

Solid Waste Management as a Response to Urban Flood: Case study of Bangkok City

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Abstract – Solid waste management is often set as a low-priority issue in cities in developing countries while urban floods induced by severe climate patterns in recent years is another challenge to urban developers. For Bangkok, both issues are closely linked to each other. An inefficient solid waste management system leads to increasing debris in drainage systems and so decreased drainage capacity and the wastewater remains longer in the sewer networks. Conversely, urban flooding often paralyzes the solid waste management service which worsens the situation. It is important that waste management in flood periods is included in the flood management plan. This research investigated the flood management and solid waste management system of Bangkok city, which is driven by the Bangkok Metropolitan Administration (BMA) and public participation. The limitations of the current system are discussed and recommendations are made for improving waste management practices in the city which would contribute to effective flood control in Bangkok.

Keywords – Solid Waste Management, Urban Flood, Drainage, Bangkok Metropolitan Administration

1. INTRODUCTION

Thailand is located in a monsoon area with frequent rainstorms during the raining season. Many parts of Thailand encounter significant flooding events during these periods. The capital city of Bangkok has included grey water management in flood situations in its urban planning [1]. However climate change has created more intensive rain events over recent times. Large volumes of storm water are distributed through the city's flood ways which were constructed in the early development of Bangkok city. Since then, there has been little attention paid to increasing drainage capacity, and many of the canals and drainage facilities have been built over. Urban flood has become a matter of critical concern in water management and needs to be solved urgently. Urban flooding brings many negative impacts, including traffic congestion, delays in all aspects of transportation, paralysis of intra-city logistics, closing down of factories and disruption to production, and

eventually serious disruption to social and economic activities.

The population of Bangkok reached 1.9 million people in 2014 [2] with the population comprised of registered Bangkok natives bolstered by a substantial migration from other regions of Thailand and neighboring countries into the city, as skilled and non-skilled labor. Consumption of goods and services increased in metropolitan Bangkok as consequence of this increased population. Accompanying this increase in population, and consumption, was the accumulation of a great deal of solid waste, especially packaging made from non-recyclable materials purchased from street markets and in informal residential areas i.e. low-income settlements along canals and floodways which developed in such volume as beyond the capacity of the Bangkok Metropolitan Administration (BMA)'s management ability. This form of debris and solid waste leftovers often account for the clogging of and therefore reducing capacity of the existing drainage networks. Effective solid waste management is therefore now an imperative to maintain the continuity of BMA's services and to reduce the flood risk in the Bangkok metropolitan area in both the short and long term.

This research reviewed the reference case studies of other cities which have undergone rapid urban development and have similar solid waste characteristics to Bangkok. Various major aspects of the flooding problem were identified and studied, including identifying the flood-risk areas of Bangkok city, the potential contributing causes of flooding, the current flood management plans, policies and practices and the solid waste management systems of the BMA. In this paper the limitations of the current systems for successful flood management for Bangkok city are discussed, and recommendations for the future waste management practices are proposed.

2. LITERATURE REVIEW

Cities in the developing world often have insufficient funding for development and maintenance of efficient solid waste management and drainage systems. As a result, the infrastructures are poorly constructed and inadequately maintained [3]. For our initial study phase, we selected Mumbai in India and Jakarta in Indonesia as example case studies. These two cities have been the among the fastest

growing urban areas in the world, and are now defined as megacities have most types of land-use and, including government offices, business districts, upper-class residences and low income settlements. The high urban density inevitably leads to increasing loads on existing waste collection and treatment systems, drainage and water treatment systems. There are, however, different geographical conditions and solid waste management approaches differentiating the two cities.

2.1 Mumbai Case Study

Mumbai is generally prone to flooding due to several natural and man-made factors including very heavy rain during the monsoon season, and increasing areas of impervious surface such as roads and pavings and loss of water reservoirs [4]. Waste products, solid and chemical, often toxic, which come from illegal dumping and a general low level of environmental awareness, often mix with storm water and block the drainage channels. The various waste management approaches include: 1) the service provided by Municipal Corporation of Greater Mumbai (MCGM) 2) 'community participation' which encourages the community to perform waste separation with support of NGOs 3) 'Public Private Partnership' (PPP) which is mainly driven by the private sector. It was observed that the community participation system is the least cost option and reduces the need for community bins and waste transportation. On the other hand, the PPP system focuses on waste treatment more than waste collection and transportation [5].

2.2 Case Studies of Jakarta

Jakarta, which is the capital and largest city of Indonesia, is crisscrossed by a river network. The sewerage network was quite limited with only 3% of the population with proper access to the sewerage networks in 2002. It has frequent flooding in regions along the urban river corridor. Tropical storms at the upper catchment areas often induce flood in downstream areas. The Indonesian Government has considered building dams in the upper catchment area to reduce river discharges into central Jakarta, but it may result in a negative impact on river water quality due to changes in hydrological and hydraulic conditions [6]. For solid waste management, there are mainly four approaches; 1) Conventional system where garbage and waste are collected and transported to the central treatment facility 2) Centralized 3Rs system focusing on compost production 3) Centralized 3Rs system focusing on digestion coupled with compost production and 4) Decentralized 3Rs system. The 3Rs approach significantly helps to increase the amount of recovery of recyclable material and the proportion of organic waste separation [7]. The waste collection is significantly driven by the Cleansing Department of Jakarta and neighborhood associations (NAs). The NAs collect money from residents to provide community services, including primary collection, transfer of waste to temporary waste storage points for further collection by the Cleansing Department. It has been reported that approximately 80% of household wastes are now collected by NA workers. The

barriers to effective waste management performance are identified as low environmental awareness of community members, limited space for temporary waste storage, and the fee charged to households being too low to provide sufficient facilities for complete daily waste collection [8].

3. METHODOLOGY

3.1 Bangkok Data Collection

Data and information were collected from the Bangkok Metropolitan Administration (BMA); the Department of Drainage and Sewerage (DDS) and the Department of Environment. Data were collected on Bangkok flood situation, flood management system, the agencies involved in flood mitigation planning and processes and their responsibilities. Further data was collected on the waste management systems in place, covering the collection, transportation, and disposal of waste. Statistical data and information of during 2009-2014 were collected. Interviews with the BMA officer in these departments were carried out to gain additional necessary information.

3.2 Research Framework

The research framework is illustrated in figure 1. The information on flood prevention and Response plan (DDS) and the waste management system in the normal situation (Department of Environment) were examined for the waste management ability of BMA in flood situation. The existing structural- and non-structural measures were also considered for their roles in flood risk reduction. The relevant solid waste management practice was suggested with regards to limitations of the current system

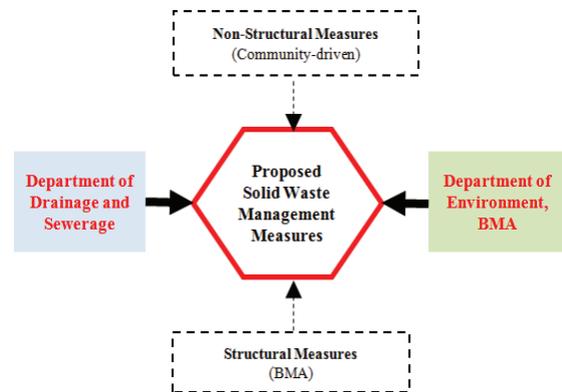


Figure 1 Research Framework

4. RESULTS AND DISCUSSION

4.1 Overview of Bangkok Flood-Risk Areas

Bangkok city is located at the lower catchment area of Chao Phraya River. The Chao Phraya River begins at the confluence of four tributaries in the central north region of Thailand, in Sukothai province. The river flows southward and passes through Bangkok city to reach the Gulf of Thailand. The geographical map of Bangkok with heights above mean sea level and frequently-flooded areas in recent years are overlaid and displayed in figure 2.

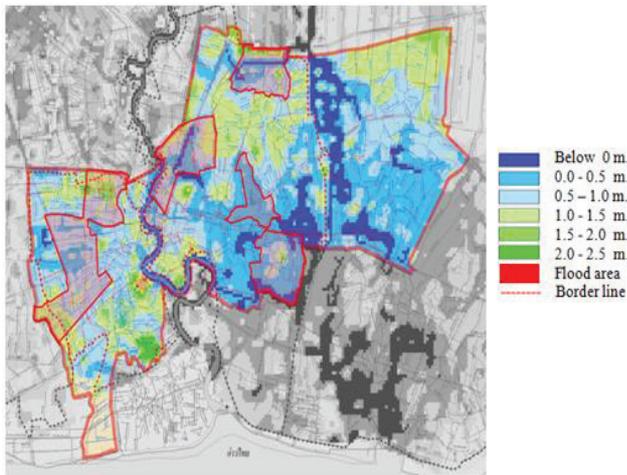


Figure 2 Flood-risk areas of Bangkok with geographical height above mean sea level
 Source: Royal Thai Survey Department, 2011

The areas which often have flood issue in the past decade are shown in red color. The areas in dark blue color represent the area which is below mean sea level. The light blue zone is slightly higher than the sea level (< 0.5 m). It was observed that certain flood-prone zones are not low-lying area. Other factors, i.e. drainage capacity, urban density, are possibly relevant determinant whether flood would take place.

The causes of Bangkok flooding must be determined to figure out the appropriate solution. This topic is discussed in section 4.3.

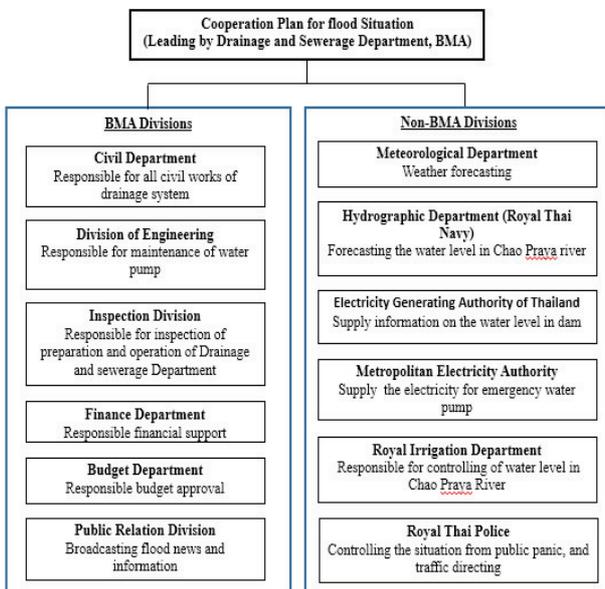


Figure 3 Cooperation Plan for Bangkok flood Situation and relating agencies
 Source: Department of Drainage and Sewerage, BMA, 2014

4.2 Bangkok Flood Management System

Bangkok's stormwater drainage performance is significantly affected by water level of Chao Phraya River as well as the ebb and flow. Therefore, flood management system was initially developed to prevent flooding by the massive river discharges in wet season and to increase stormwater drainage capacity in the high tide period. These activities require various fields of information and support from other agencies.

Figure 3 shows the cooperation plan among BMA divisions and related state agencies in flood prevention and control.

The BMA divisions are responsible for construction, operation and maintenance of drainage systems in Bangkok city, including water channels, sluice gates and stormwater pumping stations. The Meteorological Department supports BMA the information of incoming storm events. Hydrographic Department (Royal Thai Navy) and Electricity Authority of Thailand provide information of the current water level and remaining water storage capacity of Chao Phraya river and hydroelectric dams located along upstream area, respectively. Metropolitan Electricity Authority supplies power to BMA's emergency water stations. Royal Irrigation Department is in charge of regulating the water level in Chao Phraya River in the upstream area and, thus, communicating its operation, which would affect the stormwater control, with BMA. Last but not least, in flood situation, Royal Thai Police force helps containing the public panic situation and managing the traffic route for evacuation.

4.3 Potential Causes of Flood

Geographical condition: Lower height above sea level indicates lower velocity of drainage flow that creates water logging area. Due to geographical condition on sea level's height, the prevention plan of practice might be solved by providing barriers or engineering techniques, including with the capacity of urban drainage system. Nonetheless, according to figure 1, the overlay of geographical height at sea level and flood areas in Bangkok geographical condition has not much shown the relevant conditions to flash flood occurrences.

Loss of canals/water channels: Several 'Klongs', which literally means 'canals', in Bangkok that were important waterway and stormwater discharge have been replaced by road for transportation, property development and other specific purposes, then the existing urban canals as main part of urban water storage and drainage systems were disconnected to the others in lines, which cause of reduction on drainage capacity. In addition, the increased number of silt, clay and other sunken solid wastes, have block up drainage flow activity, even created shallow canal ground [9].

Economic benefit concern: The water-channel network of Bangkok is an important tool to perform flood control. According to DDS, the massive stormwater in each district shall be discharged to its nearby/surrounding Klongs. However, a number of districts, particularly the central

business districts of inner Bangkok, are unlikely to allow stormwater flowing through sluice gates under their responsibility. The stormwater is then diverted to the adjacent district's water channel, and often cause flood in such area.

Climate pattern: Climate change has already affected Thailand with uncertain climate cycle with largely-fluctuated precipitation in the past decade. Yet the other climate phenomenon, i.e. La Nina, also results in frequent heavy rainfalls over short period of time during the wet season.

Solid waste: Solid wastes which were not collected by BMA service or indiscriminately dumped are one of potential cause of flood as they reduce the overall drainage performance. Floating solid waste accumulated and block drainage channel at the end flow of each drainage unit.

Drainage capacity: Capacity of drainage pipe is determined by flow velocity which varies to the pipe size and the accumulated wastes and sediments. The combined sewer network has been designed and constructed for long time since the beginning of Bangkok city. Therefore, the increasing volume of wastewater combined with stormwater is discharged through the existing network, but cannot drain as fast as it was in the past [10].

Different factors influence in Bangkok flood as discussed above. Geographic and climate pattern are natural environmental conditions that determines hydrological and hydraulic condition. The drainage capacity expansion is cost-intensive option to BMA. In addition, BMA has already implemented the maintenance plan and provided budget to the existing drainage pipelines, but it is not sufficient to catch up with the accumulated wastes and sediments. The poor coordination upon stormwater discharge through each district area due to economic benefit concern is a subjective matter. The seemingly most promising solution to assist flood control is simple and low-cost system with public participation.

Bangkok Solid Waste Management System

Waste Collection and Transportation Services by BMA:

BMA operates waste collection service by the compactor truck as the main vehicles. General waste is collected on daily basis or alternate days depending on the waste volume scale and accessibility to the waste transfer points, i.e. daily collection service to the business districts along the primary roads. Organic/food waste is collected on daily basis. Recyclable waste is collected on every Sunday. Household hazardous waste is collected on the first and fifteenth day of every month. The waste collection on main and secondary roads and markets is scheduled at the designated location during 08.00 p.m. – 03.00 a.m. and the collection service must be completed by 06.00 a.m. MSW of communities and small roads must be cleaned every day. In areas that collection vehicle, which is mainly compactor truck, cannot access, the district offices shall find volunteers to collect waste and transfer to the designated location.

Community-Base Solid Waste Management (CBM): The CBM framework is developed and promoted to support solid waste management at sources. The main goal is to encourage community to manage its own wastes through the 3Rs (reduce, reuse, recycle) approach and to reduce dependency to BMA service.

The 3Rs activities are often performed through partnership between communities (households, community committee) and private sectors (Unofficial recycler and NGOs). Additionally, community is able to make financial benefit from waste trade to waste recyclers. According to BMA survey during 2009-2013, it was observed that residential and commercial complexes are quite attentive to CBM framework. There are 377 residential complexes, 115 academic institutions that have implemented CBM in their community area as shown in figure 4 [3].

Conversely, most commercial complexes and fresh markets still leave waste management to BMA service. Bangkok marketplaces generate a great deal of solid wastes, especially the Jatuchak weekend market. The stronger support from commercial sector would dramatically decrease load of BMA waste services.

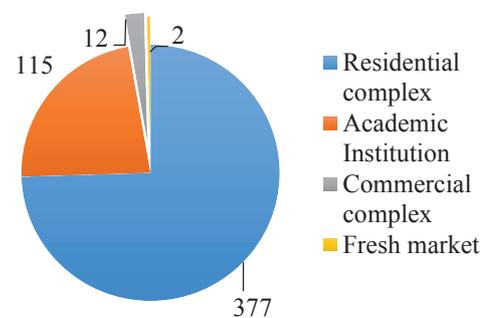


Figure 4 Number of communities joining CBM program by type (2009-2013)

4.4 The Current BMA's Solid Waste Management in response to flood

The combined waste and flood management system of Bangkok with details of relating bodies and their responsibilities are illustrated in figure 5. Once flooding occurs, DDS officers make an assessment of the flooded area, identify obstructions in the stormwater discharge channels, and inform the Civil Department to repair the drainage pipes and to clear the debris and sediments that block the water channels. The Public Relations Division and Royal Thai Police play an important role in coordinating the situation with the public. The Public Relation Division distributes and broadcasts information updates on the situation through radio broadcasts and digital media. This assists in providing traffic information to allow drivers to re-route, diverting the traffic away from the flooded areas and supporting BMA officers to gain better access and convenience in flood response tasks. Sub-contract workers are responsible to remove debris from the water channels. A specially assigned unit of Waste Management Division (Department of Environment, BMA)

collects and removes the debris and transfers it to a disposal site.

Although district offices have implemented action plans the management capacity hardly matches the volume of debris and sediments that need to be dealt with. A long term solution to provide greater resilience to flooding in Bangkok should focus on the preventive approach over the conventional end-of-pipe approach.

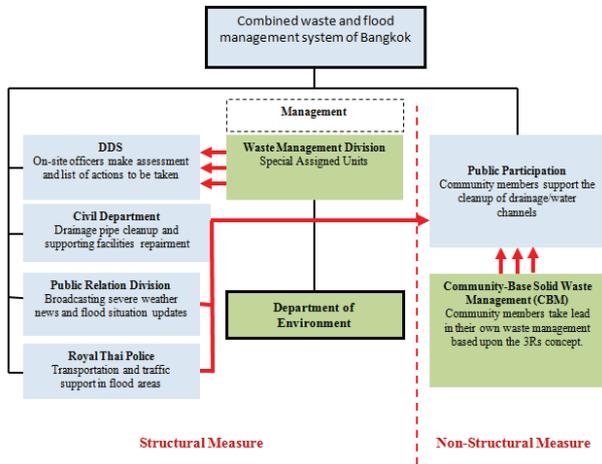


Figure 5 combined waste and flood management system of Bangkok

In terms of non-structural measures, the CBM approach significantly helps reducing the waste load on the BMA. It has had a positive outcome in preventive flood management as the uncollected or indiscriminately dumped wastes are removed. The risk of clogged drainage pipelines and water channels is reduced. It was observed that some communities do give voluntary support to keep water channels clean from waste on their own accord. Nonetheless, it is not a common practice to most communities. They feel no compelling need to support as they do not see an immediate or clear benefit out of such action. The CBM approach could be extended to clean water channels with incentives and coordination through the Public Relation Divisions and the Royal Thai Police in order to have stronger public participation.

5. CONCLUSION AND RECOMMENDATION

Urban flood is generally influenced by natural environmental factors such as geography, land topology, climate, rivers and other natural waterways and their hydraulic conditions. Manmade factors in changing the urban environment including land use purposes, population density, new and destroyed drainage systems, and solid waste management systems. The City of Bangkok has implemented its flood management plan which currently addresses post-flood actions such as cleaning of clogged drainage pipelines. The emphasis is on cleaning up after a flood event and does not seriously address more preventive approaches. The CBM positively results in waste reduction in residential communities which adopt the approach. Yet,

commercial sector has not taken much participation. In addition, the CBM is currently limited to solid waste which creates financial benefit, i.e. recyclables and organic wastes, to the communities. The economic incentives to encourage more public participation in waste removal and/or cleanup of water channels are crucial to the successful long-term flood management.

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8. BIOGRAPHIES



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