Disaster Waste Management Guideline

for Asia and the Pacific

環境省
Ministry of the Environment
Government of Japan

JSMCWM

Targets of this guideline

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Around the world, under the influence climate change and urbanization, disasters are becoming more frequent and damage from them—more immense. This tendency is most pronounced in the Asia and Pacific region. To this area requiring immediate adaptation, we hope that this guideline is especially useful.

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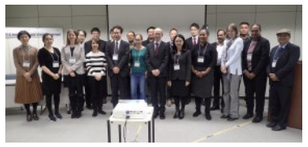

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【B】English version of guidelines on DWM and responses at large scale disasters in Japan

※English manual on the separation and treatment of disaster waste in the Great East Japan Earthquake and Tsunami (2011) published by JSMCWM can be found in Asari M., Sakai, S., Yoshioka, T., Tojo, Y., Tasaki, T., Takigami, H., Watanabe, K.: Strategy for separation and treatment of disaster waste: a manual for earthquake and tsunami disaster waste management in Japan, Journal of Material Cycles and Waste Management, 15 (3) 290-299 (2013).

Abbreviations and Acronyms

BBB	Build Back Better	MoEJ	Ministry of the Environment, Government of Japan
CC	Climate Change	MSW	Municipal Solid Waste
CD	Capacity Development	RRP	Risk Reduction Plan
CP	Contingency Plan	SDGs	Sustainable Development Goals
DW	Disaster Waste	TSS	Temporary storage site
DWM	Disaster Waste Management	WM	Waste Management
IP	Implementation Plan	3R	Reduce, Reuse and Recycling

References to this guideline

- MoEJ: Guideline on DWM and responses at large scale disasters in Japan (2018)
- UNOCHA/MSB/UN Environment: Disaster Waste Management Guidelines (2011)
- UNDP: Guidance Note Debris Management (2013)
- WHO: Technical Notes on Drinking water, Sanitation and Hygiene in Emergencies (2013)
- European Union (EU) and UN organizations: Post- Disaster Needs Assessment (PDNA) Guideline (2013)
- WB: A Handbook for Reconstructing After Natural Disasters (2010)
- OXFAM: OXFAM’ s Technical Brief (2002)
- NIES: Flood Waste Management Guidelines for Bangkok (2015)
- EPA, US: Planning for Disaster Debris/EPA (2008)
- The Federal Emergency Management Agency (FEMA), US: Public Assistance Debris Management Guide (2007)
- Other international and local guidelines, technical information and reports

Foreword

Disasters are becoming more frequent and more intense around the world. Even in Japan, after the Great East Japan Earthquake in 2011, we have experienced many disasters such as storm and floods, landslides, damaging snow storms, and volcanic eruptions. When disasters occur, not only are human life and wealth affected, but a large amount of waste is generated at once too, leading to many issues in terms of preserving living environments, including the contamination of disaster waste, occurrence of pests and terrible odors, and deterioration of public health through the diffusion of hazardous waste and damage to buildings and infrastructure.

In order to promptly restore and reconstruct from disasters, it is crucial to manage disaster waste consisting of damaged buildings, household goods, and other materials in an appropriate and rapid manner. In Japan, we have responded by utilizing waste management technology developed toward the goal of establishing a Sound Material-Cycle Society. Furthermore, we will continue to reflect on our experiences in disaster waste management conducted in previous cases and take measures from various institutional, technical, economic, and systematic aspects.

The experiences and lessons in disaster response in Japan, a disaster-prone country, must be effective and adaptable for other countries around the world after considering differences in geographical conditions and types of disasters. Therefore, we have actively disseminated our experiences and information through our participation in the World Conference on Disaster Reduction held in Sendai City, Miyagi Prefecture in 2015, a series of meetings organized by the UN Environment-International Environmental Technology Center (IETC), and the G7 Alliance Workshop.

Furthermore, in order to make effective use of our findings and to contribute to the challenges in developing resilience around the world, we have decided to compile these findings as the "Disaster Waste Management Guideline for Asia and the Pacific" . This Guideline is supported by the Japan Society of Material Cycles and Waste Management (JSMCWM), a member of the D.Waste-Net established in September 2015—a supporting network of experts made to effectively utilize knowledge and technology in related academic spheres, business, and organizations as a means of strengthening capacity development in disaster response for various places in Japan. I hope other countries will become conscious of disasters and emerge with a sense of mission, and that this guideline can provide great help in enhancing the capacity of local governments in properly coping with crisis.

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Reference: Do pre-disaster (contingency) plans make DW treatment more effective and efficient?

As preparedness for frequent disasters, countries drawing up contingency plans for DW disposal have arisen, with Japan as an example in Asia. Local municipalities in Japan are required to draw up contingency plans in DW disposal after the experiences in the Great East Japan Earthquake in 2011 and every other large-scale disaster imaginable. As of March in 2018, more than 80% of prefectural governments and about 30% of local municipalities are expected to complete plans for their respective area. Frameworks are also important to effectively maintain plans.

There is an interesting survey result from the US: statistical tests suggest apparent discrepancies in counties with or without contingency plans in their recycle rates and amount of public assistance.* Though disasters are not favorable, the importance of preparedness is evaluated quantitatively in Asia and the Pacific if disaster cases accumulate in the future. *Crowley, J. (2017). A measurement of the effectiveness and efficiency of pre-disaster debris management plans. Waste Management, 62, 262-273

Introduction

- disasters are becoming more frequent around the world and more intense in urban areas. Effective implementation of disaster waste management (DWM) will lead to smooth recovery of living environments and risk reduction for disasters and other environmental changes.
- This guideline is developed with the aim of enhancing preparedness for disasters by exchanging information, awareness, and human resources during normal (non-hazard) times.

Necessity of strategic pre-disaster measures

People are apt to pay less attention to disaster waste (DW) before a disaster occurs. However, once disasters break out, inadequate DWM causes adverse effects on living environments and sanitary conditions instantly. Moreover, it could impede disaster recovery. This situation causes serious damages for society.

Thus, this guideline is focused on not only acting as an effective and useful guideline at the time of disaster, but also during post-disaster recovery by preparing DW disposal in advance and making it a smooth process.
We expect to achieve this, as pre-disaster preparation enables progress in regular WM systems, reduces disaster risks, and encourages continuous progress during normal times.

Persons in charge must deepen their understanding of DWM first and clarify the importance of preparation to policymakers and citizens, while at the same time drawing up contingency plans by starting with plans for disasters which directly affect the capacity of regular WM and, thus, developing it strategically.

Strategical strengthening of DWM starting from normal times

[Before a disaster] Contingency plans + Preparedness
- To reduce the potential of waste generation
- To strengthen the framework of waste disposal
- To keep disposal facilities in a potentially useful condition even in disaster times

[Before a disaster]
Understanding of DWM (including the budget) in policymakers and citizens

[Disaster time]
actions during disaster (especially at the beginning) from contingency plans → support for disaster recovery

Expected readers of this guideline

This guideline mainly aims to be read by the national government, state and municipal officials in charge of DWM in Asian and Pacific countries. Though the exact structure of government may differ in each country and municipality, it is essential to determine which division will be responsible for DWM and how to cooperate with other divisions. Other stakeholders who may be involved in DWM, such as humanitarian agencies and NGOs, are also targeted (see Chapter [5]).

Although there are many kinds of disasters, this guideline mainly focuses on disasters.

Various countries in Asia and the Pacific

Asian and the Pacific countries have a wide variety of nationalities, cultures, environments, and social systems. The character and quantity of solid and disaster wastes, along with their respective management systems and technologies also differ between countries. Therefore, we must understand differences, gaps, and characteristics to promote DWM activities and networks in this region.

As a starting point, this guideline tries to compile various examples in the region to share information and good practices.

1. Disasters in Asia and the Pacific

- Frequent disasters in Asia and the Pacific region relating to geophysical activities are earthquakes, tsunamis, and volcanic eruptions, while those relating to climate are floods, tropical cyclones, and cloudbursts. Preparing for these disasters is considered one of the most important actions in climate change adaptation.
- Disasters are increasing year by year. Social factors, such as urbanization, exert a large influence on disasters.
- From the viewpoint of DW, greater attention has to be given to high functionalized building materials as well as to the increase of the amount of furniture in each household.

Management of Risks of Disasters

disasters in the world are recognized as one of the most significant barriers to sustainable development. The Sendai dialogues on disaster risk have mentioned that the achievement of long-term development efforts may disappear in an instant once some disaster occurs. In order to manage disaster risk, strategic policy on the following five points is necessary. Appropriate control of waste generated by disasters is essential for quick recovery from disasters and reconstructing livable cities.

1. Risk identification
2. Risk reduction
3. preparedness
4. Financial support
5. resilient construction

Management of Risks of Disasters

The figures below (Fig. 1-1 and 1-2) show the trend in the number of disasters. The number of disasters has been rapidly increasing in the past 50 years, especially in Asia. This is likely attributed to the region having the largest and most rapidly increasing population. That is, disasters induced by Climate Change (CC) (floods and storms) occur in conjunction with urbanization and result in immense damage to the region.

Even though people have mitigated and adapted to disasters, the rising severity of disasters (especially by CC) in recent years is increasingly beyond their capacity. Damage by disasters is exacerbated by regional vulnerability, based on poverty, land use, and poor preparation and command systems for emergency cases. Disaster itself is hard to prevent, but damage by disasters can be prevented and attenuated by appropriate countermeasures which combine physical barriers, governance systems, social dissemination, and financial allocations. This allows damaged cities to recover earlier and is a motivation for creating resilient societies against disasters.

Tackling disaster reduction requires various fields, including cities, infrastructure, transportation, education, and, most importantly, DWM.

From the viewpoint of DW, high functionalized building materials and the increase of the amount of furniture in each household in many Asian and Pacific countries increases the risk of disasters quantitatively and qualitatively. This guideline puts importance on the necessity of contingency plans in order to reduce this risk, in addition to earthquake resistance, the traceability of building materials, and hazardous materials.

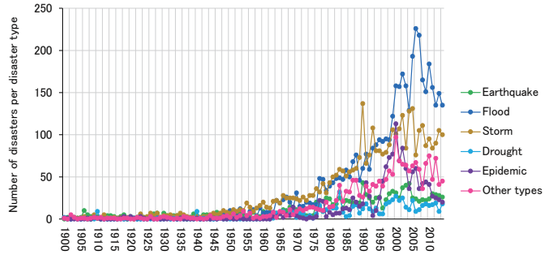


Fig.1-1 The trend of the type of disasters

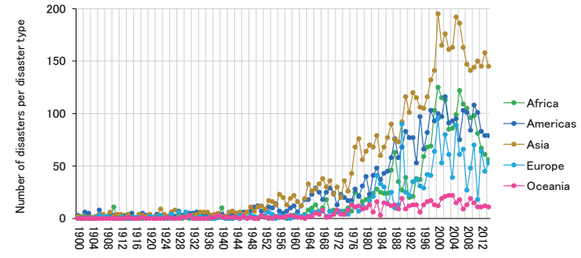


Fig.1-2 The trend of the disaster in regions

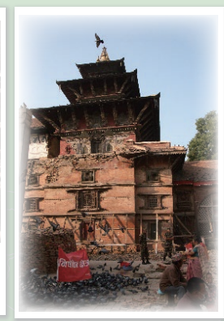
Data Source: Center for research on the Epidemiology of Disaster

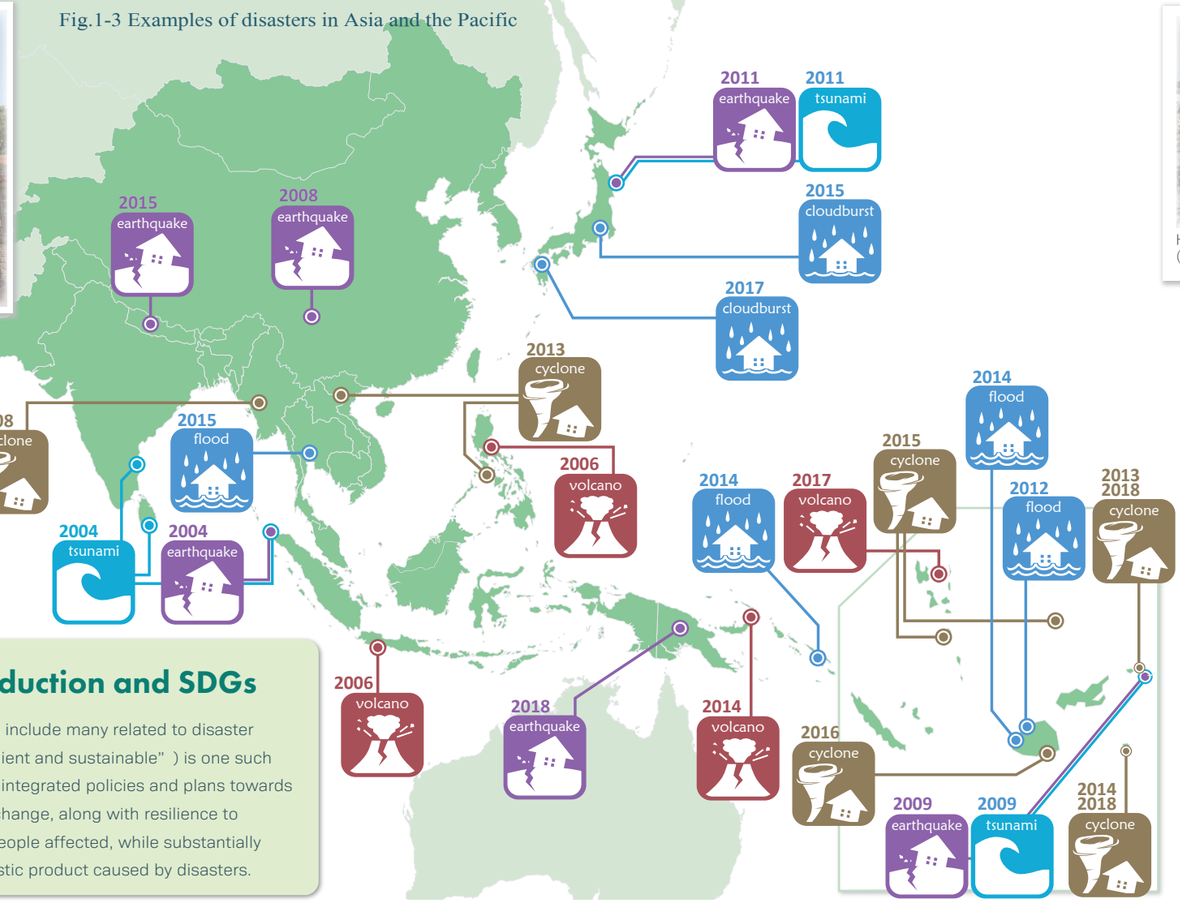
Examples of Disasters in Asia and the Pacific

Several buildings were destroyed and severely damaged, including World Heritage Sites in Nepal (the 2015 Nepal earthquake)

Properties and vegetation damaged by inundation (the 2011 Thailand flood)

Fig.1-3 Examples of disasters in Asia and the Pacific





Houses and Buildings destroyed by the tsunami (Great East Japan Earthquake, Japan, 2011)

Buildings and properties damaged by water plume and vegetation dirtied by mud and sand (Kanto-Tohoku cloudburst, Japan, 2015)

Buildings and vegetation damaged by volcanic ash (Mt. Pinatubo eruption, Philippines, 1991)

Buildings and vegetation destroyed by gales (Typhoon Haiyan, Philippines, 2013)

Huge amount of DW transported to a landfill in Port Vila, Vanuatu (Cyclone PAM, Vanuatu, 2015)

Community affected by flooding caused by the cyclone (Cyclone Evan, Samoa, 2012)

Reference: Disaster risk reduction and SDGs

The 17 Sustainable Development Goals (SDGs) of the United Nations include many related to disaster prevention and reduction. Goal 11 (“make cities inclusive, safe, resilient and sustainable”) is one such example. This goal states that, by 2020, adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation, and adaptation to climate change, along with resilience to disasters by 2030, significantly reduces the number of deaths and people affected, while substantially decreasing the direct economic losses relative to global gross domestic product caused by disasters.

2. Disaster Wastes in Asia and the Pacific

- Specific measures and approaches for DWM should be determined according to the characteristics of each type of disaster and waste.
- It is necessary to consider the type of disaster, its scale, location, and time of occurrence, which all have an impact on the amount and characteristics of DW.

Large amount of DW generation

disasters—such as earthquakes, tsunamis, and cyclones—occur frequently in Asia and the Pacific as shown in Chapter [1]. These generate a large amount of waste due to their strong destructive force. The amount of DW can equal tens of years worth of regular municipal waste amount, while DW is difficult to treat due to its characteristics (Table 2-1, 2-2 and 2-5)

Table 2-2. Estimated amount of DWs in the past disasters

Date	Name of the Disaster	Estimated amount of DWs
Earthquake/Tsunami		
Dec 2004	Sumatra-Andaman earthquake (Indonesia)	7 million-10 million m3
May 2008	Sichuan earthquake (China)	20 million tons
Jan 2010	Haiti Earthquake (Haiti)	23 million-60million tons
Mar 2011	The Great East Japan Earthquake (Japan)	31 million tons
Apr 2015	Nepal earthquake (Nepal)	14 million tons
Cyclone/Typhoon/Hurricane/Flooding		
Aug 2005	Hurricane Katrina (USA)	26.8 million tons
Oct 2011	Thailand floods (Thailand)	100,000 tons
Nov 2013	Super Typhoon Haiyan (Yolanda) (Philippines)	19 million tons
Feb 2016	Tropical Cyclone Winston (Fiji)	23,525 tons

Source; Framework of DWM Guideline in Asian & the Pacific

Table 2-2. Examples of DW generation (Case of Japan)

Date	Type of waste	Municipality	Amount (1000 ton)	Compared to annual MSW	Characteristics
Mar 2011	Earthquake and Tsunami (The Great East Japan Earthquake)	Iwate Prefecture	4,233*	56-79 years **	● Various types of communities, from small fishing villages to industrial areas ● Large damage from tsunami
		Miyagi Prefecture	11,530*	3.7-95 years**	● Same as Iwate prefecture
		Sendai city***	1,369*	3.7 years	● Ordinance-designated city ● Big damage at the sea side area by Tsunami and some at the hill side area by earthquake
		Ishinomaki ward***	5,265*	95 years	● Large part of the city was damaged ● Fishery and industry were damaged
Aug 2014	Flood and land slide	Hiroshima city	584	1.6 years	● Limited part of the city was damaged ● Large amount of waste mixed with soil and water
Sep 2015	Flood	Joso city	52	3 years	● Large part of the city was flooded and some houses were destroyed

*Not include Tsunami sediment, **Calculated in each city/area, ***Part of Miyagi Prefecture

How to manage various disaster wastes

In the event of a disaster, in addition to regular municipal waste generation, wastes from evacuation centers, excreta from temporary toilets, and DW are generated (Table 2-3). These must be treated promptly and appropriately, while preparations and countermeasures need to be considered in advance for the following reasons:

life-threatening risk, public health risk, environment risk, impact on regular WM services in place, economic impact (resource efficiency/cost effectiveness and benefit), resilience (community, comm unication, gender, training, etc.).

Table 2-3. Types of DW

Household Waste	Wastes generated from household in daily life
Evacuation	Wastes generated from evacuation centers such as containers and packaging, cardboard, clothing, relief goods and so on.
Excreta	Excreta from temporary toilets, and Wastewater from sewage flowing into the toilet bowl due to the disaster
Disaster Wastes	Wastes when the residents clean up damaged objects in and around their homes, Wastes generated due to removal of damaged houses (dismantling as necessary), and All types of wastes listed in table 2-4.

Type of DW and materials

Wastes may consist of destroyed buildings and the objects they held inside, destroyed pavements or other infrastructure, wood, sands, and other natural derivatives and so on. Not only are wastes directly generated from disasters, activities in recovery and reconstruction in the post-disaster phase also generate waste.

The identification of materials is essential to promote proper WM. Table 2-4 shows the categorization of DW generated by type of disaster.

Table 2-4. Category of waste generated by disasters

Category	Characteristics of DW	Image	Type of Disaster (✓✓; frequently generated, ✓; generated)			
			Earthquake	Tsunami	Flood	Cyclone
Green wastes	Vegetation such as fallen trees, glasses and timbers		✓	✓✓	✓	✓✓
Building rubble	Timber, wood chips, waste wood (such as column, beam wall-material), bulky items, cables Concrete/bricks *Asbestos should be categorized as Steel, rebar, aluminum material, etc.		✓✓	✓	✓	✓
Household materials	Food wastes, tatami mats, wastes mixed with fibers, paper, wood chips, packaging materials, household furnishing and belongings, other wastes (such as plastics, cardboard, paper)		✓✓	✓✓	✓✓	✓
Mixed wastes	Mixed wastes consisting of a small amounts of concrete, wood chips, plastics, glass, soil and sand, etc.		✓	✓✓	✓✓	✓
Electrical appliances	Televisions, washing machines, and air conditioners discharged from affected houses, which are damaged by disasters and become unusable		✓	✓✓	✓✓	✓
Automobiles	Vehicles, motorcycles, and bicycles that are damaged by disasters and cannot be used		✓	✓✓	✓✓	✓
Vessels	An unusable ship damaged by a disaster			✓✓		✓
Wastes difficult to treat properly	Dangerous goods, such as fire extinguishers, cylinders; and items which are difficult to treat at local government facilities, such as pianos and mattresses (including radiation sources for nondestructive inspection), fishing nets, gypsum boards, etc.		✓✓	✓✓	✓✓	✓
Hazardous wastes	Hydrocarbons, such as oil and fuel; paint; varnishes and solvents; pesticides and fertilizers; medical waste in debris; waste posing healthcare risks; asbestos-containing waste; PCB; infectious waste; chemical substances; toxic substances, such as chlorofluorocarbons, CCA (waste using chromium copper arsenic wood preservative), and tetrachloroethylene; pharmaceuticals; pesticides hazardous waste; solar panels and accumulators; etc.		✓✓	✓✓	✓✓	✓
Mementos, Valuables	Albums, photos, Ihai tablets, cash, passbooks, precious metals		✓✓	✓✓	✓✓	✓✓
Industrial wastes, Commercial wastes	Bulky wastes, hazardous wastes, food wastes, marine products and foodstuffs discharged from refrigerators, raw materials and products generated from fishery processing plants and fertilizer factories, machinery, equipment		✓✓	✓✓	✓✓	✓
Tsunami sediment	Sand and sludge sediments launched to land from the bottom of the sea as well as farmland soils by tsunami			✓✓	✓✓	
Sand and stone	Sand and stone launched to land from mountains, rivers and other areas		✓	✓	✓	✓
Household wastes	General and bulky wastes discharged from households		✓	✓	✓	✓
Wastes from evacuation centers	Waste discharged from evacuation centers, waste from relief supplies		✓	✓	✓	✓

Reference: Common and regional-specific waste – case of Japan

As a common challenge in Asia and the Pacific, kitchen wastes and timber are among DW for which quick response is tied to safety in living environments and recycling. Kitchen wastes should be a priority, collected and managed from unusable refrigerators. By swiftly separating timber from other waste and sand, the options for recycling widen. Treatment of DW affected by seawater should be also considered. If salt-watered DW is disposed directly, it may damage treatment facilities. Leaving such waste in the rain for a while lowers their salinity. This might be the simplest pre-treatment.

Waste is typified by regional characteristics, and disaster waste is no exception. As part of Japanese culture, tatami mats, made of igusa (Japanese rush), are used as floors in Japanese style house. Watered or muddied by water disasters, these mats become useless, heavy, and unwieldy disaster waste and need special storage and treatment.

Composition by type of DW

Although waste composition differs widely according to the type and scale of disaster, the ratio of inorganic waste is high. Thus, that there are many situations which require high-efficiency material recycling deserves emphasis.

Especially in earthquakes and tsunamis, as many buildings and infrastructure are damaged, much waste is composed of inorganic material like cement, as shown in Fig. 2-1. The Great East Japan Earthquake is a typical example. A high recycling ratio was achieved to ensure efforts in reusing these materials.

There is characteristic data from the Kumamoto Earthquake, which indicates that waste composition depends on the source of DW generation. As Table 2-5 shows, shortly after the time disaster breaks out, the ratio of mixed and combustible waste ratio is high, as the waste is mainly generated by household clean-up. In the disaster recovery phase, DW generation increases mainly by the demolition of buildings, and the amount and ratio of inorganic waste rise. On the other hand, the Thailand flood case in Fig.2-2 shows the highest ratio belongs to wooden furniture waste, since the survey (conducted by the Bangkok Metropolitan Administration) is based on household hazardous waste and infectious waste.

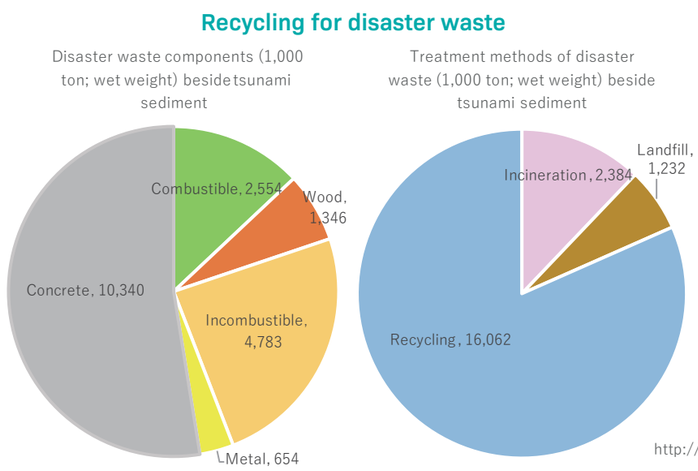


Fig. 2-1 Composition and recycling of DW during 2011 Great East Japan earthquake and tsunami

Almost 100% of tsunami sediment (11,000ton) was recycled.
http://www.nikkenren.com/doboku/saigai/pdf/report/data_gaiyou.pdf

Case of Fiji

Tropical Cyclone (TC) Winston, Cyclone Winston, February 2016

Category Five Severe Tropical Cyclone Winston cut a path of destruction across Fiji from 20th to 21st of February 2016, claiming 43 lives with 160 people injured. 35,000 evacuees found shelter in 424 evacuation centers. 97 schools were damaged while 100% of crops were destroyed in affected areas. A 30-day state of disaster was declared.

An estimated 9410 loads (23,525 tons) of waste was generated from urban centers alone, excluding rural and maritime areas.

Fiji is still recovering from these disastrous impacts, even two years later (housing, schools, agriculture, etc.).

Response lead by Lautoka City Council

- Lautoka City Council has a 3R Promotional Plan which targets recycling of green waste from wood chipping (for mulching in gardens, fuel for sugar mill, and as a component for composting).
- Estimated 575 tons of green waste were chipped after TC Winston.
- Lautoka City Council has allocated a separate site within a landfill for the reception of disaster wastes (though it requires improvements).
- Resource recovery is also promoted (biofuel, reuse, and recycling).
- 127 tons of disaster waste was recovered from landfills by waste pickers and an estimated 1,800 tons of green waste was recovered for biofuel by residents after TC Winston.

Challenges

- ✓ Fire breakout at storage site is a risk.
- ✓ Involves intensive labor
- ✓ High maintenance cost of chipping machine

Source: Mr. Shalend Prem Singh, Senior Health Inspector, Lautoka City Council, Fiji

Chips used for composting and as mulch for a flower garden

Recyclables separated from disaster waste

Table 2-5 Amount of disaster waste generation classified by material type (as of Dec. 14, 2017)

Waste generated mainly by household clean up

Waste generated mainly by building demolitions

*1,000 ton	Waste disposal/ estimated generation amount	Waste concrete	Waste wood	Waste metal	Others (remaining materials)			
					Mixed waste (landfill)	Combustible material	Tiles	Other
Apr – Aug 2016 Disposal amount*	471	137	45	4	153	68	45	18
Ratio (%)	100%	29.1%	9.6%	0.9%	32.4%	14.5%	9.6%	3.8%
Sep 2016 – Mar 2018 Estimated generation amount*	2,422	1,233	411	9	263	63	252	190
Ratio (%)	100%	50.9%	17%	0.4%	10.9%	2.6%	10.4%	7.9%
Total*	2,893	1,371	456	14	416	131	297	208
Ratio (%)	100%	47.4%	15.7%	0.5%	14.4%	4.5%	10.3%	7.2%

Note: Some totals do not match due to calculations after decimal point rounding.

Case of Thailand

Flood, Bangkok, Thailand, 2011

- Flood waste includes: MSW, infectious waste (from medical treatment, research, etc.), and industrial waste, all of which were generated both during and after flood events.
- Among these, the main types of flood waste the Bangkok Metropolitan Administration (BMA) dealt with were MSW (including household hazardous waste) and infectious waste.
- The exact amount and composition of flood waste depends on each flood event. For example, according to the waste composition survey by the Department of Environment (DoE) of the BMA, the composition of waste during flooding in 2011 was as listed in Fig. 2-2.
- As for the quantity, the estimated flood waste amount (i.e. amount of additional waste collected by BMA compared to normal times) for each BMA district is shown in Table 2-6. The total flood waste amount in Bangkok was estimated as ca. 152,000 tons, the highest amount being ca. 20,000 tons in Don Mueang district.

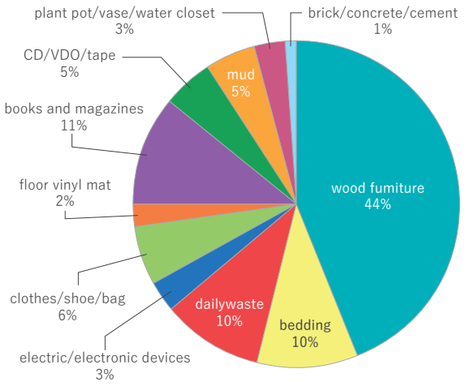


Fig. 2-2 Composition of flood waste during 2011 flooding (Source: Department of Environment, BMA).

Source: Flood Waste Management Guidelines for Bangkok, National Institute for Environmental Studies Japan, 2015

Table 2-6. Statistics relating to the quantities of waste collected from November 2011 to January 2012 (Flood Waste Management Guidelines for Bangkok).

No.	District	(a)Average waste amount during normalsituation	(b)Total waste amount from 2011/12/1 to 2012/1/12	Flood waste(=(b)-(a)*60)(tons)	Flood waste per house-hold(kg)
1	Don Mueang	157	29,642.74	20,222.74	313
2	Lak Si	147	13,263.14	4,448.14	96.7
3	Sai Mai	166	18,037.13	8,077.13	94.5
4	Bang Khen	237	17,955.30	3,735.30	41.6
5	Chatuchak	338	22,509.39	2,229.39	25.9
6	Min Buri	169	10,915.25	775.25	15.4
7	Khlong Sam Wa	127	8,567.50	947.5	14.9
8	Nong Chok	88	5,682.04	402.04	7.9
9	Khan Na Yao	98	7,724.28	1,844.28	53.4
10	Bang Khae	258	19,622.16	4,142.16	53.5
11	Bang Phlat	143	10,532.28	1,952.28	43.2
12	Taling Chan	113	7,677.55	897.55	24.2
13	Phasi Charoen	149	10,388.89	1,448.89	31.3
14	Nong Khaem	164	12,136.88	2,296.88	41.9
15	Thawi Watthana	92	6,579.84	1,059.84	35.5
16	Bangkok Noi	186	11,857.77	697.77	15.7
17	Bangkok Yai	88	5,410.72	130.72	4.9
18	Bang Bon	187	11,267.78	47.78	1.1
19	Lat Krabang	203	12,615.37	435.37	6.1
20	Lat Phrao	157	9,781.29	361.29	7.2
21	Chom Thong	192	11,024.47		
22	Bang Khon Thian	256	14,957.11		
23	Bueng Kapi	284	18,690.91	1,650.91	18.7
24	Bueng Kum	151	10,434.29	1,374.29	21.8
25	Thon Buri	163	9,558.52		
26	Khlong Toei	283.54	18,328.94	1,316.54	23.1
27	Khlong San	121.18	7,386.14	115.34	3.4
28	Din Daeng	230.53	15,149.36	1,317.56	25.4
29	Dusit	176.09	10,670.05	104.65	3.3
30	Thung Khru	115.54	6,279.52		
31	Bang Kho Laem	125.32	7,109.97		
32	Bang Sue	158.23	9,818.41	321.61	7
33	Bang Na	189.84	11,660.77	270.37	5.1
34	Bang Rak	152.56	9,794.88	641.28	24.9
35	Pathum Wan	218.5	15,653.47	2,543.47	97.6
36	Prawet	214.64	12,947.04	68.64	1
37	Pom Prap Sattru Phai	87.24	5,365.83	131.43	6.8
38	Phaya Thai	148.87	9,853.58	921.38	25.8
39	Phra Nakhon	135.57	11,151.34	3,017.14	163.4
40	Phra Khanong	190.53	8,661.33		
41	Yan Nawa	159.12	9,869.73	322.53	7.5
42	Ratchathewi	173.99	11,625.57	1,186.17	30.8
43	Rat Burana	118.2	6,704.02		
44	Wang Thonglang	195.12	12,968.18	1,260.98	22.8
45	Watthana	232.3	15,171.61	1,233.61	22.1
46	Saphan Sung	187.19	6,071.93		
47	Sathon	155.27	10,357.28	1,041.08	29.2
48	Samphanthawong	58.2	3,757.87	265.87	20
49	Suan Luang	187.19	12,347.63	1,116.23	20.9
50	Huai Khwang	149.41	10,615.56	1,650.96	32.8
51	Othew public sectors		73,657.62	73,657.62	

Other cases can be seen in the Appendix.

3. Overview of DWM and Planning

- Identifying the whole picture of management cycle of disaster and DWM must be the first and important step.
- The smooth removal, separation, and proper management of various types of DW are essential measures for emergency response, recovery, and reconstruction after disaster.
- To achieve effective DWM, formulating a contingency plan (including estimations of DW generation), grasping the current system and capacity in WM, and identifying necessary activities and resources are crucial.

Management cycle of large-scale disasters and disaster waste

Understanding the basic management cycle of DW is important. Especially when dealing with large-scale disasters, it is necessary to develop plans in the long-term, from the emergency phase to the recovery and reconstruction phase, in addition to conducting contingency plans for waste management. Understanding and cooperation with not only WM but disaster prevention and emergency response too are essential (Fig. 3-1).

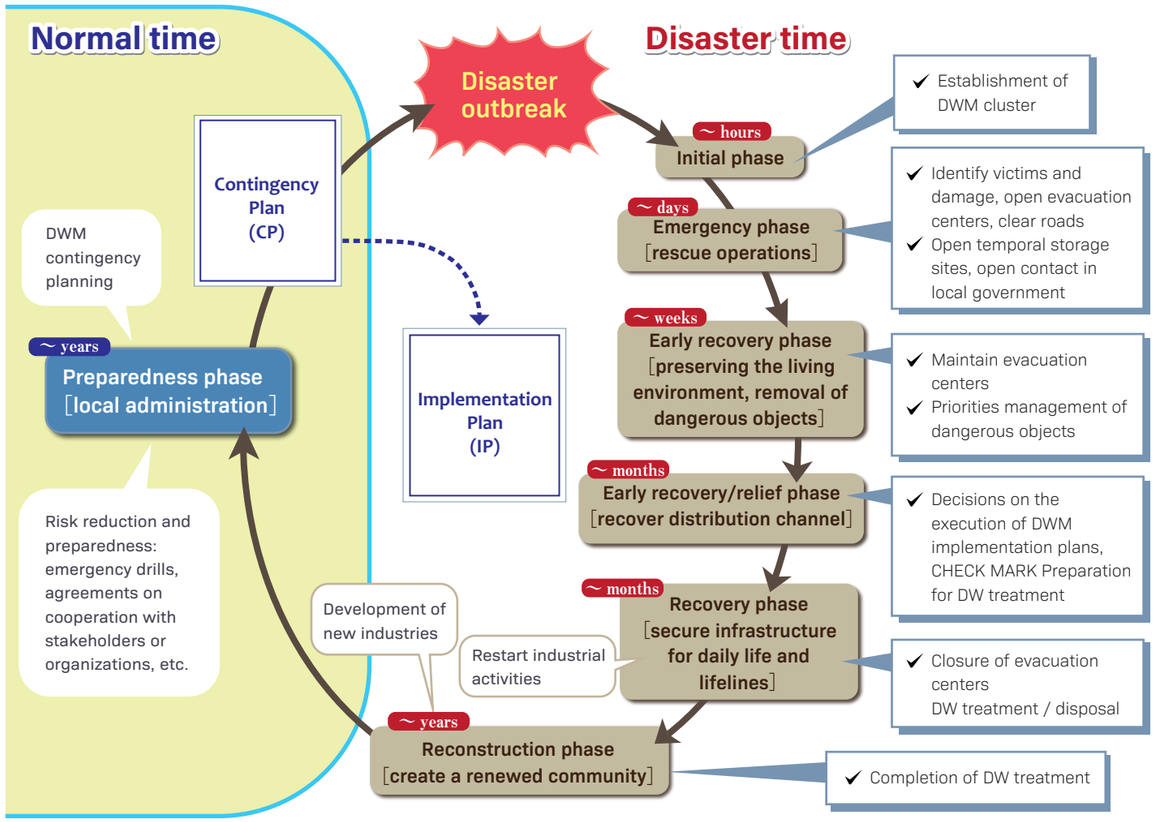


Fig.3-1 Management cycle of large-scale disasters
Source: Hatayama, M. presentation for the 4th meeting on public-private cooperation (13 Sep 2011) and MoE Japan "Guidelines on Disaster Waste Management (Mar 2014), modified by Okayama T.

Preparedness, Contingency Plan, and Implementation Plan

There are some steps for developing plans and actions which depend on the content and timing of disaster waste.

First, there are two kinds of plans: the Contingency Plan (CP) and the Implementation Plan (IP). CP is the pre-disaster plan which specifies how to react and proceed with DW disposal at the time of a disaster breakout. IP is the post-disaster plan compiling actual response policies using CP and ascertaining the real disaster situation immediately after a disaster breaks out. In some instances, it is possible for countermeasures in risk reduction to be compiled in Risk Deduction Plans (RDP).

As for the content of actions, this is also divided into three parts. Post-DWM is the most basic and can be implemented more smoothly if plan-making and securing storage sites are completed before a disaster occurs.

As for Risk Reduction Plans, if potential waste reduction is implemented, less amount of DW will be generated. Additionally, these preparations for DWM could encourage progress and strengthening of pre-waste management in normal times.

With these relationships in mind, formulating a CP should be the first step.

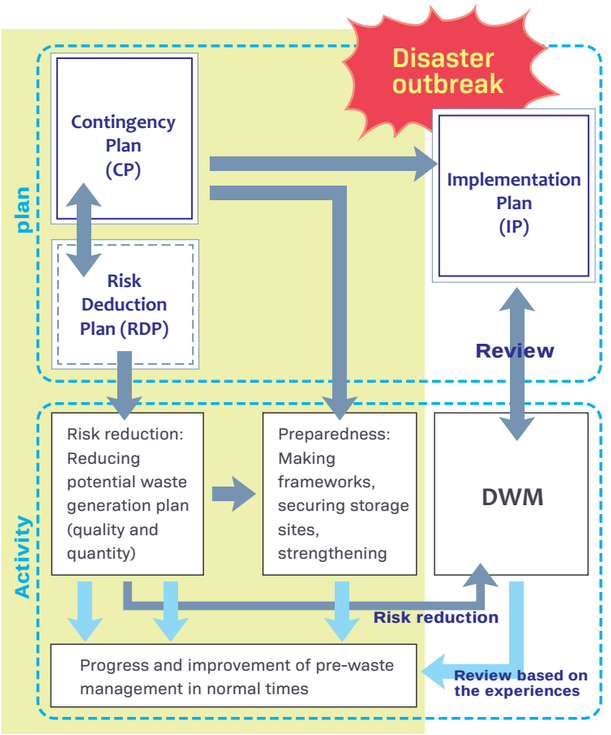


Fig.3-2 Plans and actions pre- and post- disaster

Basic Flow of Disaster Waste

For treating DW including large and hazardous materials, we recommend removing them out of living environments and stowing them in temporary storage sites (TSS) promptly. Then separation or intermediate treatment should be completed effectively, while reuse, recycling, and appropriate treatments could follow. In some cases, wide-area treatments may be done out of the affected area.

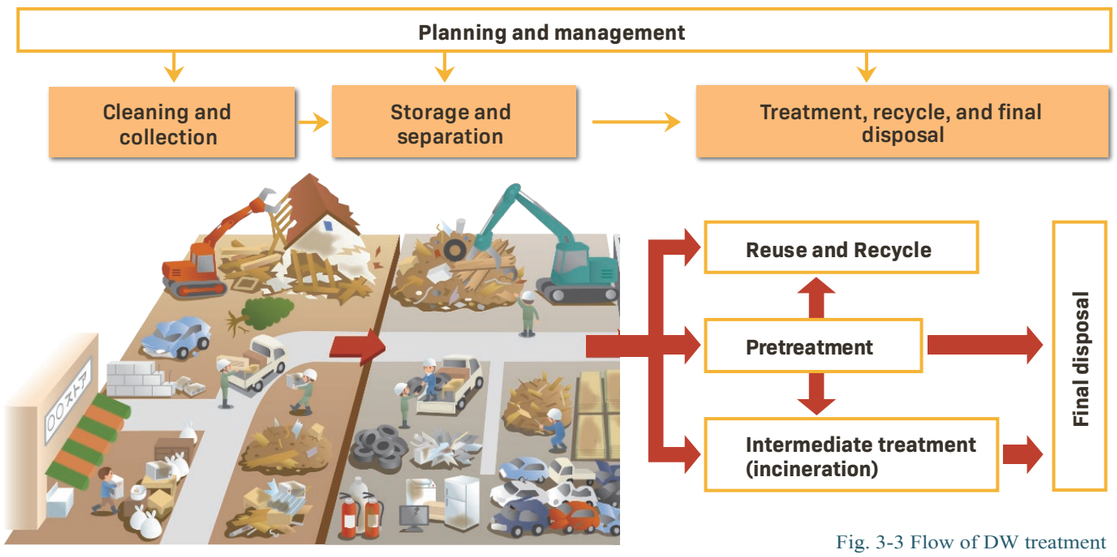


Fig. 3-3 Flow of DW treatment

Main contents of Contingency Plans for DWM

The main contents of Contingency Plans are:

- Estimate the amount of DW → Speculation on temporary storage sites (TSS): Give concrete thoughts on the necessary number of sites, required capacity/area, layouts for separate unloading, line of on-site traffic, arrangement of supervisors, etc.
- Identify the current system and capacity in WM and recycling, including private sectors and voluntary groups. → Conclude MOUs for cooperation in disaster times with waste collection providers, treatment service providers, recyclers, voluntary relief organizations, etc.
- According to the treatment timeline, define necessary activities and gauge the required manpower and equipment to conduct such activities → Define what items require external assistance (along with what can be outsourced)

The main contents of Contingency Plans for DWM are:

- Prescribe actions to be taken immediately after a disaster; organizational arrangements and resources needed for implementation should also be considered
- Understand issues and improve existing waste management and 3R systems in normal times
- Identify what external assistance is needed, avoiding confusion from inconsistent decisions made spontaneously (or indecisiveness)
- Inform citizens and businesses beforehand so they are prepared
- Make citizens and businesses aware that separated treatment will contribute to swift recovery with smaller environmental burden

Main contents of Contingency Plans for DWM

Contents		Risk Reduction Plan (RRP)	Contingency Plan (CP)
A. Institutional Framework on DWM	1. Officer/team/ organization for DWM		Designate the officer/team and organization as well as their roles and responsibilities in DWM (including excreta and wastes from evacuation center)
	2. Stakeholders		Identify networking and cooperation with stakeholders, such as other clusters, line ministries and local governments (city-city), private sectors (Cooperation Agreement), and media groups
	3. Community		Identify networking and cooperation with stakeholders, such as NGOs, and community groups, including churches, youth and women's groups
B. Treatement Flow	4. Disaster type		Identify the features of DWM in accordance with disaster type
	5. DW Information	● Collect and update all waste management information, such as waste audits, progress of 3R awareness and activities, incoming waste to landfills, and landfill conditions, etc. ● Analyze the WM system in place based on the risk and hazard maps (See DWM Impact Assessment)	Identify an estimation technique for generated DW and a list of RaNA for DWM
	6. WM Inventory	● Investigate capabilities of WM facilities for disasters and meet needs for reconstruction and improvement ● Prepare necessary WM facilities and procure necessary machinery and equipment (See DWM Impact Assessment) ● Reduction of hazardous materials	● Develop an inventory of capacities and techniques in WM as well as hazardous waste mapping ● Develop a feasible DWM treatment flow, including temporary sites, intermediate treatment, incineration (if available), hazardous waste management, final disposal, awareness, and coordination of volunteers and regional collaboration (see IP template)
	7. Awareness & Outreach	● Provide DWM awareness and education to school students and communities (incorporate DWM component into the WM or DRR awareness in place) ● Provide mutual learning opportunities among cities and local governments (as well as among countries)	Develop awareness and outreach activities in DWM including training programs (for consistent US spelling), and tool and material development both for communities along with evacuation centers
C. Law, Regulation & Budget	8. Law, Regulation, Plan, and Budget	Relevant laws, regulation and plan development, or amendments Budget allocations Self-check list (current and necessary resources, waste inventory, budget, awareness, hazardous waste mapping, data collection capacity, etc.)	● Subsidies ● Fundraising (plan)
D. Capacity Development	9. Workshop, Training, Site Visit, Awareness, etc	CD program for (D)WM regulators and implementers Awareness programs for private sectors, NGOs, and communities	

Implementation Plan (IP)			
Establishment and coordination of DWM clusters			● DWM team cluster, rotation of staff ● Coordination of supporters, external/internal actors, other stakeholders
Preparation and Coordination			Initiate all relevant data collection (in collaboration with stakeholders)
			Estimate amount of DW and its treatment capacity
			Confirm human, technical, and financial resources to treat DW
			Develop the IP based on baseline information in accordance with CP
			Discuss and introduce IP with stakeholders
			Discuss closure of temporary sites based on CP
			Contract (advanced agreement) for emergency DWM
			Discuss designation of temporary toilets and their excreta, as well as DW generated from evacuation centers
Treatment Flow	Temporary storage site	1st temporary storage site (※)	Selection of 1st temporary site
			Transportation/temporary disposal
			Separation
			Closure of the site
		2nd temporary storage site (※)	Selection of 2nd temporary site
			Introduction of treatment facility
			Crush & separation
			Closure of the treatment Facility
			Closure of the site
	Demolition and transportation		Demolition of collapsed houses and transportation of DW
	Intermediate treatment (Pre-treatment)		Discussion on recyclable materials with recycling companies and on the reuse of organic wastes with farmers
			Collection of recyclable materials
			Organic waste management
	Incineration (if necessary) and Landfill		Municipality meetings
			Test incineration (if required)
			Incineration and landfill
C. Law, Regulation & Budget	Hazardous waste management		Confirm and allocate temporary stock (disposal) site
	Monitoring		Monitor the environment and DW to prevent pollution
	Final disposal		Final disposal (including designated DW space)
	Regional collaboration		Intermediate treatment, incineration, final disposal
	Volunteers/ Awareness	Community base	Contract with community groups for DWM, Prepare for PPE
		Media	Implement media awareness on DWM
	Specific concerns		Manage wastes from evacuation centers & excreta from temporary toilets
			● Special measures which abide the law ● Seek financial support, coordinate the budget

※ In the case of a large-scale disaster, temporary storage site (TSS) may be divided into the 1st TSS to bring DW and separate roughly and 2nd TSS where detailed separation and intermediate processing (pre-treatment) would be done.

After planning the Contingency Plan (CP)

Preparedness in various aspects of DWM—including public authorities in charge of DWM, waste management operators, citizens, and the city—need to be enhanced (see Fig. 3-3). Related discussion is in Chapter [5].

Components of preparedness are interlinked. Plans are tested by their execution and/or regularly and are revised according to

Fig.3-4 How to prepare after the CP

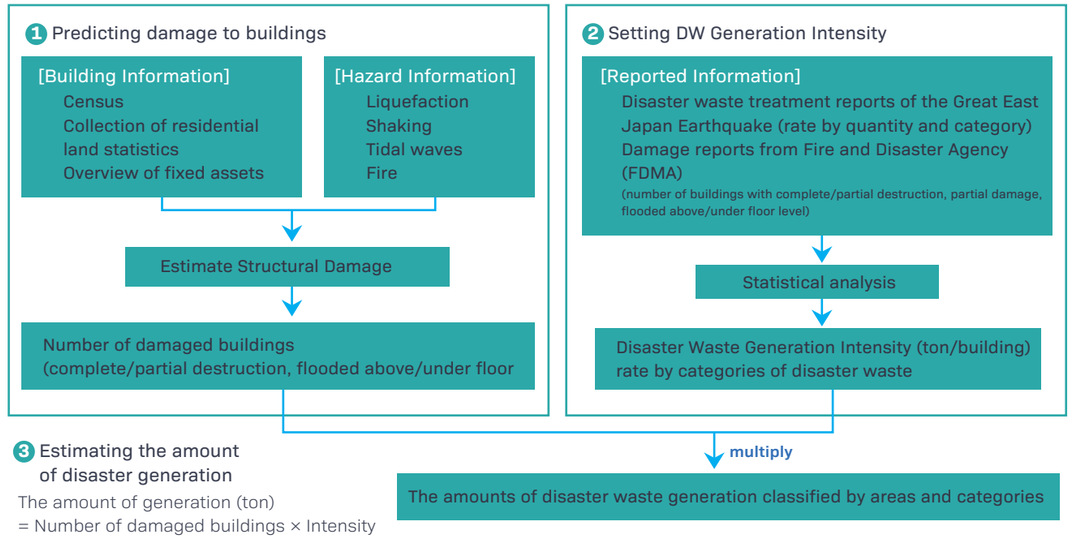
Regular communication with stakeholders regarding the CP is important to provide appropriate information to the public, with cooperation between other fields and citizens being necessary. It is especially necessary to situate DWM as important in the CP and disaster recovery plans. For this reason, efforts in promoting awareness through hearings at relevant departments, gaining understanding and cooperation, and asking for opinions on the completed plan are crucial in making a CP.

A related discussion is in Chapters [4] and [5].

Reference: Estimating the amount of DW generation - a typical example in planning in Japan

There are several methods for estimating the amount of DW generation. Fig. 3-5 and following example of calculation shows typical method used in Japan.

Fig.3-5 Estimation flow of DW generation



Example of calculation:

(100 fully collapsed households×113 tons per building)
+(1000 inundated households above floor level× 4.6 tons per building)
+(10000 inundated households below floor level×0.62 tons per building)
=22,100 tons

Given that DW generation rate for fully collapsed, inundation above the floor level, and inundation below the floor level are 113 tons/building, 4.6 tons/building, and 0.62 tons/building respectively

Reference: Implementation plans in Japan

In the planning phase, frameworks and sharing roles are important. In Japan, after the Great East Japan Earthquake, drawing up plans for DWM along with establishing frameworks have progressed. One of the features of this progress is cooperation with disaster reduction field. In other words, DWM Policy (refer to Appendix) has been enacted based on the Disaster Risk Management Basic Law and Master Plan as well as the Waste Management Law. This makes smooth and efficient initial action for DW possible, even during the confusion at the time of a disaster.

Another feature is the hierarchical approach which has been taken, phased in along with national government, prefectural government, and local municipalities, making use of the general administrative system. As a general rule, DW disposal is carried out as a responsibility of municipalities in Japan. Therefore the formulation of CPs by local municipalities should be important. This plan is formulated based on municipal waste treatment plans and local contingency plans at first. However, CPs by prefectural governments also become important in situations exceeding the response capacity of local municipalities or when a disaster affects a wide area. In order to support both governments to formulate CPs, MOEJ prepared the Disaster Waste Management Policy for DW treatment plans and technical data, which can be adjusted appropriately and provide new perspective.

Fig.3-6 Planning and Institutional

4. Development of Disaster Waste Management Policies

- The basic principles of DWM are listed as the preservation of the living environment and the promotion of the 3Rs. It is necessary to examine circumstances from various angles and proceed to treatment.
- In general, the goal is to make use of existing facilities and equipment for appropriate management to the greatest limits. For this, waste management system during normal times is critical.
- Promotion of the 3Rs depends on the source of DW, in addition to the skill levels, treatment methods, instruments, and equipment available.

Guiding Principles of DWM

Here we confirm the basic principles of DWM (excluding the preparation during normal times). To decide the process and flow of treatment, we need to examine the conditions of both hard and soft aspects and from various angles too. For this, the following principles are required.
Obviously, depending on the condition of the disaster, it might be hard to follow the principles of DWM perfectly. In the CP, countermeasures are considered using these principles, with the intention to apply them to the IP as well.

The hard aspect: Ideas on treatment skill and flow

Reduce health and environmental risks	3Rs (Reduce, Reuse, Recycle) and proper treatment	BBB (Build Back Better)
Prevent the deterioration of the living environment and/or health due to abandoned DW / accident due to hazardous materials (in the next page)	Promote the reuse, recycle and reduction of final disposal for large amounts of DW (next page)	Support reconstruction of infrastructure to be stronger than in pre-disaster times (in Chapter [5])

The soft aspect: Ideas on the treatment process

Community Resilience/ Awareness/ Training	Organization/ Stakeholder Coordination	Networking/ Information sharing/ Communication
Acquire understanding and cooperation from residents and the community (in the second page to follow)	Coordinate framework structures, various stakeholders and supporting organizations (in the second page to follow)	Smooth treatment with networking, information sharing, and communication (in the second page to follow)

Timeline focused on DW

	Establishment of DWM cluster	Excreta	Waste from evacuation centers	Disaster waste
~ hours Initial phase	✓ Set up a disaster waste management team/cluster	✓ Identify victims and damage, open evacuation shelters, clear roads, open contact in local government		
~ days Emergency phase [rescue operations]	✓ Coordinate with stakeholders	✓ Secure temporary toilets Secure treatment facilities for excreta	✓ Confirm damages on treatment facilities ✓ Confirm collection method and awareness ✓ Respond to infectious waste	✓ Estimate amount of DW generated ✓ Arrange vehicles for waste collection ✓ Prioritize management of dangerous objects and corruptible waste ✓ Remove collapsed houses ✓ Open temporal storage sites
~ weeks Early recovery phase [preserve the living environment, remove dangerous objects]	✓ Mobilize staff for operation and management ✓ Coordinate with external/internal actors	 Disaster response headquarter	 Clear roads and open to the transportation of DW. Open temporal storage sites	✓ Decide execution of DWM implementation plans ✓ Seek financial support ✓ Prepare DW treatment and contracting ✓ Arrange wide-area treatment ✓ Demolish or remove houses
~ months Early recovery/ relief phase [recover distribution channel]				
months~ Recovery phase [secure infrastructure for daily life and lifelines]		✓ Restart ordinary treatment	✓ Close evacuation shelters ✓ Restart ordinary treatment	✓ Conduct DW treatment/disposal ✓ Prevent environmental pollution ✓ Monitor
~ years Reconstruction phase				✓ Complete DW treatment

Fig. 4-2 Timeline after outbreak and example of response to DW

Securing and operating TSS

Securing and operating TSS are indispensable for smooth treatment. To ensure feasibility, some candidate sites should be examined considering the conditions in Table4-1.

In operation, we should promote separation, while monitoring the height of buildings to avoid fire or environmental pollution. The layout and rules should be decided in advance.

Table 4-1. Conditions of TSS

Enough space	Enough for storage, traffic, and separation
Low disaster risk	Located in low flood risk area
Easily accessible road	Easily accessible to disaster victims (but not too close to hospitals, schools, and residential areas) Located along a wide road (to enable access by 10-ton trucks)


Preventing leakage of oil or hazardous substances to the soil with a simple water-shielding sheet

Fire prevention


Separation of hazardous waste


Hand sorting area in TSS

Reducing Health and Environmental Risks

The following measures could be considered to preserve living environments and health.

- Estimating the amount by type.
- Prioritizing treatment: as shown in Table 4-2, DW may degrade living environments and health; this is why collection and treatment deserve priority.
- Warning residents: attention towards not burning in fields or touching/mixing hazardous materials without reason.

Table 4-2 Priority of treatment

High priority	Infectious waste, food waste, excreta (night soil), hazardous waste
	Wooden waste, other burnable waste
Low priority	Plastics, concrete/ceramics, other non-putrefactive recyclables

- Hasten collecting, separating DW, removing mud or DW out of affected houses, and other activities involving people/volunteers in order to reduce injury (Fig. 4-3).
- Monitoring: manage and monitor ambient levels of hazardous materials and the condition/temperature in TSSs or DW treatment facilities to prevent fires, pollution, or other incidents.

① long sleeves / long pants
② thick-soled shoes/boots
③ thick-rubber work gloves
④ waste bags
⑤ towels
⑥ hats/helmets
⑦ food/drinking water
⑧ identification cards
⑨ household medicines/masks

Fig. 4-3 Example of equipment and clothes for DW removal

【Note】 Identification and segregation of hazardous materials is essential to address international cross-border collaboration on DWM based on the Basel Convention.

Equipment and resources for 3Rs (Reduce, Reuse, Recycle) and proper treatment

We must consider the various types of DW to decide management strategies based on sources and materials of DW. Fig. 4-4 shows an example of categories based on sources, tasks, and required equipment.

Though the availability and capacity of equipment differs in each country and region, DWM might be a chance to improve WM techniques by implementing various equipment for amounts of waste larger than usual.

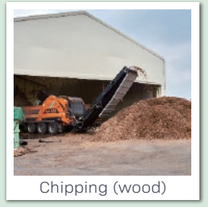
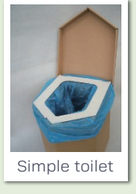
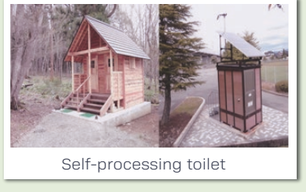
Category based on sources	Description of task	Required equipment and resources
Elimination of road obstacles, removal of objects requiring special care 	Removal of sediment (mud), timber, log, rubble, dangerous/hazardous objects, etc. Recovery and safekeeping of corpses.	Bulldozer, excavator, tarpaulin sheets, body bags  Hand barrows are useful for narrow streets and short distance transportation.  Boats are used in inundated areas. Also useful to collect vegetative wastes (e.g. water hyacinth)   Large, special trucks are useful to remove rubble and logs.
Waste from evacuation centers and ordinary houses 	Waste collection from evacuation shelters in public facilities and camps. Waste collection for people remaining in existing housing can be suspended and resumed if circumstances allow.	Collection vehicles, cardboard boxes and bags for separated collection, equipment for evacuation camp (timber, tarps, blankets etc.)  Support from other local municipalities and the private sector (through contracts) is needed to collect MSW and waste from evacuation 
Damaged objects 	Damaged furniture etc, debris and mud from affected houses. Collection system and temporal storage site required.	Collection vehicles, TSS, signage for separated unloading, on-site supervisor, information flyers  Shovels for mud removal  Vehicles to temporary storage sites  TSS, signs for separation
Rubble from demolition 	System for receiving requests and scheduling for demolition. Provide temporal storage site and treatment facilities for demolition waste.	Heavy equipment for demolition, shredder, sieve, workers (demolition and sorting), temporary storage site  Chainsaw  Chipping (wood)  Heavy machine for demolition and separation  Flatbed trucks with sides are useful for bulky disaster waste collection and long-distance transportation.
Toilets and human waste 	Provision of portable toilets or latrines, simple wastewater treatment.	Portable toilets, galvanized sheets, tarps, digger equipment, pipes  Portable toilet  Simple toilet  Temporary toilet  Manhole toilet  Self-processing toilet  Simple digger equipment is useful in emergency situations.

Fig. 4-4 Example of items, tasks, and required equipment for typical disaster wastes

Community Resilience, Awareness, Training

For appropriate treatment of DW, understanding from residents, volunteers, and the private sector is indispensable. Awareness of waste separation in normal times is useful in case of a disaster. Educational activities regarding the following points are implemented, sequentially, to promote residents' understanding.

- How to separate and discharge corruptible waste or hazardous waste at TSSs
- Attention needed for foods, vegetation, timber, metals, hazardous materials, glass, and oil.
- Prohibited treatment methods, such as illegal dumping or burning in fields

After a disaster outbreak, information needs to be unified to avoid confusion. As for announcements on DW treatment, we coordinate with publication offices and confirm the means and contents of printed publications, media, and evacuation centers.

Immediately after a disaster outbreak, we need to make a publication plan reflecting a timeframe regarding the opening of TSSs and the "with or without" of waste collection as soon as possible.

Examples of actions to enhance community resilience in DWM

Understanding and participation from residents and the community are very important for the following points regarding inevitable disasters. In Asia and the Pacific, there are examples of advanced approaches; therefore sharing good practices is effective.

- ✓ Resilient communities will produce less disaster waste, and will respond to DW appropriately.
- ✓ Resilient communities are communities which can manage waste appropriately in normal times.
- ✓ Residents who frequently experience disasters know how to cope with them; sharing their skills and knowledge is useful.

Residents in high-flood risk areas know how to prevent furniture from getting soaked. For example, the resident of this house knows when, where, and how to evacuate her belongings when the area is at high risk of inundation. This kind of preparedness action could be enhanced by mutual support of community members (Sena, Thailand).

Public space, including waterways, should be waste-free in normal times, as wastes may clog the drainage system and increase flood risks. Besides regular waste collection, awareness, raising and improvement of waste collection system should also be considered to tackle problems upstream (Bangkok, Thailand).

DWM is one of the main activities for disaster volunteers. Opportunities to learn and think about volunteer activities in disaster areas are effective to know about proper DWM. Youth, citizens, and even high school students can be targeted in lectures and table-top exercises. (Kyoto City, Japan)

Opportunities to learn and discuss DWM are effective to enhance preparedness of the community. A workshop supported by WM experts is a simple but powerful tool. In the workshop shown in the picture, actions to be taken by individual residents before and after disasters were discussed, and the results were delivered to local authorities (Kanagawa Prefecture, Japan).

Avoid excessive accumulation of hazardous and flammable wastes, including pesticides, oils, and paints. They should be disposed appropriately in normal times; otherwise, it is difficult to deal with these substances during DWM, which could lead to environmental and health impacts (Miyagi prefecture, Japan.)

Internal and external coordination of organizations

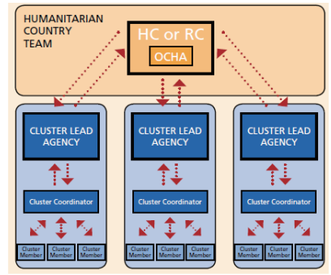
Identifying networks and cooperation with stakeholders, such as other clusters, line ministries, local governments (city-city), private sectors (Cooperation Agreement), and media groups is important.

Internal coordination

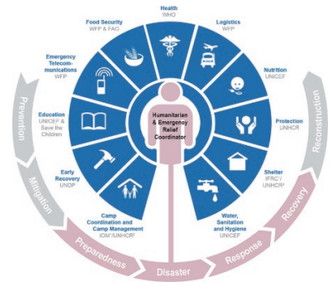
As shown in Fig. 4-5, inside organizations (the government/ municipalities) each line ministry leads each cluster and responds after a disaster. Organizations like WM departments need to organize clusters for DWM according to each country' s case and collaborate with them.

This framework is as same as the cluster system promoted by UN. DWM is a cross-national activity, so organizing individual clusters is recommended.

Fig. 4-5 UN field cooperation image in disaster



Disaster response in Asia and the Pacific: A guide to international tools and services (OCHA-ROAP, 2013)



https://www.humanitarianresponse.info/en/about-clusters/what-is-the-cluster-approach

After structuring the framework, the following points are important for organizational coordination:

- Coordinating with other disaster response operations (e.g. reconstruction, evacuation center management)
- Negotiating resource allocations (e.g. open space, personnel, budget)
- Collecting and sharing latest disaster (response) information

External coordination (coordination of supporters)

Beyond organizations exist various stakeholders, and the following points of cooperation and support are important. For efficient and effective cooperation and support it is necessary to share roles among organizations. Especially in developing countries, it is highly important to support and adjust through international agencies or governments. We should plan the framework for acceptance in advance.

- Request and coordinate support for additional resources
- Request exceptional arrangements (e.g. fast-track contracting, fast-track permitting process)
- Seek expert opinions
- Seek assistance from donors

Networking and Information sharing

Considering the countermeasures in large-scale disasters or small nations with few material possessions, as in the Pacific, networking of DWM over local or national government frames is also important. In normal times, sharing information, plans, and experiences through face-to-face relationships enable building of support and the smooth acceptance of frameworks using such networks. Networking support groups and allowing them to operate more efficiently are effective.

Examples of regional networks for DWM

In the Pacific, SPREP establishes the platform and educates persons responsible in waste management to be experts of DWM. They promote networking to respond to disaster over nations or local areas. Concretely, their activities include promoting:

- ✓ Disaster Waste Management Guide in the Pacific (DWMGP)
- ✓ Knowledge-sharing & Information Hub
- ✓ Capacity Development
- ✓ Database of experts on DWM
- ✓ Funding mechanisms to respond DWM in the Pacific
- ✓ Development of the pilot project

D.Waste-Net 災害廃棄物処理支援ネットワーク 環境省

In Japan, experts of DWM (societies and industry groups) are networked as D.Waste-Net. In normal times, they share information and make the framework, e.g., after outbreak they go in the affected area and support the investigation, planning, and coordination. Actually, D.Waste-Net participates actively in recent disasters.

5. Beyond DWM and response

Disaster waste management requires a much know-how, systems, and techniques. As such, sharing experiences, developing human resources and organizations are important. It requires too the following ways of thinking

- Completing preparations in normal times
- Coordinating with actors in the private sector
- Setting policies toward better recovery (BBB: Build back better)

Evolution of DWM into ordinary 3R policies and stakeholders

Incorporating DWM in ordinary WM is important to improve community resilience, ordinary waste management skills, capacity and technology, as well as to keep motivation for DWM preparedness.

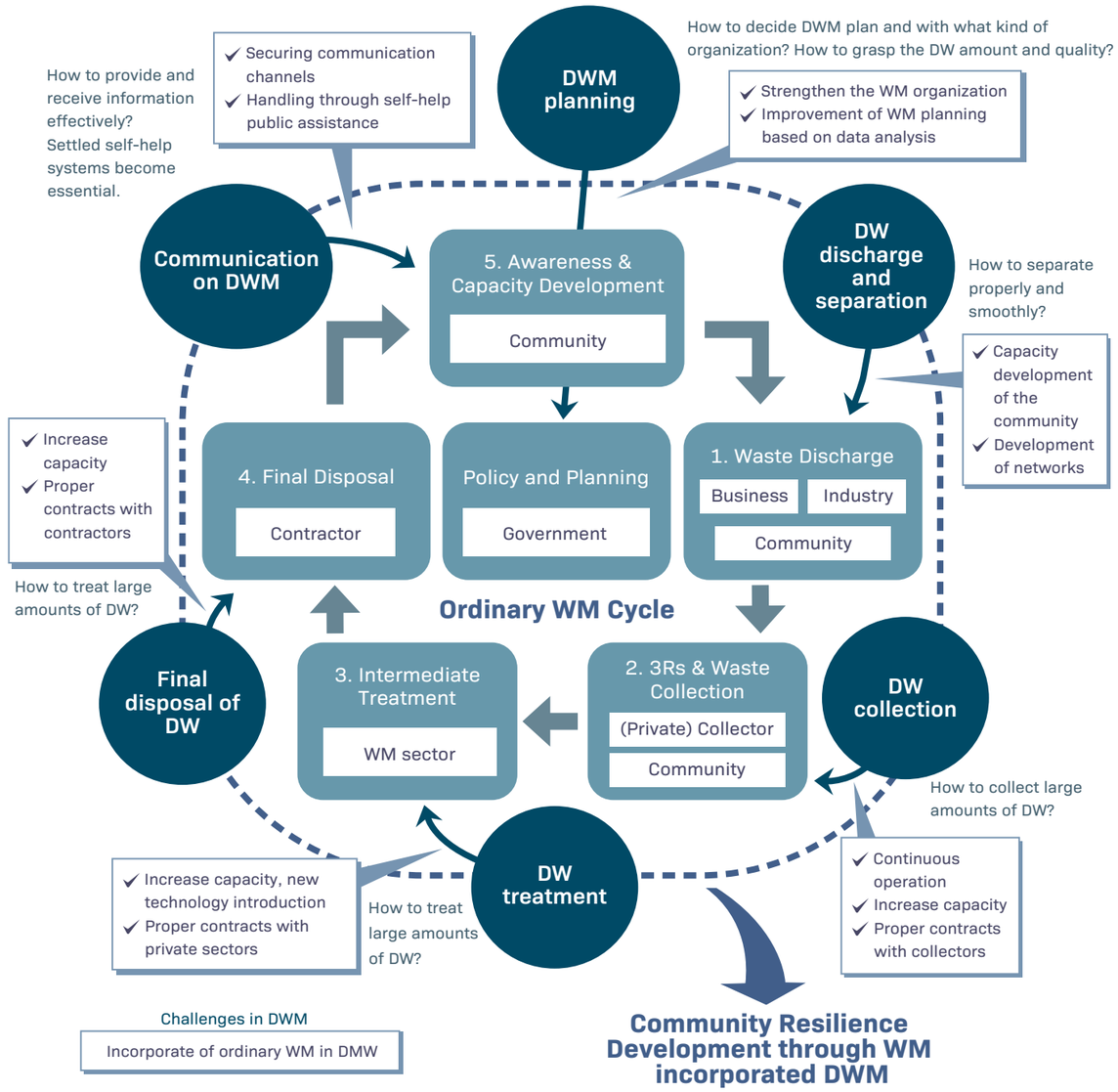


Fig.5-1 Incorporation of ordinary waste management in DWM

Continuous usage of DWM equipment and capacity building

DWM can be a chance to use new equipment (see examples in Fig. 4-4) and improve ordinary WM technology. Accordingly, the option of providing new equipment, which could lead to improvement of ordinary WM, can be considered in order to support developing countries in disaster times.

Capacity building is essential before and after a disaster. There are several aspects as follows:

- Develop capacity of WM officers to enhance effectiveness of the contingency plan.
- Skills and knowledge regarding WM are important in both normal and in emergency circumstances.
- Have staff regularly train and exercise to avoid loss of skills/knowledge by staff rotations.

Table 5-1. Key training methods

Workshop	● Intensive group discussion on a specific topic on DWM (e.g. What is our vulnerability? How can we prepare and manage TSSs?)
Tabletop exercise /Functional exercise	● Respond to a hypothetical disaster situation in which various DWM issues occur
On-site training	● Test operation procedures and DW separation skills at a simulated TSS

DWM Networking and stakeholders

Many stakeholders are getting involved in DWM. As the examples shown in Fig. 5-2, it is effective to build up face-to-face relationships on a daily basis, organized in light of characteristics and the actual situations of countries and regions.

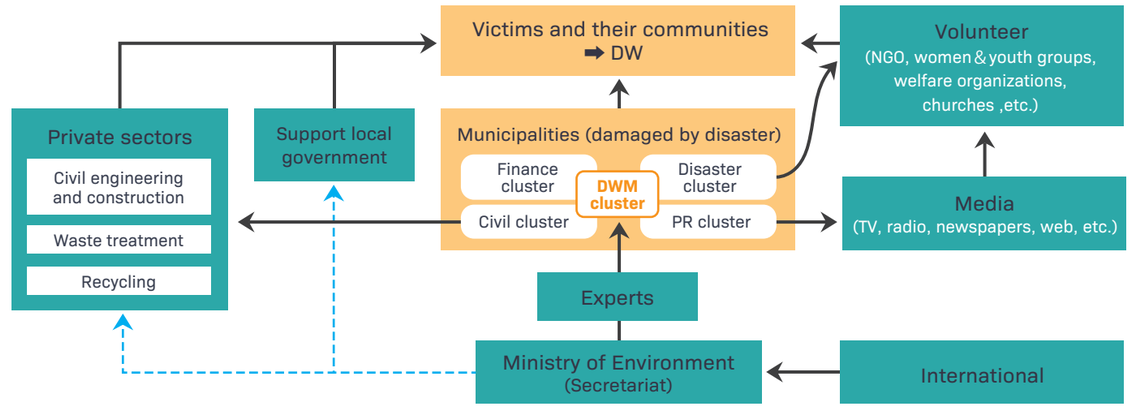


Fig.5-2 Example of stakeholders related to DWM

Recording, data analysis, and accumulation of lessons learned

Recording, analyzing, and sharing facts and experiences from disaster are important for other countries. As for the content of records, an overview of the disaster and damage, damage situation of the waste treatment facility, quantity of DW generation (by composition), the flow of DW (qualitative and quantitative),temporary storage sites, sorting and processing methods, frameworks, budgets, and the like are useful. For reference, the appendix of this guideline compiles some treatment cases of DWM from recent disasters in Japan.

Resilient communities and Build Back Better (BBB)

In order to improve resilience in local areas, there are several ways which reduce DW:

- Earthquake-proof housing and buildings* should be widely constructed to reduce damage and the amount of DW.
- Local reinforcement works should be supported and enhanced by national or international institutions.
- Construction works should avoid high disaster (floods, landslides, tsunami) risk areas: land use planning should incorporate disaster risks.

It is essential to incorporate these points in post-disaster recovery plans or BBB policy.

*UNESCO guidelines for earthquake-resistant non-engineered construction

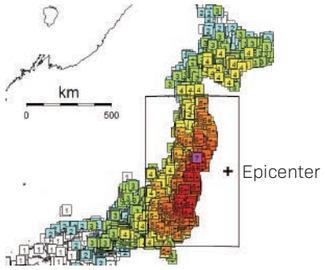
Introduction of Appendix Case Studies (see more details in the Appendix)

Great East Japan Earthquake , March 2011

The Japanese archipelago was hit by an unprecedented earthquake on March 11, 2011. This resulted in a significant loss of life, with a tsunami causing catastrophic damage along the Pacific coast of eastern Japan. Infrastructure and houses were damaged across a wide area of eastern Japan by shaking, liquefaction and subsidence resulting from the earthquake. The disaster waste (DW) generated was estimated to be over 30 million tons (including tsunami sediment deposits). The government set up local countermeasures headquarters in the three worst affected areas (Iwate, Miyagi, Fukushima prefectures) and established various discussion and liaison groups with relevant ministries and prefectures. It requested cooperation from relevant organizations and municipalities and implemented a range of initiatives, such as applying special measures under laws and ordinances (including budget matters), waste processing across a wide area, and recycling measures. Various DW disposal processing and recycling initiatives were put in place under the DW management (DWM) guidelines (Master Plan) formulated in May 2011 after the disaster. The processing and disposal of DW and material deposited by the tsunami in Iwate and Miyagi prefecture was completed by the end of March 2014, as intended under the plan. This disaster has highlighted a number of key themes and provided valuable knowledge. This must be utilized effectively to ensure the country moves from being “disaster susceptible” to being “disaster prevention aware” .

Outline of the Great East Japan Earthquake

- Main shock – Date: March 11, 2011, 14:46 JST
- Epicenter: 130 km off the Pacific Coast of the Tohoku District, depth 24 km
- Scale: Magnitude 9.0, maximum seismic intensity 7 (Miyagi Prefecture, Kurihara City; the largest earthquake ever recorded in Japan)
- Aftershocks (in three weeks): Over 400 times (M5 and above)



Seismic intensity map

Scope of damage (As of March 1, 2016, by the Fire and Disaster Management Agency)

Damage to life

- Deceased: 18,958 (secondary casualties: 3,472, Reconstruction Agency)
- Missing: 2,655
- Injured: 6,219

Damage to houses

- Fully collapsed: 121,291
- Half-collapsed: 272,810
- Partially collapsed: 766,097

Non-residential damage

- Public buildings: 14,179
- Other: 81,903

Fires: 330

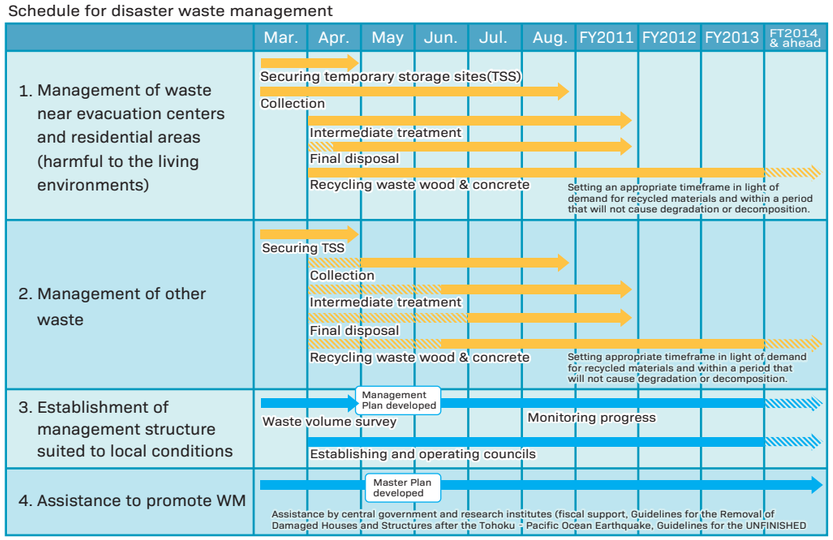

Sendai City
(Photo by Sendai City)


Minamisanriku-cho,
Miyagi Prefecture


Higashimatsushima City,
Miyagi Prefecture

Timeline of DWM

Schedule for disaster waste management



See more in this guideline
Waste components and recycling ratio for DWM is shown in Fig. 2-1.

Landslide in Hiroshima , August 20, 2014

This section reports the damage and disaster waste created by the Hiroshima landslide (resulting from heavy rainfall on August 2014) and outlines the waste management (WM) process that was applied. Immediately after the disaster, the government’ s investigation team conducted field inspections. A local countermeasure office consisting of ministries and agencies (including the Ministry of the Environment Japan (MoEJ) and the Ministry of Land, Infrastructure, and Transport) was established in response. The municipal waste disposal department responded to disaster waste (DW) right after the disaster outbreak. A large volume of earth and sand mixed waste generated by the landslides disaster was a particular issue we struggled to manage. Therefore, this report is a pioneering effort to address such difficulties. The national and local organizations responsible for DW and those for lifelines and infrastructures considered the division of roles and enforced its relationship between planning of operation. Some private sectors were registered by public offers to respond to disaster emergency, which enabled prompt responses during the disaster. We also describe the complete disposal process of DW through a year and a half.

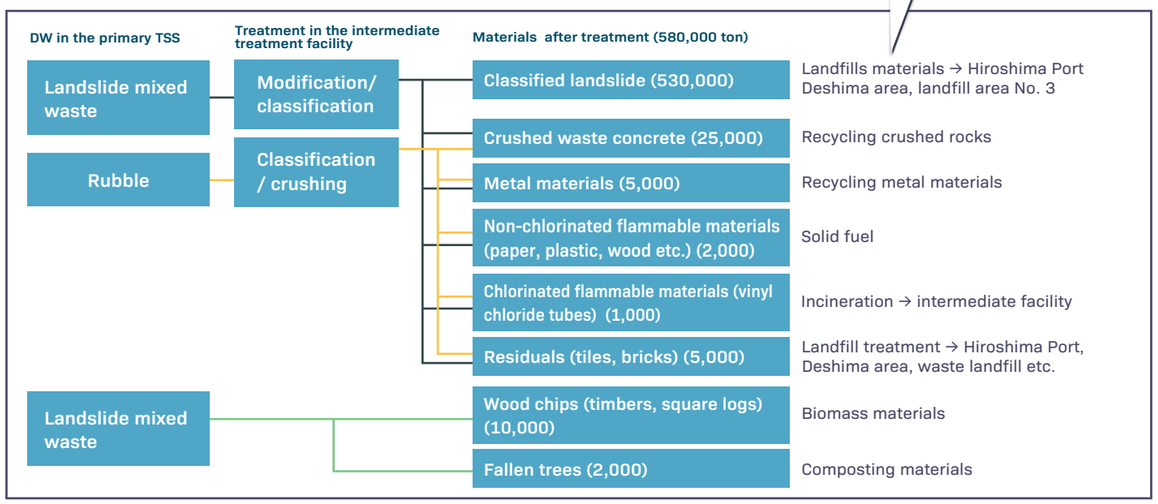
Outline of landslides in Hiroshima

- Heavy rain: in northern area of Hiroshima city, heavy rain by Back building storm due to topography on August 19-20, 2014
- Landslides: DW flow and flood by closure of water channels Hiroshima city Asakita-ku, Asaminami-ku on August 20, 2014
- Damage to life:
  Death toll: 76
  Injured: 68

- Damage to houses
  Fully collapsed: 179 as of December 16, 2015
  Half-collapsed: 217
  Partially collapsed: 189
  Inundation above floor level: 1,084
  Inundation below floor level: 3,080
  as of December 26, 2014

Flow of DW treatment

DW flow was determined by the following principles:
①Preserving the living environment of citizens
②Aiming treatment to affected areas
③Reducing landfills and promoting recycling
④Creating local employment
⑤Trying to reduce costs
⑥Cooperating with relevant organizations



Joso city Flood , Sep 09, 2015

This section reports on the damage caused by flooding from the Kanto-Tohoku Heavy Rainfall disaster in Joso City in Ibaraki Prefecture and the management of the disaster waste (DW) generated. Joso City has an area of 123.64 km2 and a population of about 64,000 people. The main part of the city is located on a plain that is bounded on one side by the Kinugawa River flowing through the center of the city and on another by the Kokai River in the east. Around 1/3 of the area of the city (40 km2) was flooded by the collapse of the riverbanks. The Ministry of the Environment Japan (MoEJ) dispatched technical experts, such as D. Waste-Net, along with experts from its Kanto office to provide support and advice. About 35,400 tons of waste (68% of the total waste generated by this disaster) was so-called “mixed waste” that could not be disposed of in the city. When the disaster occurred, DW and household waste was mixed up at the collection points in the city due to poor instructions for temporary storage sites (TSS) given to residents and contractors. A DW management (DWM) plan was formulated for the mixed waste. The basic policy was for treatment across a wide area, utilizing private processing facilities in the prefecture and waste disposal facilities outside the prefecture. As a result, the processing of large volume, highly perishable waste was completed by the end of March 2016—one year after the disaster. In addition, waste material such as scrap metal, home appliances, tatami mats, and tires were successfully recycled.

Based on lessons learned from this, networks and support systems for disaster contingency planning, as well as the initial response are noted for being important. Joso city is planning to strengthen cooperation between the city, the private sector, and residents to ensure that it is an “advanced city for disaster prevention” , with a system in place to transmit and promote the lessons of this disaster throughout the country.

Outline of the Joso City flooding

- Heavy rainfall:

Caused by extratropical low pressure from Typhoon 18 and concentrated torrential rain from numerous precipitation bands from Typhoon 17 (highest value in recorded history) (September 9 - 11, 2015; known as the “Kanto-Tohoku Heavy Rainfall, September 2015", Japan Meteorological Agency)

- Flood (Kinugawa River):

Overflow in Wakamiyado region (AM 6.30)
Collapse of 200 m of riverbank in Kami-misaka District (12.50) on September 9, 2015

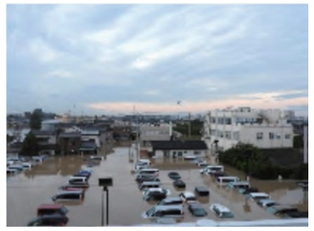

Water overflow in Wakamiyado

- Damage to life:

Deaths 2 (8)
njured 44 (80) as of February 19, 2016,

- Damage to houses:

Fully collapsed 53 (80)
Half-collapsed: 1,581 (7,200)
Partially collapsed: 3,484 (343)
Flooding above floor level: 165 (1,925)
Flooding below floor level: 3,084 (10,353)
as of February 16, 2016

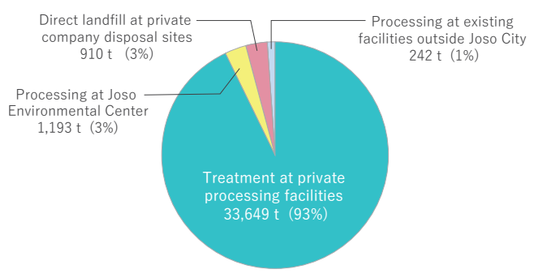


Flooding in front of City Hall

Treatment of “mixed waste”

“Mixed waste” accounted for about 60% of DW and most of the total waste processed. DW was treated as general waste. Although the law states DW should be processed by the municipalities (cities) where a disaster occurred, the basic policy in this case was to utilize processing facilities owned by private enterprises (see figure below). This reflects the problems arising from establishing temporary sorting stations for handling DW to be processed at existing facilities. For this process, resources were recycled as much as possible (wood chips, concrete rubble, scrap metal etc.), and RPF (Refuse Paper & Plastic Fuel) initiatives were implemented.


Mixed waste at TSS



Results of processing “mixed waste”

Kumamoto Earthquake , April, 2016

This section reports on the damage and disaster waste (DW) created by the Kumamoto earthquakes in 2016 and outlines the waste management process that was applied. “Recycling” is a key aspect of the process for managing DW. Therefore, this report gives examples of how primary and secondary temporary storage sites (TSS) were established in Kumamoto, along with full-scale stand-alone recycling systems. We have also described specific examples of the establishment of cooperative networks in the municipalities, which are critically important for dealing with DW. In addition, we outline the development of contingency DW management (DWM) initiatives, providing information and further data related to the events in Kumamoto.

Outline of the Joso City flooding

- Foreshock

Magnitude 6.5 beneath Mashiki town on April 14, 2016

- Main shock

Magnitude 7.3 beneath Mashiki town on April 16, 2016

- Damage to life

Death toll: 244
Injured: 2,709

- Damage to houses

Fully collapsed: 8,664
Half-collapsed: 34,026
Partially collapsed: 147,742 as of Aug.10, 2017



Kumamoto castle was also damaged

Flow of DW treatment

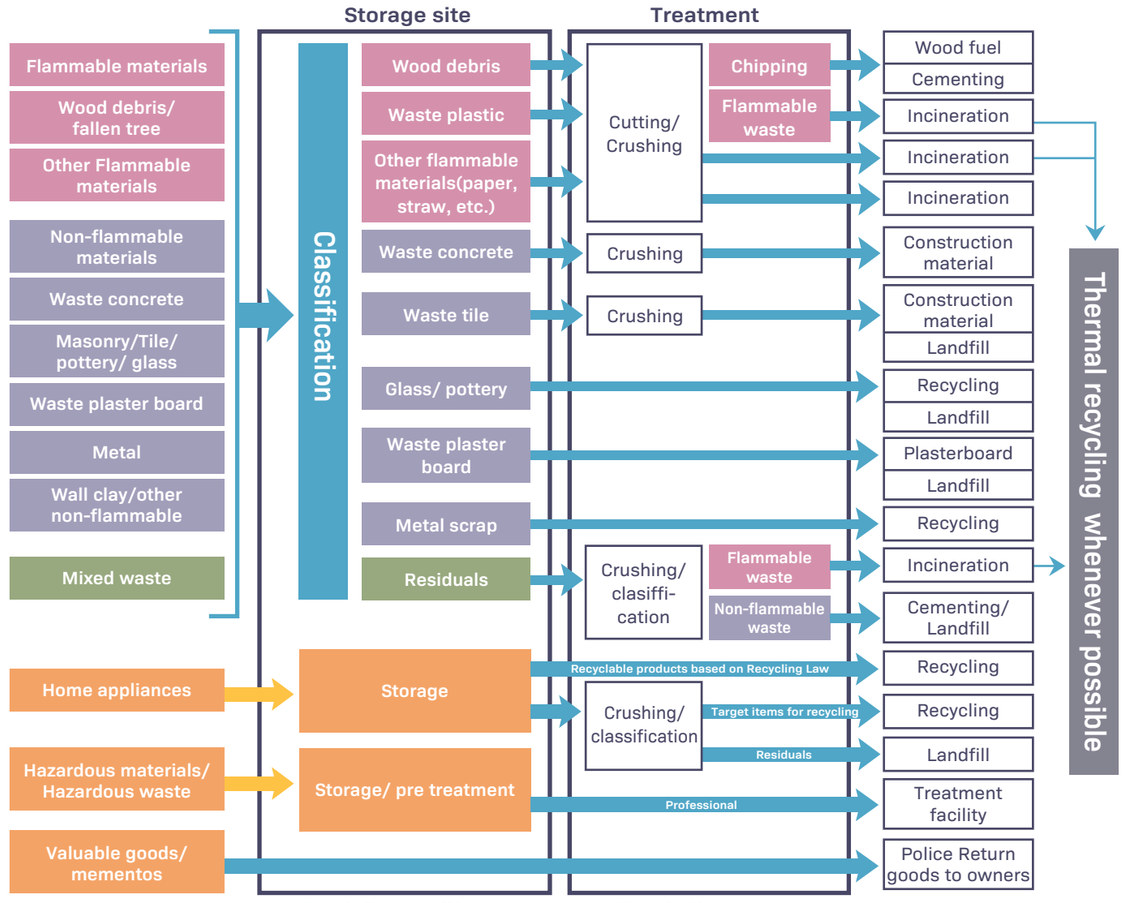


Fig. 3 Disaster Waste management Flow In Kumamoto

See more in this guideline
Amount of DW generation classified by material type in different periods is shown in Table 2-5.

Technical information accompanying this guideline will be provided. If interested, please contact through e-mail (hairi-saigai@env.go.jp).