



Flood Waste Management Guidelines for Bangkok



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Foreword

Globally, especially in the Asia and Pacific region, risk of flood has been increasing within the context of climate change. In 2011, Thailand has experienced a massive flood that damaged and deterred the economic activity for almost half a year. Against this backdrop, many Asian cities are urged to improve the preparedness for flood in the wake of rapid urbanization.

The impact of solid waste in the city during flood is significant. Appropriate management of flood waste will enhance rapid, environmentally and economically sound recovery of the stricken area. The primal concerns related to waste management during flood are sanitation and safety of the people. In many Asian cities, solid waste management is one of the largest issues of urban development, and the impact of flood on the solid waste management system tends to be more significant in developing countries. To mitigate the impact of flood on solid waste management system and to ensure the safety and sanitation of the residents after flood, appropriate planning, before and after flood, and their timely implementation are crucial.

These guidelines have been prepared based on the lessons learned from Thai and Japanese flood waste management experiences, integrating perspectives from both technical engineering and social science. They are intended to provide you with the basic principles of flood waste management together with a quick guide of important solid waste management actions at each stage of flood event to help both getting prepared in advance and responding effectively. The Vulnerability Assessment Tool in the appendix will help you to understand the current state of your waste management system against flood.

I sincerely hope these guidelines and the tool will help improving the resiliency of the waste management system in Bangkok, and in other Asian urban cities.

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1. Introduction and purpose of these guidelines

The 2011 flood crisis was the most severe flood in the history of Thailand, and it resulted in the greatest amount of damage and numbers of affected people that the country has seen so far. This flood event started at the end of July 2011 and continued until mid-January 2012, and caused serious loss of life and property. A total of 65 out of the entire 77 provinces of the country were affected.

After the floodwaters receded, a large amount of waste remained. Waterborne waste from neighboring flooded provinces also accumulated and created a huge quantity of waste to be disposed of. One of the most serious problems during this flood event was the waste disposed of from the affected households. This included both small and large items such as damaged furniture, which were dumped in front of houses, along streets, or on empty land which caused environmental and sanitary problems in the form of offensive odors and contaminated wastewater. In addition, the delay in flood waste disposal caused a detrimental impact on the recovery of peoples' livelihoods.

In order to deal with such flood waste and to avoid environmental, sanitation, and other social problems, it is important to plan ahead and be prepared for such flood events. The objective of the Flood Waste Management (FWM) Guidelines for Bangkok is to provide good mitigation, preparation, and response actions for appropriate management of flood waste in the event of flooding. This will help in reducing the risk of environmental and sanitary problems that may affect the population. The primary target of the FWM Guidelines is a situation involving slow-onset floodwater that remains above ground level for more than one day. However, parts of this guidelines may also be referred to in the case of flash floods.

Please note that the FWM guidelines do not give detailed "how-to" instructions. Detailed planning needs to be undertaken by local officers, considering institutional arrangements and local resources at the time of planning (Fig. 1).

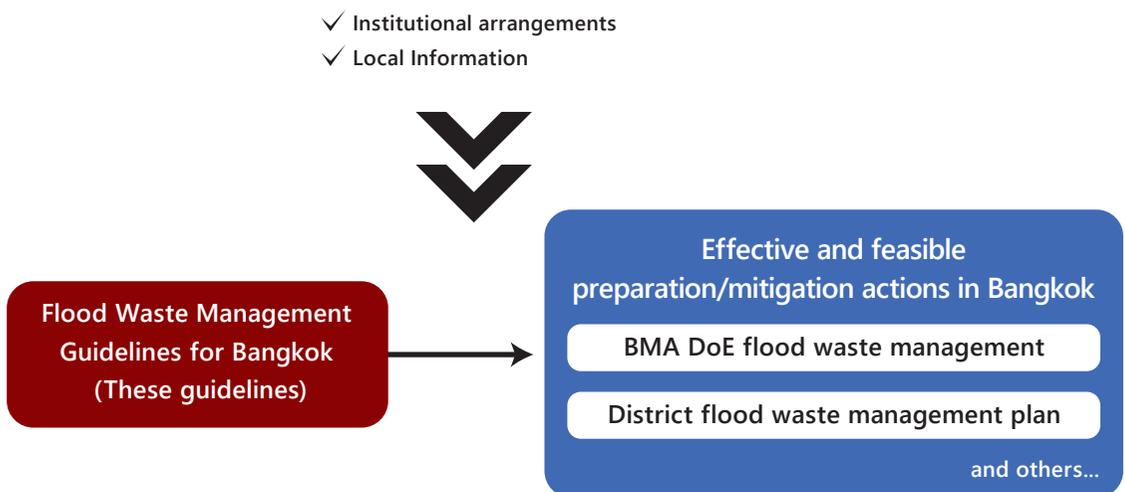


Fig. 1. Usage of the Flood Waste Management Guidelines

2. List of abbreviations

BMA	Bangkok Metropolitan Administration
DDPM	Department of Disaster Prevention and Mitigation
DoE	Department of Environment, BMA
FWM	Flood Waste Management
ICT	Information and Communications Technology
MSW	Municipal Solid Waste
PCD	Pollution Control Department
PAO	Provincial Administrative Organization
TSS	Temporary Storage Site



3. Basics of flood waste management

3.1 Flood waste management in different phases

FWM should be considered in the following four different yet interrelated phases; “mitigation,” “preparedness,” “during flood,” and “after flood” phases. During the mitigation and preparedness phases, there is no flood waste present, but relevant actors of FWM actors need to take actions to prepare for its management. During the flood and after flood phases, there will be flood waste that will need to be disposed of. Each phase poses different challenges in waste management and sanitation, as each situation and condition are different. These four phases are sequential, and form a cycle, as shown in Fig. 2.

The mitigation phase, which occurs in “normal” time, starts at the completion of recovery from the previous flood, and ends at the inception of the warning of the next flood. The main task to be done during this phase is to develop a resilient waste management system so that the next flood will not cause too much harm to society. The preparedness phase follows this, and its length differs significantly depending on whether the flood is a flash flood or a slow-onset one. During the flood phase, when land is covered by water, the waste management functions will be extremely limited while the daily generation of waste continues. After the water recedes, during the after flood phase, the flood waste generation rate will rise and the full FWM operation will take place.

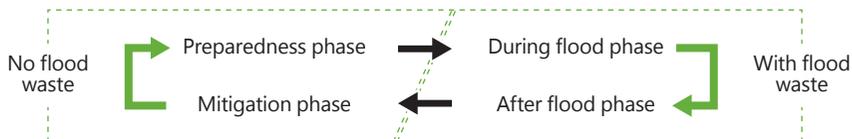


Fig. 2. Flood waste management cycle

3.2 Different aspects of flood waste management

For appropriate FWM, public management, administrative aspects, and technical engineering aspects will need to be taken into consideration. The following section illustrates the wide variety of aspects to be considered here.

For example, there may be a severe shortage of resources to enable flood waste collection because of insufficient preparation. Firstly, during the flood phase, many officers may be affected by the flooding and will not be able to commute to work, which may result in a shortage of staff needed to implement the operations. Secondly, equipment for flood waste collection, including waste collection trucks, heavy vehicles for transportation, and plastic bags for waste disposal may have limited availability during flooding. Financial resources may not be immediately available to assist with the situation. As a severe flooding situation becomes obvious, offers of donations and assistance need to be coordinated. Waste collection times and locations need to be announced effectively, so that people will know how to store and dispose waste during flooding events. These public management and administrative aspects are crucial for efficient operations.

As for the technical engineering aspects, flooding will pose various technical and operational challenges. During the flood phase, many items including electronic appliances, household items, and furniture become soaked in floodwater and most of these items become waste. Some people abandon this waste to the floodwater. After the floodwater starts to recede, people start to dispose of their flood waste at Temporary

Storage Sites (TSS) or beside roads, wherever space is available. Waste separation should be conducted at the TSS before transportation to the waste transfer stations. This makes the transportation of waste easier and promotes recycling. The peak of waste collection occurs immediately after the floodwater start to recede, indicating that BMA might need to dispose of huge amounts of waste from residents within a short period of time. BMA may request help in acquiring FWM knowledge and experience from international donors and academic institutions. Depending on the severity of the flooding, some waste transfer stations may not be in use and this may cause heavy traffic in the areas around open transfer stations and may therefore lower the efficiency of transportation. How these different aspects should be dealt with is detailed in Chapter 4.

3.3 Composition and quantity of flood waste

Flood waste includes: municipal solid waste (MSW), infectious waste (from medical treatment, research, etc.), and industrial waste, generated both during and after flood events. Among these, the main types of flood waste that BMA must deal with are MSW (including household hazardous waste) and infectious waste.

The exact amount and composition of flood waste will depend on each flood event. For example, according to the waste composition survey undertaken by the Department of Environment, BMA (DoE), the composition of waste during flooding in 2011 was as follows: wooden furniture 44%; books and magazines 11%; bedding 10%; daily waste 10%; clothes, shoes, and bags 6%; CDs, videos, and tapes 5%; mud 5%; plant pots, vases, and water closets 3%; electric and electronic devices 3%; vinyl floor mats 2%; and brick, concrete, and cement 1%. The composition of the flood waste is shown in Fig. 3. As for the quantity, the estimated flood waste amount (i.e. amount of additional waste collected by BMA compared to normal situation) for each BMA district is shown in Table 1. The total flood waste amount in Bangkok was estimated as ca. 152 thousand tons, the highest amount being ca. 20 thousand tons in Don Mueang district.

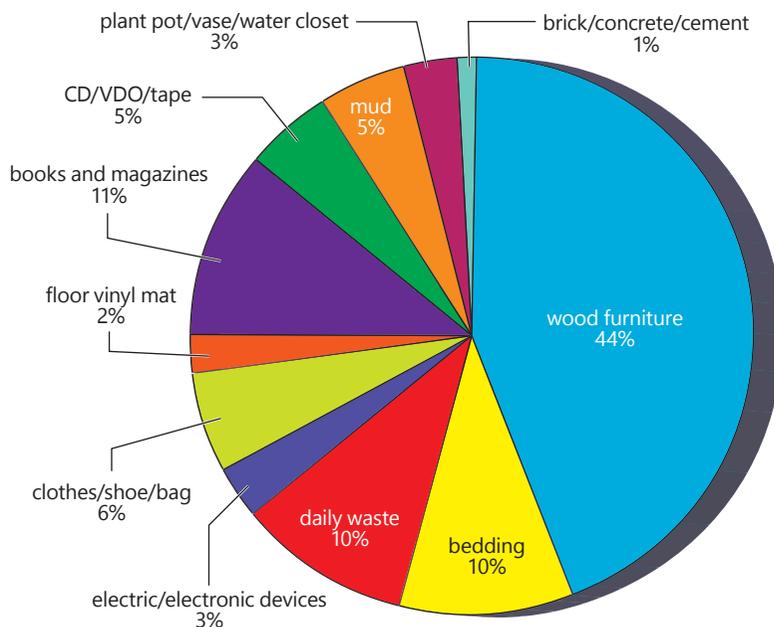


Fig. 3. Composition of flood waste during 2011 flooding (Source: Department of Environment, BMA).

Table.1 Statistics relating to the quantities of waste collected from November 2011 to January 2012
(adapted from the Department of Environment, BMA).

No.	District	(a) Average waste amount during normal situation	(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	13,268.14	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 Khun Thian	256	14,957.11	-	-
23	Bang 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	158.28	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

No.	District	(a) Average waste amount during normal situation	(b) Total waste amount from 2011/12/1 to 2012/1/12	Flood waste (= (b) - (a)*60) (tons)	Flood waste per house-hold (kg)
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	Other public sectors		73,657.62	73,657.62	



4. Principles of flood waste management

4.1 Functions

It is important to be able to see the entire picture with regard to the functions and tasks necessary for FWM, in order to be fully prepared for the next flood event. The structure of FWM functions is shown in Fig. 4. It is based on the Incident Command System, the standard disaster management system used in the U.S., with some modification made in accordance with past FWM experience. Under each function there are more specific functions and tasks which are elaborated further in the following sections.

4.1.1 Operations

Functions included here are based on a typical waste management process: collection, separation, transportation, temporary storage, intermediate treatment, recycling and final disposal (to landfill). Transportation refers to both transporting waste from the collection point to TSS and transporting waste to the treatment and disposal sites (or waste transfer stations) from TSS. Specific intermediate treatment, recycling, and disposal options should be selected according to the technology available, and the state and composition of generated flood waste. For operational details refer to Chapter 4.3. Other supporting functions (sub-sections 4.1.2 to 4.1.5) are necessary to enable the efficient implementation of this function.

4.1.2 Command

The commander is responsible for the entire FWM operation, and prioritizes necessary tasks, and makes decisions. In order to ensure minimum confusion, it is important to unify command. The commander should set targets in terms of time boundaries or quality (e.g., recycling rates). It is also important to establish priorities between different types of waste (e.g., putrefacting waste should be collected and treated with high priority). Other functions that support the commander directly include public relations, external affairs, and internal affairs.

Operations	Command	Logistics	Finance/admin.	Planning
Collection	Target setting	Human resources	Contract	Plan marking
Separation	Public relations	Equipment	Payment	Information gathering
Transportation	External affairs	Facilities	Financial source	Information sharing
Temp. Storage	Internal affairs	Systems (incl. ICT)		Information analysis
Intermediate treatment				Information support
Final Disposal (incl. recycling)				

Fig. 4. Necessary functions for flood waste management

Public relations, or the communication of information to the public, are necessary in terms of: (1) reducing the amount of waste, (2) appropriate collection, and (3) maintenance of public sanitation. Flood information, together with tips for evacuating household furniture, should be made public early enough to enable good preparation, which in turn will reduce the amount of flood waste. Note that in some circumstances, the public may have optimistic views on flood risks (e.g., “The water will never come up to my house.”). During and after flood events, instructions for appropriate in-house waste storage, and collection plans, including what, where, how flood waste will be collected, will need to be announced. Improper disposal of waste and waste bags leads to odor, plague, and a reduction in water drainage capacity. It is also advisable to give instructions for waste separation. Multiple media outlets, including television, newspapers, and radio, should be utilized constantly to make people aware of waste disposal information.

The term “external affairs” refers to coordination and negotiation with external actors, including individuals, and public and private organizations. Requests and inquiries from the general public need to be handled (public inquiries are important information sources during flood events). Regarding private organizations, coordination with suppliers, waste management companies, construction, forestry, and heavy industries may become necessary. Coordination with junk buyers is also advisable in order to enhance appropriate treatments. Negotiation with landowners (individual or companies) is an important task in the early stages of TSS preparation. Coordination and negotiation with other public bodies, such as adjacent PAOs or central government agencies and military forces, is equally important, as each organization has different authorities over FWM, and support from these actors needs to be coordinated.

The term “internal affairs” refers to coordination with other departments or sections within BMA. Coordination with district level actors is crucial in order to efficiently bring flood waste into transfer stations with minimum traffic, and to ensure the necessary separation at source. In order to minimize miscommunication between DoE, district offices, waste management facilities (waste transfer stations), and private operators, the roles and responsibilities of these actors need to be clearly defined and then followed. The responsibilities of other sections within BMA, including the department or section of disaster management, environmental protection, and urban planning, will sometimes conflict with FWM functions and tasks. For example, the urban planning section might want to build temporary housing for flood victims on an open space where flood waste managers were planning to temporarily store flood waste.

4.1.3 Logistics

The management of human resources, equipment, facilities, and systems are necessary supporting functions for efficient FWM. Regarding human resources, tasks should be assigned to staff in accordance with their daily responsibilities. If there is no staff with appropriate expertise, then staff may have to be seconded from other departments for a certain (not too short) period of time. A cross-sectional task force could be organized. When temporary staff are hired, training should be given prior to the commencement of operations.

Equipment and facilities need to be procured, repaired, or refurbished to cope with large amount of flood waste. Trucks (with drivers and fuel), small boats, weighing scales, are some examples. Other items, to ensure the health and safety of staff (e.g., food and water, safety gloves, masks) are also important. In addition to protecting and repairing the existing waste transfer stations, TSS will become necessary. Appropriate site locations and layouts will avoid traffic jams and the inappropriate mixture of recyclable materials with other wastes. The closure and restoration of these sites to their original state will also be required (also refer to 4.3 for technical details).

Systems refer to information systems, such as quantity management systems and social systems, i.e., laws and regulations. In the case of large scale flooding, consider disregarding administrative procedures (e.g., land use permitting procedures) that significantly impair efficient operations, or taking alternative simplified measures.

4.1.4 Finance and administration

Contracts with private waste management companies and suppliers may be different from those in place during normal situations. Although it might be impossible to execute written contracts in emergency circumstances, these may not be disregarded entirely. In order to ensure appropriate spending controls the workload of contractors will need to be checked. As local administrations are the most likely to face financial difficulties, revenues need to be secured, typically in the form of subsidies. Requests to the national government for subsidies will involve some administrative burden.

4.1.5 Planning

Planning is a set of functions that puts together all the different FWM functions and tasks. For example, if all three waste transfer stations become inaccessible due to high floodwater levels, flood waste will either be transported directly to the final disposal sites or stored at TSS. To prepare TSS, equipment and additional staff to oversee TSS will be necessary, new arrangements for waste disposal and transportation will need to be communicated to the residents and contractors, etc. All these factors need to be coordinated, and for this, an FWM plan is an effective instrument.

As the flood event situation changes over time; e.g., access to two of the three waste transfer stations is re-established, the whole arrangement will need to be redesigned. Floods may bring new, unfamiliar challenges for flood waste managers, and these could change targets and priorities. Plans may not be implemented as initially intended, therefore, it is important to collect, analyze, and share information (on the flood situation, on sanitary conditions, on residents' complaints, on work progress, etc.) in a timely manner. By evaluating this information, plans may be revised successfully. Technical information (advice) from experts may also help.



4.2 Governance

In order to coordinate and undertake FWM tasks, governance schemes and organizational arrangements (organizational structure and the assignment of roles and responsibilities) must be prearranged.

An example of a basic governance framework for FWM in Bangkok is given in Fig. 5. Based on the understanding that districts are mainly responsible for collecting and transporting waste to transfer stations, and that DoE is mainly responsible for managing transfer stations, final disposal, and coordination of districts: districts will give orders and collect reports from operators, inform residents and businesses; meanwhile, DoE will give orders and information to waste management facilities and collect their reports. DoE will also deal with central government, other provincial government departments, and external supporting bodies (experts). While each organization has its unique responsibilities, there should be close coordination between districts and DoE. Information sharing, or working on common situation awareness, is especially important. It is also important to coordinate with flood management committees.

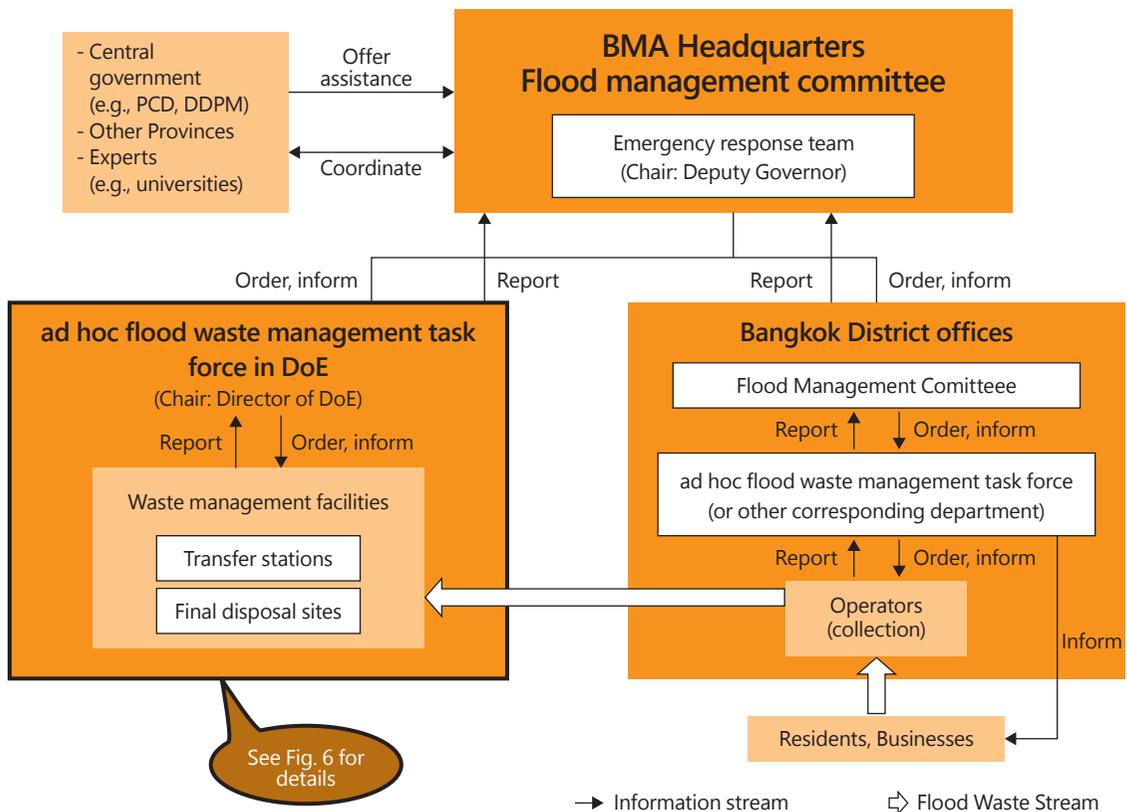


Fig. 5. An example of a governance framework for Flood Waste Management in Bangkok

In terms of the ad hoc Flood Waste Management task force (in DoE), there are various ways to organize the necessary functions, an example of this is given in Fig. 6.

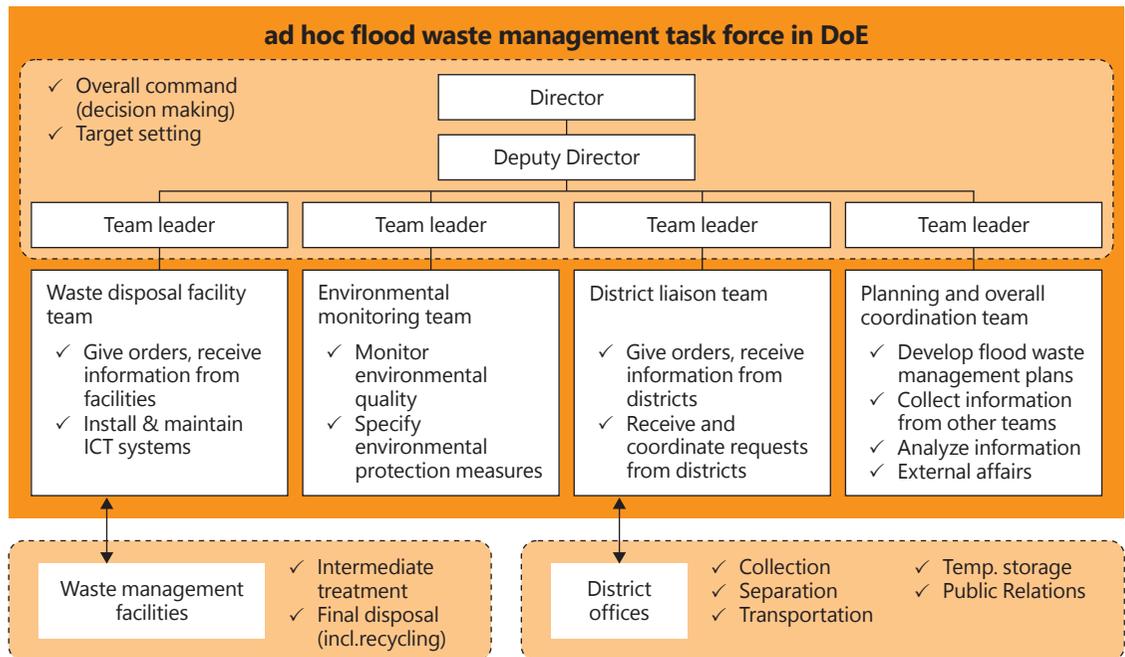


Fig. 6. Example of organizational structure of ad hoc flood waste management task force

Here, the “Waste disposal facility team” is responsible for the management of the three waste transfer stations and final disposal sites. As the quantities of flood waste would be recorded at those facilities, management of such ICT systems is also this team’s responsibility. The “Environmental monitoring team” gathers information on water and air quality, odor, and the release of hazardous substances. As the tasks related to this function will require special expertise, this team will concentrate solely on this task. The “District liaison team” serves as the contact between each district and DoE. This team will accept requests from different districts for various resources (equipment, financial, human resources, etc.) and coordinate those requests. A specific section within this team will then start procurement and contracting. Another important function of this team will be to share the same information with all districts. All the information gathered from the different teams will be coordinated, recorded, analyzed, and managed by the “Planning and overall coordination team”. This team will develop a plan, to be discussed at executive meetings (attended by the director, deputy director, and team leaders), which will be also organized by this team. This team will also coordinate and negotiate with external actors, and seek financial resources.

The section above gives just one example, and there will be other ways to organize resources and functions. The actual organizational chart should be developed on the basis of the organizational structure under normal circumstances. In emergency cases it is not reasonable to expect people (officers) to participate in tasks that they are not familiar with.

Other general recommendations are as follows:

- The organizational structure of the ad hoc Flood Waste Management task force does not necessarily need to correspond precisely with the functional structure presented in Fig. 4. For example, it is not realistic to designate a section specialized only in internal affairs. However, it is advisable to ensure that all functions are present in one form or another.
- The governance and organizational structure should be shared, at least among managers in higher positions.
- As illustrated by the above example, FWM functions are interrelated, and therefore should not be implemented in absolute independence of each other. In the case of large organizations, such as BMA, functions related to planning (gathering, sharing, and analyzing information) and internal affairs become critical for effective internal coordination.



4.3 Technical aspects

4.3.1 Flood waste collection from districts

- Rapid collection of waste from the community is very important. The waste collected by small trucks should be initially dumped at TSSs, then those trucks can go back to continue collecting waste in many round trips, and therefore limited resources can be managed effectively.
- Separation of flood waste of source is recommended. If separated, load only one waste type on one truck to avoid mixed piling at TSS.
- Consideration should be given to the collection of waste from shelters and evacuation centers.
- Consideration should be given to providing residents with garbage bags of different colors to promote separation of the waste, e.g., waste can then be divided into food waste, night soil and others.
- It is recommended that the following vehicles are prepared for waste collection following a flood event:
 - **Rubber tire loaders** or **backhoe loaders** to be used for the removal of wastes from communities to TSS.
 - **Four-wheeled cars** (pick-up) and **six-wheeled trucks** are appropriate for transferring damaged furniture from communities to TSS.
- The recommended number of machines for collections from districts according to the amount of flood waste are as follows:

Type	Number of heavy machines depending on the estimated amount of flood waste		
	<1,000 ton	1,000-2,500 ton	2,500-5,000 ton
Backhoe loader (JCB) >90 H.P. (Rubber tire loaders)	3	5	10
Six-wheeled truck for transporting waste from communities to transfer station.	5	10	20

4.3.2 Management at temporary storage sites

- Calculate¹ the size of TSS. General recommendations are given as follows:
 - Flood waste of 1,001–2,500 ton, recommend temporary area for 2-5 Rais
 - Flood waste over 2,500 ton, recommend temporary area for 8 Rais or divide 5 Rai between two sites instead.
- The recommended number of machines for TSS according to the amount of flood waste are as follows:

Machine Type		Estimated amount of flood waste		
		<1,000 ton	1,000-2,500 ton	2,500-5,000 ton
Machine Type	Excavator, Cap.> 130 H.P.	2 units	3 units	5 units
	Front-end loader Cap. > 120 H.P.	1 unit	2 units	3 units
	Backhoe (JCB) Cap. > 90 H.P.	1 unit	1 unit	2 units

¹ Calculations for the necessary area of TSS is based on the following formula:
 Necessary land area for TSS (m²) = [Estimated volume of flood waste (t)] / [waste bulk density (0.4 t/m³)] / [height of pile of waste (m)] * [auxiliary land area factor (0.3)]

4

- The principles governing the location of TSS are as follows:
 - Access to the site should be easy.
 - Located away from rivers, canals, swamps, ponds, lakes, and drainage to avoid water contamination.
 - Located close to the disaster areas, but far enough from residential areas, infrastructure, and business areas because the TSS may affect their environment.
 - Located away from areas at risk from flooding (wetlands, river banks, or agricultural areas). Use the elevation and flood risk maps (refer to Appendix 2) to determine the location.
 - Consider using public land first in order to avoid difficulties in acquiring agreement for use.
 - Space in temples can also be considered to be utilized as TSS. District administration should survey and ask for permission from relevant authorities.
- The principles of the design of TSS are as follows:
 - If possible, place vinyl layer on the ground before start piling waste to prevent leachate leaking out of area.
 - Control the flow of internal traffic by providing one-way street inside the TSS. Incoming truck drivers should follow the instructions given by the TSS officer.
 - Access routes for the acceptance of waste at TSS should be controlled, for example, there should be only one incoming and outgoing gate, respectively.
 - A plan to reinstate the site to its original condition (including long-term environmental monitoring plans, if necessary) should be prepared for the appropriate closure of TSS.
 - An example design of TSS is presented in Fig. 7.

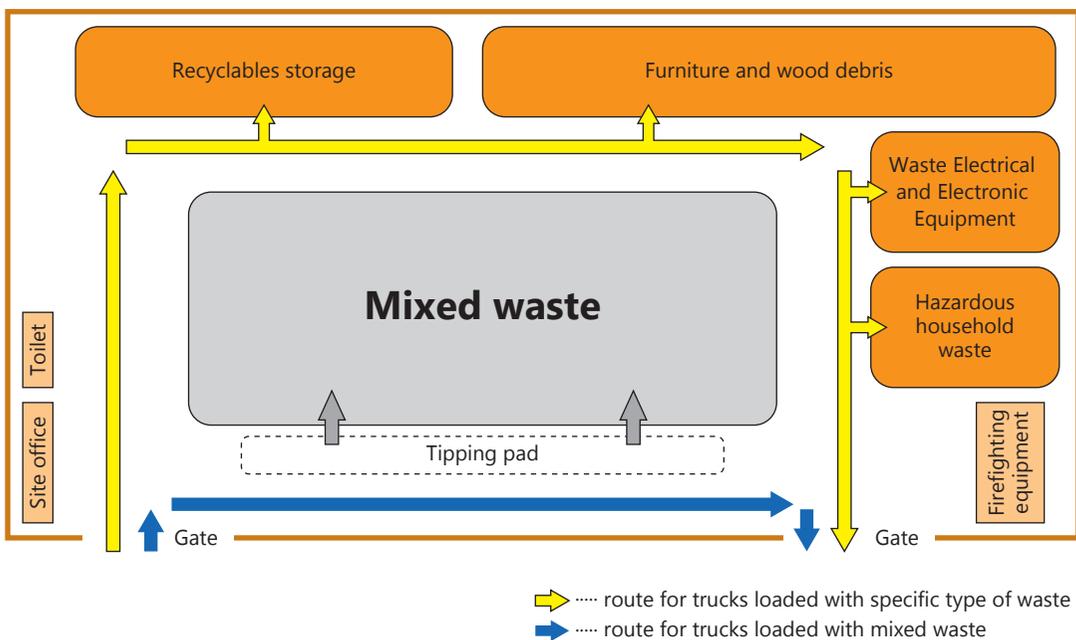


Fig. 7. Example layout of temporary storage site

- There should be a plan for monitoring the environmental impacts that may occur during the use of TSS, including monitoring surface water quality, groundwater quality, air quality, and especially odor problems.
- The District office should consult with DoE to check the appropriateness of locations and designs upon plan preparation. Meanwhile, DoE may ask for advice from PCD and/or other waste management experts.
- Once the waste starts to accumulate, monitor, and control secondary accidents, such as fire outbreaks and explosions. Piles of mixed waste should not exceed 5 m in height.
- In the case where waste cannot be transported to a waste transfer station for a long period of time, the District office should cover the flood waste pile at the TSS with soil or plastic sheets to avoid sanitary problems.
- Damaged furniture should be separated upon transportation from communities to TSS to enable appropriate reuse, intermediate treatment, and final disposal. For example, sofas can be separated into wooden and padding parts. The wooden parts can be chopped up by using an excavator truck and the padding parts can be sold to recycling agents. The storage of the wooden parts, after chopping up, should take into consideration dust and fungal spore distribution problems. The District office will need to provide masks and dust goggles for operators. With regard to the wooden parts disposal, the District office should consider contacting cement companies or biomass power plants because the wooden parts can be used as co-fuel for cement production and electricity generation.

4.3.3 Transportation from TSS to waste transfer station

- It is recommended that the following vehicles are prepared for waste collection following a flooding event:
 - **Ten-wheeled trucks or articulated lorry trailer trucks** should be used to transport wastes from communities or TSS to waste transfer stations or landfills. The articulated lorry trailer truck is suitable for transferring between TSS and waste transfer stations or landfill.
- Calculate the required number of 18-wheeled trucks or 10-wheeled trucks with trailers² for waste transportation from TSS to transfer stations. The number of trucks depends on various factors, including how fast the districts can clear waste, severity of flooding, amount and type of flood waste, traffic conditions, location of TSS, etc. For example, if the district has to clear the waste within one week, and the available truck can only make one round-trip per day, districts or DoE can follow the suggestions below.
 - ◇ Flood waste of less than 1,000 ton: 18-wheeled truck 5 units (or 10-wheeled truck 10 units)
 - ◇ Flood waste of 1,000 – 2,500 ton: 18-wheeled truck 10 units (or 10-wheeled truck 20 units)
 - ◇ Flood waste of more than 2,500 ton: 18-wheeled truck 20 units (or 10-wheeled truck 40 units)
- In order for district offices to rent 18-wheeled or 10-wheeled trucks, they should ask private companies (leasing companies etc.) for rental availability information.
- If there is an urgency to transport the waste out of the district, the District office may consult with DoE to transport the waste directly from TSS to the final disposal site.

² 18-wheeled truck capacity is 30 t. 10-wheeled truck capacity is 20 t.

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5. Check list of recommended actions in each flood management phase

To achieve an appropriate FWM, it is advisable to take appropriate actions in each phase of FWM. Some important actions to be taken by DoE and/or districts in each phase are recommended below.

5.1 Mitigation phase (normal time)

Category	Actions	DoE	District
Improve organization	Clearly delineate the FWM responsibilities of each officer in advance.	✓	✓
Communicate with stakeholders	Communicate with other districts, provinces, suppliers of equipment, and vehicles regarding postflood assistance.	✓	✓
	Build good face-to-face relationships with internal and external actors through planning, workshops, and table-top exercises.	✓	✓
	Communicate with residents on solid waste management during and after flooding.		✓
Gather and analyze data	Make a list of public open spaces that could be used as TSS.	(✓)	✓
	Estimate the quantity and composition of possible flood waste referring to the data from the 2011 mega flood.	✓	
	Develop a data base of stakeholders who can accept flood generated waste as a resource (i.e., furniture waste could be used as wood or a source of fuel at cement factories or biomass power plants).	✓	
	Count and record the available equipment, including vehicles and boats.	✓	✓
	Identify places that generate infectious waste on a map.	✓	
	Identify solid waste buy-back centers in districts on a map.	✓	(✓)
Plan making	Develop plans for collection, transportation, storage, treatment, and final disposal of flood waste.	✓	✓
	Develop a common format for subsidy application.	✓	
	Develop a public communications plan that indicates who disseminates what information, how, and to whom.		✓
	Prepare guidelines for residents on solid waste management during and after flooding.	(✓)	✓
	Develop environmental monitoring plans, which include the target substance, place, frequency, personnel, and equipment required for monitoring.	✓	
	Organize the above plans/information as an FWM plan (always leave some flexibility!).	✓	✓
Prepare for equipment	Prepare for (e.g., purchase, make assistance arrangements) postflood procurement for necessary equipment and vehicles.	✓	✓
	Prepare occupational safety equipment.		✓
Conduct training	Conduct workshops among staff to identify strengths, weaknesses, and external positive and negative factors of the organization using the Vulnerability Assessment Tool (refer to Appendix 1).	✓	✓

5.2 Preparedness phase (after flood warning)

Category	Actions	DoE	District
Improve organization	Set up ad hoc flood waste management task force, if necessary.	✓	✓
Communicate with stakeholders	Start public relation activities according to the public communications plan.	(✓)	✓
	Hold meetings with district offices to develop a common understanding on the scope of work, and to prepare for the flood waste operations.	✓	
	Start discussing the procurement of equipment budget with DoE and private companies.		✓
Gather and analyze data	Revisit the estimation of the volume of flood waste and required equipment and personnel to carry out the waste collection.	✓	✓
	Check the condition of potential TSS.		✓
Plan making	Review the plan again and recognize the roles and responsibilities.	✓	✓
Prepare equipment	Consider modifying vehicles to avoid them being damaged in the floodwater (e.g., raise the position of the exhaust pipes).	✓	

5.3 During flood phase (initial response)

Category	Actions	DoE	District
Communicate with stakeholders	Provide information on waste collection (separation) and in-house storage to secure public sanitation, according to the public communications plan.	✓	✓
	Share information among DoE, district administrations, and external partners. Effectively coordinate with the Emergency Operation Centre.	✓	✓
	Hold a meeting to coordinate waste transportation to transfer stations.	✓	
Gather and analyze data	Gather latest information on the impact of flooding on transfer stations (e.g., availability, access)	✓	
	Collect latest inundation map.	✓	✓
	Gather latest information on evacuation centers (e.g., location and number of evacuees).		✓
	Gather latest information on damage to housing, infrastructures, agricultural buildings, hospitals, and clinics.	✓	✓
	Re-estimate flood waste amount.	✓	
Plan making	Revise the FWM plan (especially the collection plan) according to the actual situation.	✓	✓
Prepare equipment	Prepare cost estimates to secure budget.	✓	✓
	Set up TSS, if necessary (details on the preparation of TSS is discussed in 4.3).		✓
	Start preparing trucks for transportation of the large amount of flood waste out of TSS after flooding.	✓	
Undertake FWM operations	Collect waste disposed of from flooded houses.		✓

5.4 After flood phase (secondary response and recovery)

Category	Actions	DoE	District
Communicate with stakeholders	Provide information on waste collection (separation) to secure public sanitation, according to the public communications plan.	✓	✓
	Hold a meeting to coordinate waste transportation to transfer stations.	✓	
Gather and analyze data	Obtain updated information on the impact of flooding on waste transfer stations (e.g., availability and access).	✓	
	Obtain updated information on the inundation situation within the jurisdictional area.	✓	✓
	Obtain updated information on damage to housing, infrastructures, agricultural buildings, hospitals, and clinics.	✓	✓
	Re-estimate flood waste amount.	✓	
Plan making	Revise the FWM plan (especially transportation and disposal plans) according to the actual situation.	✓	✓
Prepare equipment	Prepare cost estimates to secure budget.	✓	✓
	Properly manage TSS, if any.		✓
	Properly manage waste transfer stations.	✓	
	Close TSS and reinstate the site to the original condition, if required.		✓
	Secure budget through subsidy application and negotiation.	✓	✓
Undertake FWM Operation	Collect scattered waste and waste disposed of from flooded houses (give appropriate instructions to contractors).		✓
	Transport collected waste to waste transfer stations.		✓
	Transport collected waste to final disposal sites.	✓	✓
Improve future FWM	Keep records of each FWM activity, challenges, issues, and good practice.	✓	✓
	Review lessons learned and budget spent.	✓	✓
	Revise the FWM plan to be suitable for future FWM.	✓	✓
	Improve waste management systems during normal times in accordance with lessons learned.	✓	✓



Appendix

A1. Vulnerability Assessment Tool for Flood Waste Management

A Vulnerability Assessment Tool for Flood Waste Management was developed by the authors to help officers of local authorities identify the weaknesses of their waste management systems with regard to flood events. In this tool, the vulnerability of the locality will be evaluated from six perspectives (Issues). To what extent your locality is vulnerable from each issue will be evaluated by criteria and indicators. These are written in the form of questions. Answer "Yes" or "No" to each question to quickly review the state of resilience of your FWM system. For questions answered "Yes," evaluate subjectively the quality of the information and effort being questioned. Score 1, 2, or 3 – given that 3 is the highest. Focus on issues answered "No" or issues given with low scores, and consider the actions that could be taken towards improving the situation.

Please use the electronic version of this tool for more detailed assessment (available on: <http://waste-management.asia/2015/08/666>). It is advised to use the tool in a team of your colleagues, possibly in a form of workshop to reflect the situation of the locality.



Explanation of Issue 1

If the existing waste management systems do not work during and after flooding, it is probable that special measures (e.g., installation of temporary waste management facilities) will need to take place for flood waste management. In addition, repair of the normal waste management system needs to take place. This could lead to slow and costly flood recovery.

In order to minimize impacts on existing waste management systems, waste management facilities, equipment, and other resources should not be exposed to floodwater. If that is not avoidable, they should then be flood-resistant.

Issue 1	Prevent flood impact on usual waste management system	
Criteria 1.1	Waste management facilities are not damaged by flooding	
Indicators	1)	<p><u>Are transfer stations and/or landfills located outside high flood risk areas?</u> Note: Consider what percentage of the total capacity would be exposed to flooding, and how high that risk would be. Give special attention to facilities that manage/store hazardous waste. Select "NA" if there are no transfer stations/landfills in your locality.</p>
	2)	<p><u>Does your department use multi-access options to current transfer stations and/or landfills?</u> Note: Consider whether several different routes are available from the city to transfer stations and landfills (routes in low flood risk areas are preferred).</p>
	3)	<p><u>Are any reinforcement measures undertaken on waste management facilities for the purpose of flood preparation?</u> Note: Consider what percentage of the facilities are flood proof, and how effective those reinforcement measures are (e.g., dykes). <i>*select "Yes" and score "3," if all the facilities are located outside high flood risk areas*.</i></p>
Criteria 1.2	Equipment for waste management system are not damaged by flood	
Indicators	1)	<p><u>Do you have parking space for waste collection/transportation vehicles outside high flood risk areas?</u> Note: Consider what percentage of the vehicles that you usually use will be flooded.</p>
	2)	<p><u>Are waste collection vehicles used in normal circumstances usable in shallow water?</u> Note: Consider what percentage of your vehicles used normally are converted to be able to work in water (e.g., lifting the car body), and its effectiveness. If vehicles are not owned by your organization, also give consideration to whether the leasing company will allow them to be used in water.</p>

Explanation of Issue 2

Appropriate and efficient flood waste management will require a lot of resources, including facilities, equipment (heavy vehicles, trucks, fuel, etc.), finance, and personnel (information is also important - see Issue 4). If the city does not have enough resources, assistance will have to be sought from external bodies such as the national government, military service, provincial government, and private companies. Resource shortage will lead to slow waste management operations.

In addition to having stockpiles, pre-flood arrangements for obtaining support from external bodies are effective.

Issue 2		Secure flood waste management resources
Criteria 2.1		There is enough capacity in locality to temporary store waste
Indicators	1)	<u>Does the current waste transfer station have capacity to store additional waste (e.g., future flood waste)?</u> Note: Consider whether you can find extra space in your transfer stations to store and handle flood waste, based on your flood waste estimation. Select "NA" if there are no transfer stations/landfills in your locality.
	2)	<u>Have you prepared a list of available land areas for Temporary Storage Site?</u> Note: The address, area, and property owner should be all listed and updated on a regular basis.
	3)	<u>Do you have prearrangements (e.g., written agreements) with property owners?</u> Note: Consider how reliable and easy to implement the prearrangements (negotiations, pre-flood contracts, etc.) are.
Criteria 2.2		The city has or can obtain enough resources to manage flood waste
Indicators	1)	<u>Have you prepared a list of collection/disposal equipment, including heavy vehicles, trucks, and boats usable during flooding?</u> Note: The type and capacity of all vehicles should be listed and updated on a regular basis.
	2)	<u>Have you prepared a list of special vehicles that the city owns for hazardous and medical waste collection/transportation?</u> Note: The type and capacity of all vehicles should be listed and updated on a regular basis.
	3)	<u>Do you have prearrangements (e.g., written agreements) with equipment owners?</u> Note: Consider how reliable and easy to implement the prearrangements (negotiations, pre-flood contracts, etc.) are. The equipment owners may include construction and leasing companies, etc.
	4)	<u>Do you have stockpiles of other important items for flood waste management (i.e., fuel, masks, and gloves)?</u> Note: Consider how confident you are in terms of types and amounts of stockpiles.
	5)	<u>Do you have prearrangements (e.g., written agreements) with the owners of those items (fuel, masks, and gloves)?</u> Note: Consider how reliable and easy to implement the prearrangements (negotiations, pre-flood contracts, etc.) are.
	6)	<u>Is there any relationship with external actors (association, alliance, personal contacts, etc.) that would enhance monetary or human resource assistance for flood waste management?</u> Note: Main external bodies include military, other local authorities, and private companies. Consider how reliable the relationships are.
	7)	<u>Are special budgets/subsidies/human resources to conduct planning for flood waste management available?</u> Note: Consider whether any officer or team has clear responsibility for planning, or whether a budget has been allocated in order to subcontract planning to consultants, and whether the personnel and finance available seems sufficient.

Explanation of Issue 3

In order to ensure its efficiency flood waste management should be undertaken strategically. Impromptu flood waste management activities will cause unnecessary confusion among stakeholders and also cause delays. It is equally important to be adaptive and flexible, as past experience shows that situations change and new issues arise over time.

As a principle, flood waste management should be planned ahead of time, before flooding occurs. This will minimize unexpected events and will also be a good opportunity for capacity development. Sufficient information, resources and explicit yet flexible planning, and framework implementation should be included.

Issue 3	Adaptively plan for and implement flood waste management	
Criteria 3.1	Necessary plans and rules for flood waste management are prepared	
Indicators	1)	<p><u>Have you prepared a flood waste management plan?</u> Note: Good flood waste management plans should prescribe the framework and procedure for postflood waste management actions.</p>
	2)	<p><u>Have you prepared rules for storing (in-house) and disposing of flood waste for residents?</u> Note: For example, rules for storing and disposing night and general waste during flooding, and how to dispose of household waste after flooding should be prescribed.</p>
	3)	<p><u>Have you prepared rules for separation of flood waste to promote recycling and proper disposal?</u> Note: Basic separation rules should be considered taking recycling and disposal options into account.</p>
Criteria 3.2	The ability of adaptive planning and management is sufficient	
Indicators	1)	<p><u>Can you collect information on flood damage (to be used for flood waste estimation) from various sources (e.g., disaster management section, site visit) during/after flooding?</u> Note: Information referred to here includes area of inundation, number of flooded houses/facilities, and others. Consider how reliable the information would be, and how quickly you could obtain it.</p>
	2)	<p><u>Does the decision making system give discretionary powers to officers working at the lower level of command line for actions taken during flooding?</u> Note: Consider whether you need to ask permission from your superior (or his/her superior) for every action, or only for significant actions.</p>
	3)	<p><u>Is there any team/department designated to be the center of information gathering, sharing, and plan revision during the flooding period?</u> Note: Consider whether an officer or a team has clear responsibility for information gathering, sharing, and plan revision, and whether the number of personnel seems sufficient.</p>
	4)	<p><u>Are roles/responsibilities of relevant teams/departments shared and prescribed?</u> Note: Consider how clearly responsibilities are prescribed, and whether all the necessary roles for flood waste management are shared.</p>
	5)	<p><u>Is there any special (fast-track) procurement procedure for emergency cases?</u> Note: Consider how quick that procedure is compared to normal procurement procedures.</p>

Issue 3	Adaptively plan for and implement flood waste management	
Criteria 3.3	Basic information necessary for planning appropriate and efficient flood waste management is available	
Indicators	1)	<p><u>Do you have a useful road map showing elevations?</u> Note: The map should be up-to-date (updated at least within the last 5 years).</p>
	2)	<p><u>Do you have an up-to-date land use map?</u> Note: The map should be up-to-date (updated at least within the last 5 years).</p>
	3)	<p><u>Do you have a flood risk map indicating which part of the locality might be flooded in the future?</u> Note: The map should indicate both high and low risk areas, and should be up-to-date (updated at least within the last 5 years)</p>
	4)	<p><u>Do you have information regarding generation/use/storage of major hazardous chemicals and infectious waste?</u> Note: The information should include industrial, agricultural, and clinical substances, and the names of the chemicals should be specified.</p>

Explanation of Issue 4

If buildings (housing, factories) and infrastructure (e.g., bridges) collapse, they become flood waste. If those buildings contain hazardous materials, they will become hazardous flood waste. Actions to reduce vulnerability in this sense need to be undertaken in collaboration with the urban development section.

In order to minimize the impact on housing and other structures, these should be outside high flood risk areas. If that is not avoidable, they should be flood-resistant or flood-adaptive.

Issue 4	Prevent flood impact on buildings and infrastructures	
Criteria 4.1	Most of the housing will not be affected by flood	
Indicators	1)	<p><u>Are there land use regulations that restrict residential development in high flood risk areas?</u> Note: Consider how well that regulation is implemented, and its effectiveness.</p>
	2)	<p><u>Is current housing located outside of high flood risk areas?</u> Note: Consider what percentage of the housing would be exposed to flood, and how high that risk would be.</p>
	3)	<p><u>Is the housing located in high flood risk areas resistant or adaptive to flooding?</u> Note: Consider what percentage of the housing is flood resistant or adaptive, and how effective those measures are (e.g., high-floored housing).</p>
Criteria 4.2	Most of the factories and infrastructures will not be affected by flood	
Indicators	1)	<p><u>Are factories with hazardous materials located outside high flood risk areas?</u> Note: Consider what percentage of those factories would be exposed to flooding, and how high that risk would be.</p>
	2)	<p><u>Are those factories located in high flood risk areas resistant to flooding?</u> Note: Consider what percentage of those factories are flood resistant, and how effective those measures are. <i>*select "Yes" and score "3," if all the facilities are located outside high flood risk areas*.</i></p>
	3)	<p><u>Are major public infrastructures located outside high flood risk areas?</u> Note: Consider what percentage of those infrastructures (bridges, railways, etc.) would be exposed to flooding, and how high that risk would be.</p>
	4)	<p><u>Are those public infrastructures in high flood risk areas resistant to flood?</u> Note: Consider what percentage of those infrastructures are flood resistant, and how effective those measures are.</p>
	5)	<p><u>Is scattered garbage and vegetative waste normally collected to avoid blockage of drainage ditches?</u> Note: Dumped garbage could block drainage ditches during flooding. Consider how widely scattered and how often such wastes are collected compared with normal situations.</p>

Explanation of Issue 5

Flood waste management is mainly undertaken by public bodies, the local authority being at the top of the list. However, without the cooperation of the public, this would become disorganized. Wet household goods (e.g., sofas, TVs, etc.) become flood waste. Improperly stored and disposed of waste during flooding could cause public health issues and impair water discharge functions. Typically, socially vulnerable people suffer more.

To ensure good preparation and the capacity development of the public, local authorities should provide appropriate information and support to communities. Special care should be taken for socially vulnerable people.

Issue 5		Develop coping capacity of the public
Criteria 5.1		Residents can effectively evacuate their household goods before the water arrives.
Indicators	1)	<u>Is there any early warning system for flooding?</u> Note: Consider how well the warning is disseminated to the public, and its reliability.
	2)	<u>Do residents have area/space to evacuate their household possessions?</u> Note: Consider whether there is enough space inside housing, and if not, whether public space is available to keep their possessions dry.
	3)	<u>Are there community groups that can lead/guide preparation for flooding?</u> Note: Consider whether there are a sufficient number of community groups within the locality that is active compared with the normal situation.
	4)	<u>Are residents aware of methods to evacuate household goods before the water arrives?</u> Note: Consider whether such knowledge is broadly shared based on past experience or provision of training.
Criteria 5.2		Residents can effectively separate, store, and dispose waste during and after flooding.
Indicators	1)	<u>Are plans/rules to promote recycling, proper storage (inside housing), and proper disposal informed to residents?</u> Note: Consider whether the above information has reached all residents (use of a single media outlet may not be sufficient).
	2)	<u>Are plans/rules/procedures for cleaning after flooding communicated to residents?</u> Note: Consider whether the above information has reached all residents (use of a single media outlet may not be sufficient).
Criteria 5.3		
Indicators	1)	<u>Does the waste management department have good contact with social welfare sections or groups?</u> Note: Consider how well you know about the people working in social welfare sections. These people should be contacted for information about socially vulnerable residents (who might need special assistance for waste disposal) and to coordinate waste collection at shelters.
	2)	<u>Are there any institutional arrangements to support socially vulnerable residents to evacuate their household possessions?</u> Note: Consider whether the community or vulnerable people (disabled, elderly, etc.) have sufficient support from the local authority.
	3)	<u>Is there any opportunity for the informal sector (waste pickers, junk buyers) to participate in flood waste management?</u> Note: Consider whether the informal sector has more or less opportunity compared to normal situations, making sure not to deprive them of their livelihood.
	4)	<u>Is there any channel to collect the opinions of the public living in slum districts during flooding periods?</u> Note: Consider whether people living in slum districts would be able to make complaints if there is social injustice during flood waste management (e.g., temporary storage sites are sited right next to their houses).

Explanation of Issue 6

There are chances to improve vulnerability conditions. Important opportunities exist after flood waste management efforts are completed, as a high political attention is given. However, if there is no system to enable learning and improvement, the locality is likely to face the same challenges they faced in previous flood events.

It is especially important to keep records of flood waste management to the greatest extent possible. Information collected through these efforts should be used for future preparedness planning and training.

Issue 6		Improve vulnerability condition
Criteria 6.1		There is a system that enables improvement of flood waste management capacity
Indicators	1)	<u>Is there a plan for flood waste management preparedness actions? (i.e., an action plan that aims to reduce vulnerability)</u> Note: Aims, responsibilities, and schedules of necessary preparedness actions (e.g., estimation of future flood waste amounts) should be organized as a plan.
	2)	<u>Is there a special budget to be used for improving waste management systems?</u> Note: Consider whether that budget is sufficient and sustainable.
	3)	<u>Are training opportunities for flood waste management provided to officers?</u> Note: Training should be provided annually, at least, to input necessary information/knowledge and improve flood waste management skills/mindsets.
Criteria 6.2		There is a system that enables learning from previous flood events
Indicators	1)	<u>Is it possible to produce an after action report of flood waste management activities to draw lessons for future flood events?</u> Note: Consider whether there is an institutional framework and/or enough political will and/or administrative resources for such reflection.
	2)	<u>Are there records of procedures/data on flood waste from previous floods?</u> Note: Consider how well information is recorded (especially quantitative data) and the quality of this information.

A3. Report of Flood Waste Management Workshops in Bangkok

National Institute for Environmental Studies, Joint Graduate School for the Energy and Environment and Kasetsart University have organized series of workshops on flood waste management in Bangkok from 2012 to 2015. In post-disaster phase, accumulation of knowledge, lessons-learned and data is an important activity to review the past countermeasures at the time of flood and also to improve preparedness for the next flood event. Details of each workshop are as below;

1. International Seminar: Flood Waste Management in Urban Area –Lessons Learned in the Aftermath- Date: 20th of March, 2012 Venue: Bangkok, Thailand

The objectives of this seminar were to share experiences and lessons learnt on flood waste and disaster waste management in the Asia-Pacific region, especially to rethink the post-disaster flood management in Bangkok after the flood in 2011, and to formulate a guideline for municipal government to cope with waste management after natural disasters. Natural disaster and flood waste management experiences were shared from Thailand, Japan and New Zealand and the possible policies formulation and implementation for the next flood event in Thailand were discussed.



2. Workshop on flood waste management and the role of local practitioners. Date: 31st of July, 2012 Venue: Bangkok, Thailand

In cooperation with BMA, we have implemented the capacity building workshops for the local practitioners in waste management targeting officers from 50 districts of Bangkok. Local officers from each district have had an opportunity to analyze the current condition of waste management system in each district and also received the training on how to estimate the amount of flood waste generation from the available data. The participants commented that the workshop was useful in acquiring knowledge on when to do what by who for the municipal solid waste during flood event.



3. APN Seminar Workshop: "Adaptation of Solid Waste Management to Frequent Floods in Vulnerable mid-Scale Asian Cities"

Date: 7th of August, 2014 Venue: Bangkok, Thailand

The workshop was held with the purposes to share the flood waste management experiences of Ayutthaya Thailand and Hue, Vietnam and to discuss the structure and contents of the Vulnerability Assessment Tool for flood waste management for local government to build resilient waste management system.

During the meeting, institutional arrangements for flood waste management during the Great East Japan earthquake, and some case studies of Japanese cities on how they prepared for the waste management in emergency cases were also discussed.



4. APN Capacity building workshop on flood waste management for local administration in Thailand

Date: 16-17 of June, 2015 Venue: Bangkok Thailand

The objectives of the workshop were to share experiences on the flood waste management of Ayutthaya, Bangkok, and Japan, and to establish action plans for flood waste management. To discuss what contents should be included in the flood waste management action plans for local government, the Vulnerability Assessment Tool had been used.



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