



Assessing the Sustainability Level of Municipal Solid Waste Management in Bangkok, Thailand by Wasteaware Benchmarking Indicators

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Abstract

The rapid increase in waste volume leads to numerous and widespread impacts on sustainable development including social, economic and environmental dimensions. This study applied Wasteaware benchmarking, which is a set of international indicators, to evaluate the effectiveness and sustainability of municipal solid waste management in Bangkok. The indicators allow identification of strengths and weaknesses of the urban waste management system, providing evidence-based guidance for further improvement. Structured questionnaires were developed based on the indicators and its manual for in-depth interviews with key stakeholders from Bangkok Metropolitan Administration (BMA). The data were analyzed using wasteaware datasheet under Microsoft Excel with score coding, generating a clear and detailed overview of the performance of Bangkok's municipal solid waste management system (MSW). The overall assessment demonstrated that all waste collected is disposed through official treatment facilities. However, the system's effectiveness is constrained by ineffective enforcement of relevant regulations. Moreover, waste collection services were found to be not fully efficient. In terms of financing sustainability, improvements are needed to reduce disposal costs. Even if BMA prioritizes waste collection and disposal, it is equally important to promote the 3Rs and fully implement source separation to reduce waste volumes at source. In this regard BMA's efforts to waste volume reduction targets have met with limited success, and the volume of waste generated in Bangkok continues to rise each year. To enhance the sustainability of MSW management, the outcome of this study could be used to support decision-making and further development, as well as provide inputs for future research.

Keywords: Municipal solid waste management; Wasteaware benchmarking indicators; Bangkok; Thailand

Introduction

According to the United Nations, the world's urban population has grown from 746 million in 1950 to 3.9 billion in 2014. Our urban population now represents more than 50 % of the world population [1]. At the same time, economic growth in cities combined with increased population generates higher demand for goods or production, leading to ever-increasing pressure on municipal solid waste (MSW) management systems, particularly in mega-cities.

Based on the United Nations Human Settlements Program (UN-HABITAT), MSW refers to "wastes generated by households, and wastes of a similar nature generated by commercial and industrial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens" [2]. According to World Bank, the global volume of MSW was about 1.3 billion tons in 2012, but is estimated to almost twice double by 2025 to 2.2 billion tons per year [3].

The increase in generation of MSW generates numerous social, environmental and economic impacts. The environmental impact of MSW is particularly significant in terms of air pollution, water and soil contamination, and also climate change [3]. Improper waste management practices such as waste transportation, collection and sorting, open dumping and landfill, and burning of waste are major sources of pollution and greenhouse gases emissions [4]. Moreover, additional direct and indirect social impacts exist in terms of healthcare and food security impacts. According to the Food and Agriculture Organization (FAO), one third of the food produced worldwide is wasted [5]. Management on MSW is also considered to hugely affect economic development in terms of cost and financing. For example, in Asia, governments spend about US\$ 25 billion each year on waste management, and this figure is estimated to double by 2025 [6].

Considering the diverse impacts of MSW and the rapid increase of its volume, several studies have found that in many countries, particularly in low and middle income countries, waste management is poorly implemented. As presented by the United Nations Environment Program (UNEP) and the International Solid Waste Association (ISWA), in Asia the average waste collection coverage is only between 50 % to 90 % [4]. Furthermore, between 30 % to 60 % of MSW is not collected, and uncontrolled dumping or open burning of waste has become the norm in many developing countries [7]. In this regard, implementing sustainable management solutions related to MSW issues is very important.

The "3Rs concept" (Reduce, Reuse, and Recycle) has been promoted and implemented in many countries during the last decade. However, its success is constrained by lack of State regulation and enforcement, as well as limited stakeholder participation [8]. Similarly, the Integrated Sustainable Waste Management (ISWM) concept was developed to address some issues of municipal waste management in low and middle income countries [9]. Nevertheless, some questions remain in terms of financing as applying appropriate technology requires huge investment [7].

In the case of Thailand, while total waste generation of the country was 27.06 million tons in 2016, 4.20 million tons were generated in Bangkok [10], a very rapid growth from the 3.2 million tons reported for 2009 [11]. In this regard, 87 % of waste collected by The Bangkok Metropolitan Administration (BMA) is disposed of through landfills, while only 10 % is composted and 3 % incinerated. This leads to problems not only in terms of increasing MSW volume requiring additional space for landfill, but also many potential social and environmental impacts [12]. The impacts of waste are long term issues, but in the case of Bangkok some studies suggested that improvements are

needed in terms of quality of service [13], information of population on recycling [14-15], and stakeholders inclusion [13, 16]. Assessing the sustainability of waste management in Bangkok is therefore a necessity in order to identify long term solutions.

To conduct this research, wasteaware indicators were found appropriate as they are designed to be applied in any city, independently of its level of development. The Wasteaware indicators approach covers all aspects of Integrated Solid Waste Management (ISWM), in terms of both physical components and governance [17]. Thus, the objective of this research is to evaluate the sustainability of MSW management performance of BMA by applying wasteaware benchmarking indicators to identify local strengths and to prioritize the key issues that need to be addressed. This research provides a full dataset related to waste collection, recycling, disposal, inclusivity, financial sustainability, sound institutions and proactive policies. This could be used for decision making related to new policies or enhancement of waste management of the city.

Materials and methods

1) Wasteaware benchmarking indicators

This study used qualitative methods, applying wasteaware to benchmark Bangkok in terms of the sustainability of MSW management. The wasteaware indicators were developed in 2012 and 2013 by researchers from multiple institutions, with the support of GIZ and the German Federal Ministry for Economic Cooperation and Development [17]. The objective of Wasteaware indicators is to provide a single comprehensive tool to benchmark and compare cities or municipalities in terms of ISWM performance, regardless of their level of development. Wasteaware indicators provide information to support decision-making by providing a synthesis of the strengths and weaknesses of MSW management systems.

Wasteaware indicators help to prioritize key issues requiring improvement and also are useful in monitoring changes over time.

Wasteaware is based on previous indicators developed by UN-HABITAT on the “State of solid waste management in the world cities”, which allowed a comparison of 22 cities from developed and developing countries [2]. Wasteaware developers revised the UN-HABITAT factors in order to improve the analysis. New tools have also been developed to facilitate analysis, and a simple yet efficient “traffic lights” coding has been implemented to present results [17]. Wasteaware is based on the ISWM framework, which characterizes 3 dimensions of solid waste management system. One is the physical system, the second is sustainability criteria, and the third is stakeholder involvement. The system was later simplified and categorized into two components which are physical and governance aspects. The physical component focuses on three main drivers of waste management related to public health, environmental protection and resource value (3Rs). The governance component focuses on inclusivity (government strategies for waste management and stakeholder involvement), financial sustainability (to ensure that SWM services and activities are affordable and cost-effective), and sound institutions. This tool is designed to be specifically applicable to cities in all countries, irrespective of income levels.

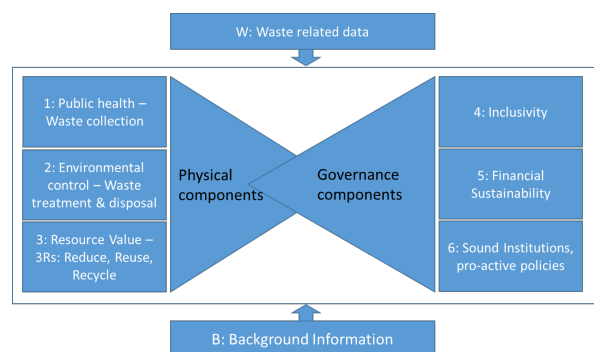


Figure 1 The ISWM framework used by Wasteaware indicator set.

2) Data collection

The data for wasteaware indicators were collected mainly through in-depth interviews with BMA representatives and secondary sources. However, for some indicators, self-survey or site observation were used to support assessments. The interviews with BMA were performed three times during June 2016 to January 2017. A semi-structured questionnaire was prepared in advance, in order to systematically cover all the criteria necessary for wasteaware analysis. Before developing questionnaires, all wasteaware indicators were studied using detailed guidelines contained in the wasteaware user manual. The list of Wasteaware indicators is presented in Table 1. Key information for wasteaware indicators were collected either through the interviews or secondary sources such as research papers and government reports, where such data were available.

3) Data analysis

The complete data were entered in an MS-Excel format developed by the wasteaware project. The scoring method was precisely applied, following wasteaware guidelines. The coding aimed at converting both the qualitative and quantitative data collected into 5 level “traffic lights” where low = red, low/medium = red/orange, medium = orange, medium/high = orange/green, and high = green. Coding instructions for each indicator were provided in the wasteaware manual. For quantitative indicators, the coding specified numerical ranges, expressed as a colour code. The manual also provided precise coding instructions for qualitative data.

Finally, composite indicators were calculated by adding the scores between 0 and 20 from several sub-indicators, For example 1C “Quality of waste collection and street cleaning service” was calculated by adding the scores between 0 and 20 of the 6 indicators used: $C = \sum_{i=1}^n S_i$ (where

C is composite score, S is sub indicator an n = number of sub-indicators in the composite indicator). A normalized score expressed in percentage was also calculated as not all composite indicators have the same number of sub-indicators: $N = (\sum_{i=1}^n C_i / 20n) \times 100$ (where N is normalized score). This percentage was then colour-coded as indicated in the manual.

Results and discussion

1) Background information on the city and key waste-related data

Thailand is considered as an upper-middle income economy country with a GNI per capita of US\$ 5,720, and a total population of 68,261,443 people [18]. The capital city, Bangkok, covers an area of about 1,568 km² and comprises 50 districts. According to the latest available statistics, the total registered population is about 5.7 million inhabitants, with an average population density of 3,625 persons km⁻² [19]. However, including non-registered inhabitants, the total population is estimated at 10.6 million people [20-21]. The city is administered by the BMA which is also responsible for MSW management, including collection and disposal. Currently, BMA has plans and strategies to improve waste management through a 5-year plan targeting a 7 % reduction in household waste by 2019, together with a 20 % increase in collection of household hazardous waste 2019. In addition, the plan calls for a 30 % improvement in waste treatment through technology innovation, compared to 2013. The 20-year plan has been implemented to promote a 20 % waste reduction and separation at source from 2013 to 2032, increase waste recycling or treatment to 50 % and reduce waste disposal through landfill by 50 % by 2032. BMA has also set a “Green Metropolis” policy to improve its waste management system to be more environmentally friendly, particularly through the use of clean technology.

In terms of waste generation, the city generates a total of 4.2 million tons annually of MSW [10]. This figure is based on a definition of solid waste which includes organic waste, recyclable waste, hazardous waste, and general waste [22]. In this regard, BMA collects approximately 10,130 tons of solid waste per day, equivalent 3.7 million tons per year. The current production of MSW per capita is about 1.09 kg d⁻¹. In terms of waste composition, the waste collected by BMA is composed of a large portion of organic waste (48.29 %), plastics (25.68 %) including both recyclable and non-recyclable plastics, and metals representing only 1.57 % of collected waste [23]. The waste density of MSW collected by BMA is estimated to 380 kg m⁻³ in average [24], while the moisture content is about 50 % to 60 % [25].

2) Physical components

In terms of “public health - waste collection”, Indicator 1 was used to quantitatively assess BMA waste collection coverage in Bangkok, which averages about 90 % [23]. This corresponds to a rating of medium/high (orange/green) under the wasteaware coding system. The waste collection service by BMA includes door-to-door and collection of MSW deposited at designated waste collection points. In terms of waste collected by the system, the rating is high as BMA claims that 100 % of the waste they collect is delivered to official waste treatment facilities.

The overall quality of waste collection and street cleaning service was evaluated to be average as per composite indicator 1C, with a normalized score of 50 %. Strongest elements were the efficiency and the effectiveness of waste transport. Despite photographic evidence revealing a lack of protection from windblown litter from trucks, BMA’s questionnaire response insisted that all MSW vehicles were fitted with adequate environmental protection equipment, and that transfer stations have sufficient capa-

city. The appropriateness of service planning and monitoring was also ranked as medium/ high compliance under the wasteaware criteria. 80 % of trucks are rented from the private sector, but waste collectors are employed by BMA, and monitoring procedures of MSW operation by private or public sector are under the responsibility of each district office as well as the BMA itself. Site surveys indicated that the appearance of waste collection points and the effectiveness of street cleaning could be ranked as average, both immediately and a few hours after waste collection, where evidence of littering or over-flow of bins could be seen in central Bangkok. In “low income districts” the situation seems to be more problematic, with a high observed incidence of accumulated waste, illegal dumping and open burning. BMA recognizes that in some cases very narrow streets does not allow door-to-door daily collection service. The health and safety of collection workers was also identified as a weak point, mainly due to the insufficient use of personal protection equipment by waste collectors, and lack of vaccinations.

Wasteaware benchmark indicators 2 and 2E were used to evaluate the degree of environmental protection of waste treatment and disposal processes in this study. Quantitatively, the degree of controlled treatment and disposal was rated as high; according to interviews and BMA published reports, all collected waste is disposed in controlled treatment facilities, being either controlled landfills (87 %), composting (10 %), and thermal treatment (i.e. incineration) (3 %) [23]. From a qualitative point of view, environmental protection of waste treatment and disposal was rated as medium/high, with a normalized score of 75 %. It has to be noted that optional criteria on efficiency of energy generation were excluded from the study, as implementation of waste-to-energy is still marginal in Bangkok. In regard to the degree of control over site management, the analysis

showed a medium/high ranking. The two main landfill sites apply an appropriate level of control over waste reception, and waste treatment systems use most required technologies such as access control, fencing, truck logging, compacting, leachate treatment and landfill gases (LFG) collection, as necessary. Design and operation of the sanitary landfills are in compliance with Pollution Control Department regulations and guidelines [26], and possess required operating permits. BMA reported that there is strong technical competence within BMA in the planning, management and operation of treatment and disposal facilities, and that appropriate safety procedures and equipment are in use at waste treatment sites. However, the literature review reveals potential for improvement in terms of supervision and

control by BMA. An Administrative Court case related to unsanitary operation of Rajatheva landfill in Samut Prakarn Province noted insufficient level of control from BMA [27].

Wasteaware indicator 3 showed a “low-medium” rating in terms of recycling rate. According to PCD, 0.48 million tons per year (1,315 tons d⁻¹) were recycled in Bangkok, excluding composting [10]. At the same time, 10 % of waste collected by BMA (10,130 tons d⁻¹) was composted in On Nuch district and 3 % was disposed of through thermal treatment at Nongkhaem, representing about 11 % of total waste. Based on this data, we can conclude that the recycling rate is about 23 %, while the national recycling rate is 21 % [10]. As per wasteaware manual, a range of recycling rate from 10-24 % is considered as low-medium.



Figure 1 Pictures showing (a) illegal dumping, (b) leftover waste after waste collection service, (c) waste accumulated at collection point, (d) overflowing bins.

Qualitatively, composite indicator 3R showed a medium quality of resources management under 3Rs – Reduce, Reuse and Recycle, with a normalized score of 42 %. The weakest element identified is 3R. (Integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system). Despite BMA's recognition of the importance of IRS, no programmes have been implemented to promote or upgrade the informal sector in order to encourage waste separation at source. Another weak point comes from the occupational health and safety related to recycling activities. According to field survey, IRS workers generally collect recyclable waste with their bare hands or with very limited protection. The source separation of "dry recyclables" is also not fully sufficient as (based on a household survey in Bangkok) less than 65 % of the population separate household waste at home. The quality of recycled organic materials is also rated medium. In Bangkok, segregation of food waste does not exist at household level but some commercial enterprises such as shopping malls, restaurants or canteens do separate and then sell it to farmers. However, a good level of separation is done at the composting facility, as both magnetic and manual sorting is done before composting. Room for improvement was also noted in terms of the focus strategies on the top levels of the waste hierarchy, which is to favour reduction, followed by reuse, and finally recycle [28]. BMA have policies and promotion activities related to reuse of second hand products, and a 5 year plan exists with a target to reduce household waste by at least 7 % by 2019 based on the principles of the 3Rs [21]. However, the lack of financial allocation for promoting the 3Rs is a key issue at district level, and waste generation continues to increase. Finally, environmental protection in recycling also received a medium score. The collection of recyclables and the collection of Waste Electric and Elec-

tronic Equipment (WEEE) is currently done by IRS. This is not well structured as it is implemented by independent operators. A regulation is currently under development to ensure private sector recalls their products after use, but this is not implemented yet. In terms of compliance with environmental regulations, bigger companies processing high value recyclable are satisfactory, but small junk dealers or recycle shops in Bangkok are not in a good condition nor environmental sound.

3) Governance factors

Indicator 4U was used to evaluate the level of user inclusivity in Bangkok solid waste management. Improvements are possible in this field, the rating being average with a normalized score of 42 %. Key issues identified include lack of equity in service provision, in particular in high density areas where a door-to-door collection service is not available. Also the effectiveness in achieving behavioural change is an issue, as despite BMA communication and actions, volumes of solid waste continue to increase, and the source recycling rate remains low. In terms of the right to be heard, public involvement, and public feed-back, the situation is ranked as average. A BMA hotline exists, but is not dedicated to waste and there is no evidence to indicate that this feedback influences future decisions. Also, the mechanisms to ensure full stakeholder participation in decision-making processes are for the most part, not in place. Finally, the activities promoting public education and awareness on waste are also ranked as average, since even where such activities exists, budgets are insufficient (only THB 20 million, or US\$ 580,000 for the last fiscal year); there is no budget allocation for the district office level.

In terms of provider inclusivity (indicator 4P), the situation is also ranked as average, with a rating of 50 %. One of the key issues identified in this part is related to the role of the informal

and community sector. Without clear cooperation, BMA allows IRS to collect hazardous waste independently. Also, no budget is allocated at district level to strengthen cooperation with IRS and communities. The Waste-aware analysis results indicated an average ranking regarding management of private operators (landfills, rental trucks, etc.). Some provisions exist within the legal framework, including the Public Health Act which allows municipalities to use the private sector to fulfil their statutory public duties in terms of waste management [29]. The regulation and guidelines of solid waste management also specify requirements for private sectors operators [26]. However, the bidding processes for selection of landfill operators is typically questionable [27] [30]. Also, formal representation of private sector stakeholders in waste-related decision making process is unclear.

Financial sustainability was then reviewed using indicator 5. The analysis showed a good result, with a normalized score of 71 %. The total cost of waste management in BMA was about THB 6,500 million (or over US\$ 184 million USD) in 2015, but asking the availability of budget to cover waste management of the city, BMA claimed to have sufficient funding both to maintain current level of service, and also ensure some improvements. However, subcontractors are typically selected on the basis of bid price than on quality criteria. These waste management costs are properly defined and independently audited. The coverage of disposal costs is satisfactory as BMA was paying from 438 to 535 THB per ton (US\$ 12-15) to landfill operators in 2014 [27]. This rate is considered sufficient as it was proposed by the operators themselves during the bidding processes. Composting is charged using a similar principle. In terms of recovery from households, a large part of Bangkok households pay waste collection fees, even though the amounts are considered low-household fee

collection covers only 7 % of total costs. Finally, access to capital investment was ranked as only average. Funds come mainly from BMA budget and the private sector, with no access to grants or other government investment. According to BMA, lack of funding acts as a serious constraint to extend service coverage. Overall, it seems that BMA spends heavily on waste collection and disposal, but only a limited budget is used to support 3Rs which can help reduce waste volumes.

The evaluation of the national solid waste management framework under indicator 6N was ranked as medium, with a normalized score of 50 %. Solid waste management is covered by several regulations, and the regulatory framework has recently been improved by the enforcement of a new National Cleanliness and Orderliness Act in 2017 [31]. An extended producer responsibility (EPR) regulation, forcing manufacturers to recall and recycle their products at the end of their useful life cycle is however, missing. Strategies and policies related to waste are in place, and a yearly action plan called "Thailand without waste" also exists for year 2016-2017 [32]. There are also some implementation guidelines for certain aspects of waste management, such as detailed actions for crisis provinces, or environmental impact assessment for waste treatment facilities [33]. However, guidelines on increasing recycling rates, extending collection services or improving environmental standards are lacking. Another issue is the lack of a single responsible institution in charge of implementing solid waste management policy, as responsibilities are shared between six different ministries [34]. This situation affects the regulatory control and enforcement capability at national and local levels.

Finally, evaluation of local institutional coherence, which analyzed the strength of BMA waste management functions, was performed following indicator 6L. A medium rating was

given, with a normalized score of 50 %. BMA’s organizational structure related to waste management is clear; however, responsibility is split between two departments. According to BMA, these departments are fully staffed with qualified personnel; however, no evidence was offered on this point. In terms of data collection, a management information system (MIS) is in place to measure the quantity of waste collected and treated daily. Waste composition is monitored monthly, but publication of data is typically subject to long delay: the latest publicly available datasets date from 2014. Control and supervision of service delivery are a mix of positive and negative elements. Timing and position of trucks are controlled by GPS and

by an online messaging system. However, another research study suggests that control over privately owned landfills by BMA is sometimes insufficient, citing an Administrative Court judgment blaming BMA for insufficient supervision of the operation of their contractor [27]. Finally, BMA declared that cooperation with government bodies in charge of MSW is good. However, cooperation with other government agencies is mainly on regulatory matters, rather than funding, control or enforcement issues. The overall results of the MSW management study based on Waste-aware indicators are summarized in Figure 3 and Table 1 below.

Wasteware indicators analysis for Bangkok

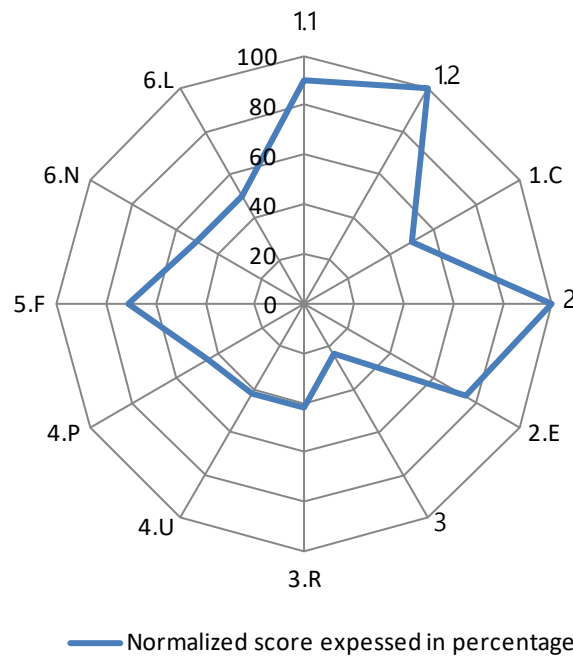


Figure 2 Radar graph summarizing wasteaware ISWM benchmarking indicators analysis for Bangkok.

Table 1 Summary of Wasteaware analysis on SWM in Bangkok

Background information on the city						
City		Bangkok				
Country		Thailand				
Date since previous application of indicators:			No known previous application of indicators			
B1	Country income category	World Bank income category	Gross National Income (GNI) per capita			
		<i>Upper Middle Income Economy</i>	5,720 USD			
B2	Population of city	Total population of the city	10,600,000			
B3	Waste generation	Total municipal solid waste generation (tonnes/year)	4200000			
No	Category	Data/ Benchmark Indicator	Results	Code		Progress
Key Waste-related data		Data		-	-	-
W1	Waste per capita	MSW per capita	kg per year	396	-	-
			kg per day	1.09	-	-
W2	Waste composition:	Summary composition of MSW for 3 key fractions – all as % wt. of total waste generated	-	-	-	-
W2.1	Organic	Organics (food and green wastes) %	48.29	-	-	-
W2.2	Paper	Paper %	12.14	-	-	-
W2.3	Plastics	Plastics %	25.68	-	-	-
W2.4	Metals	Metals %	1.57	-	-	-
W2.5	Solid waste density	Solid waste density	380	-	-	-
W2.6	Moisture content	Moisture content	50 to 60%	-	-	-
Physical Components		Benchmark Indicator	-	-	-	-
1	Public health – waste collection	1.1 Waste collection coverage	90			
		1.2 Waste Captured by the System	100			
1C		Quality of waste collection service	50			
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	100			
2E		Quality of environmental protection of waste treatment	75			
3	Resource Management – Reduce, Reuse, Recycle	Recycling rate	23			
3R		Quality of 3Rs – Reduce, reuse, recycle	42			
Governance Factors		Benchmark Indicator	-	-	-	-
4U	Inclusivity	User inclusivity	42			
4P		Provider inclusivity	45			
5F	Financial sustainability	Financial sustainability	71			
6N	Sound institutions, proactive policies	Adequacy of national solid waste management framework	50			
6L		Local institutional coherence	50			

Conclusions and recommendation

The study has revealed both strengths and weaknesses in Bangkok's MSWM system. Based on wasteaware analysis, some strengths were identified under physical components such as indicator 1.1 with a high degree of waste coverage, indicator 1.2 as all waste collected is

disposed through controlled treatment, indicators 2 and 2.E, with high degree of control and monitoring of environment protection in waste treatment facilities. Weaknesses identified under this component included those under indicator 1C with only an average quality of collection service as waste accumulation, illegal dumping

and overflow bins are sometimes found, particularly in high density communities, and Indicators 3 and 3R as recycling rate is low and 3Rs principles are not enough promoted. For the governance component, indicator 5F revealed a strength, as BMA claimed to have sufficient budget to maintain the current level of service delivery. However, negative elements were noted for indicators 4U and 4P, as users are insufficiently included or consulted in waste management decision making, and cooperation between the formal and informal sectors was found to be inadequate. Another significant issue was also identified in indicators 6N & 6L, as there is no single institution controlling waste management and regulations such as EPR.

To sum up, it is interesting to note that while BMA claimed to have sufficient financing on waste management, the amount of MSW of the city has increased each year with no increase in manpower; this could eventually affect the financial sustainability of the collection and disposal service. This research found that several aspects of waste management could be potentially improved by the following means:

- *Enhance implementation of 3Rs and recycling rate.* To broaden adoption of 3Rs and increase waste recycling rate within the city, one of the most important elements is to enhance waste segregation at source. In this regard, more focus should be given at district and community levels to training and increasing public awareness of the need for, and how to segregate wastes through activities, traditional media and social media. Long term education programmes for the younger generation are key to the success of such efforts.

- *Enhance the quality of user and provider inclusivity.* This research found that IRS plays a central role in waste collection, transport and processing of recyclable waste in Bangkok. Therefore, enhancing integration among municipal waste services and IRS is very important. In this regard, implementing a clear regulatory

framework related to the role, rights and obligations of IRS could help address the current constraints.

- *Enhance quality of waste collection service.* In several areas of Bangkok, waste accumulation, overflow bins, or illegal dumping are frequently found, particularly in low-income, high population density areas. A focus should therefore be given to such areas either by providing a regular collection service or giving more communities containers within walking distance as this would encourage people to dump their waste at collection points. Additional budgets should also be allocated for waste collection in these areas. To complement these interventions, there is a need to build enhanced public awareness on waste related issues at community level by promoting the 3Rs, and by providing more information about the adverse impacts of waste through community activities. Such interventions would help not only to reduce illegal dumping through peer pressure and social sanctions but also to enhance waste separation at source which would lead to a better collection and facilitate waste management.

- *Strengthen waste management-related institutions and the regulatory framework, both at local and national levels.* Empowering a single national institution to supervise all waste management related issues and enforce regulations may help in developing, applying and enforcing coherent plans and regulations. Furthermore, improving the regulatory framework to involve the private sector in waste management could also contribute to improved recycling levels and more cost-effective management of the country's solid wastes.

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