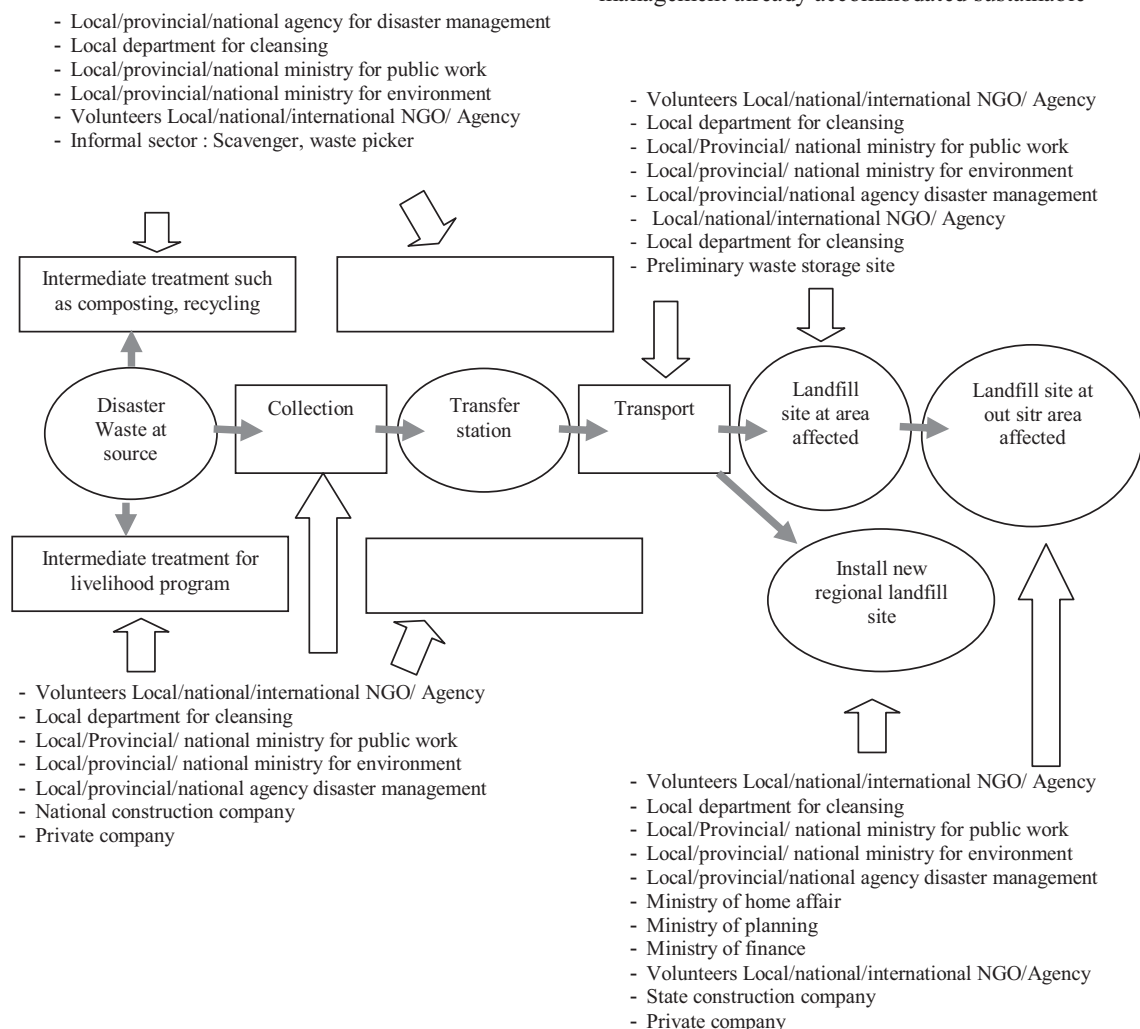


Figure 4. Possibility institutional involvement on Indonesian major disaster waste management



Mechanism due to prevention action and action respond both in emergency and post rehabilitation and recovery in all aspect including disaster waste management. For developing countries like Indonesia, this is not yet established.

Daily waste management will be determined disaster waste management process. Intermediate treatment including recycle faced technological

choice due to effectiveness. For Indonesia, an informal sector mostly taking into account for recycling, furthermore, for disaster waste management, recycling also running by informal sector, both by the owner in line with disaster management or by waste picker (scavenger). Cash work program mostly applied effectively in disaster waste management in Indonesia due to economic and social condition.

Due to disaster waste process and technological availability, it is very complicated, since in normal condition, recycling technology not yet applied formally. It is seems like habitual that waste management using principle collect-transport-discharge as soon as possible. No intermediate treatment applied formally in daily waste management. It is complicated for running environmental sound disaster waste management with a holistic determination using intermediate treatment such as recycling, reduction and setting other intermediate treatment technical tools such as incineration. Limited resource and equipment are a major boundary and serious problem due to timeframe.

Gotong royong is the traditional community enhancement which very usefully in the term of disaster was management in Indonesia. With gotong royong framework, formal-informal from local stakeholder and international agency can be involved for disaster waste management. It is also use for enhance the problem in transfer from emergency condition to recovery condition which is not simple to transfer since the normal condition very low and complicated due to management requirement .

Detail proposal for fostering disaster waste management in Indonesia are as follow:

- (1) Fostering statistical record on disaster waste generation and estimation due to high potential hazard in Indonesia, development new model and formula in estimating disaster waste generation in local state agency for disaster management is needed.
- (2). Incorporating planning for waste management in normal condition and disaster waste is needed, by incorporating MGD's program and Hyogo framework for action, especially how to conduct detail action for water and sanitation sector.
- (3) Incorporating resource and enhance governance system in disaster management, especially in water and sanitation sector is needed. Critical point is how to

perform a sustainable maintenance facility of water and sanitation due to normal condition.

(4) Developing financial mechanism in local level-local resource is needed, modified of ``gotong royong`` as traditional system for disaster management to enhance all of stakeholder.

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