ASSESSING SUSTAINABILITY OF MUNICIPAL SOLID WASTE MANAGEMENT IN BANGKOK, THAILAND

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ปัจจุบันการเพิ่มขึ้นของปริมาณขยะมูลฝอยนับเป็นปัญหาสิ่งแวดล้อมที่ส่งผลกระทบต่อการพัฒนาที่ยั่งยืนทั้งมิติสังคม เศรษฐกิจและสิ่งแวดล้อม งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาประสิทธิภาพการจัดการขยะมูลฝอยชุมชนในเขตกรุงเทพมหานครของประเทศไทย โดยประยุกต์ใช้ตัวชี้วัด Wasteaware Benchmark ซึ่งถูกใช้อย่างแพร่หลายในระดับสากล และการสัมภาษณ์เชิงลึกกับผู้มีส่วนได้เสียในการจัดการขยะมูลฝอย รวมถึง การใช้แบบสอบถามเชิงโครงสร้างในการสำรวจปัจจัยที่มีผลต่อการลดและคัดแยกปริมาณมูลฝอยระดับครัวเรือนในเขตกรุงเทพมหานคร (n=1,076) ผลการศึกษาพบว่าการจัดการขยะมูลฝอยในภาพรวมของกรุงเทพมหานครมีความเหมาะสม อย่างไรก็ดี การขาดการบังคับใช้กฎหมายและระบบการจัดการและบริการเก็บขนขยะที่มีประสิทธิภาพ รวมถึง ขาดการรณรงค์เรื่อง 3Rs อย่างทั่วถึงนับเป็นจุดอ่อนสำคัญของการจัดการขยะมูลฝอยของกรุงเทพมหานคร อีกทั้ง การพิจารณาถึงการจัดสรรงบประมาณและลดต้นทุนการจัดการขยะมูลฝอยนับเป็นประเด็นสำคัญในเชิงเศรษฐศาสตร์ นอกจากนี้ ผลสำรวจครัวเรือนตัวอย่างพบว่าพฤติกรรมการคัดแยกขยะ ความรู้และความชำนาญในการคัดแยกขยะ พื้นที่จัดเก็บ ความไม่เชื่อมั่นในระบบเก็บขนและความรู้ทั่วไปเกี่ยวกับขยะมูลฝอยนับเป็นปัจจัยสำคัญที่ส่งผลต่อความตั้งใจในการคัดแยกขยะจากแหล่งกำเนิดของประชากรกลุ่มตัวอย่าง

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BOKHAM CHANHTHAMIXAY: ASSESSING SUSTAINABILITY OF MUNICIPAL SOLID WASTE MANAGEMENT IN BANGKOK, THAILAND. ADVISOR: SUJITRA VASSANADUMRONGDEE, Ph.D., CO-ADVISOR: SUTHIRAT KITTIPONGVISES, Ph.D., 179 pp.

The significant increase of waste volume causes numerous impacts on several aspects of sustainable development including social, economy, and environment. This research aimed at investigating the effectiveness of municipal solid waste management in Bangkok by applying Wasteaware indicators. Structured questionnaires were used for in-depth interviews with key stakeholders. The data was analyzed using Wasteaware datasheet under Microsoft Excel with score coding. In parallel, this research investigated factors that influence public participation intention in terms of waste separation at source, using random sampling method among Bangkok population (n=1,076) and logistic regression for data analysis. The overall assessment demonstrated the appropriate management on waste treatment and disposal of Bangkok which are found to be positive points. However, the lack of effective regulation enforcement related MSW management, the efficiency of waste collection services, and the insufficient promotion of resource management are identified as key weak points. In terms of financing sustainability, some improvements are needed to reduce disposal costs particularly on the promotion of 3Rs. Apart from waste management issues, the analysis result on households survey showed that the current behavior at home or at workplace, knowledge on how to separate waste, available space, subjective norm, mistrust in the MSW service, and general knowledge about waste are the key factors influencing waste separation intention among Bangkok population.

Field of Study: Environment Development and Sustainability
Student's Signature .....
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1. Introduction

1.1. Background and Statement of the Problem

According to the United Nations, the urban population has been significantly increasing from 746 million in 1950 to 3.9 billion in 2014. Moreover, urban population now represents more than 50% of the world population (United Nations, 2014). At the same time, the economic growth in cities combined with the increased population generates higher demand for goods or productions, and therefore municipal solid waste (MSW) generation.

MSW is defined differently depending on sources, but 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" (UN-Habitat, 2010). According to World Bank (2012), the global volume of MSW was about 1.3 billion tons annually but estimated to rise almost twice (2.2 billion tons per year) by 2025 (Hoornweg and Bhada-Tata, 2012).

The significant increase of MSW generates numerous impacts on environment, social, and economy. The impact of MSW is particularly significant on the environment in terms of air pollution, water and soil contamination, but also climate change (Hoornweg and Bhada-Tata, 2012). The burning of waste or waste management activities such as; waste transportation, collection or sorting, including open dumping and landfills are sources of pollution and greenhouse gases emission (ISWA, 2015). Moreover, additional direct and indirect social impacts exist in terms of healthcare and food security issues. According to the Food and Agriculture Organization, one third of the food produced worldwide is wasted (FAO, 2014). Management on MSW is also considered to hugely affect economic development in terms of cost and financing. For example, in Asia, governments have spent about USD 25 billion each year on waste management, and this figure is estimated to be double by 2025 (World Bank, 1999b).

Considering the diverse impacts of MSW and the rapid increased of its volume, some studies found that in many countries, and in particular in low and middle

income countries, waste is not fully well managed. As presented by the United Nations Environment Program (UNEP) and the International Solid Waste Association (ISWA), in Asia average waste collection coverage is only between 50% to 90% (ISWA, 2015). Furthermore, between 30% to 60% of MSW is not collected, and uncontrolled dumping or open burning of waste become the norm in many developing countries (World Bank, 2016b). In this regard, implementing sustainable management solutions related to MSW issues is very important to ensure waste reduction. In a global scale waste issue is mentioned in Sustainable Development Goals (SDGs), especially in the goal 12: *'Ensure sustainable consumption and production patterns'*, stating that waste per capita should be reduced by half by 2030. Also, SDGs insists on the necessity to reduce waste impacts on environment and human health following international framework by 2020, and emphasizes on waste reduction through the implementation of 3Rs concept by 2030 (United Nations, 2015).

The "3Rs concept" which is reduce, reuse, and recycle has been promoted and implemented in many countries during the last ten years, including Thailand. The objective of 3Rs concept is to propose a sustainable solution to waste management by defining priorities between potential actions (UNCRD, 2009). However, several gaps appears during management processes, including insufficient government regulations concentrating on 3Rs practices, and also limited participation from all stakeholders such as local residents (Visvanathan, Adhikari, and Prem Ananth, 2007).

Similarly, the Integrated Sustainable Waste Management (ISWM) concept was developed to address some issues of municipal waste management in low and middle income countries (Van de Klundert and Anschutz, 2001). However, some questions remain in terms of financing as applying appropriate technology requires huge investment (World Bank, 2016b).

In this regard, several studies suggested that apart from waste management itself, public is a key stakeholder that play a central role in waste reduction by practicing in waste separation at sources. Therefore, understanding factors that influence people intention and behavior related waste issues is very important. To study social behavior and intention, some theories were applied in many researches. The Theory of Planned Behavior (TPB) which was introduced by Ajzen in 1985 has then been applied as a psychological theory to understand human pro-environmental behaviors such as

predicting separation or recycling behavior (Ajzen, 1991). Ajzen identified that human behaviors are influenced by their intentions which are coming from attitude towards behavior, but also subjective norm, and Perceived Behavior Control (PBC). Thus people who have higher intention on something are more likely to perform their behavior (Ajzen, 1991). However, some elements of analysis are missing in TPB. Matthies's Comprehensive Norm Activation Model was then applied also to have a deeper understanding of people behavior in terms of habit, as well as an understanding of social norms in general, and not only external norms related to surrounding people important for them (Matthies, 2005).

1.2. Significance of the Study

Due to the significant increase of waste volume together with its numerous impacts on social and ecological environment, Thailand is not an exception facing the rapid increase of MSW issue. According to the Pollution Control Department (PCD) report on "State of municipalities solid waste of Thailand 2016", the national MSW generation is about 27.04 million tons in 2016 (74,073 tons/day) which increased by about 190,000 tons or 0.7% from 2015 (Pollution Control Department, 2016b). In this regard, Bangkok is one of the main contributors of those waste. Bangkok is the capital of the country with the rapid economic and population growth. There are currently about 5.7 million people (this is not including non-registered population) and approximately 2.6 million households in Bangkok metropolis area (BMA, 2013). In 2016, the total MSW generated in this city is about 4.20 million tons (Pollution Control Department, 2016b). This figure demonstrated that MSW in Bangkok has significantly increased as it was only about 3.2 million tons in 2009 (Pollution Control Department, 2009b). Facing the rapid rise of MSW in this city and its potential impacts on both social and ecological environment (Sukholthaman and Shirahada, 2015), the Bangkok Metropolitan Administration (BMA) reported that only about 10,130 tons of waste is collected per day or approximately 3.6 million tons per year. Furthermore, only 10% of the waste collected is composed and 3% is disposed through thermal treatment, while 87% is disposed through sanitary landfills (BMA, 2016). This induces problems not only in terms of the diminishing surface of landfills but also numerous potential social and environmental impacts in the long term (Sukholthaman and Shirahada, 2015). In this regard, to improve waste management situation, it is very important to study the current performance of MSW management in Bangkok, as several studies suggested that some improvements are needed in terms of quality of service (Sukholthaman, Chanvarasuth, and Sharp, 2015), information of population on recycling (Challcharoenwattana and Pharino, 2016; Ittiravivongs, 2012a), and stakeholders inclusivity (Muttamara and Leong, 2004; Sukholthaman et al., 2015). In parallel, to enhance waste management of the city, some papers found that population is a key stakeholder that play an important role in waste separation and recycling at source

which can help not only to mitigate MSW volume but also to reduce waste management costs (Ittiravivongs, 2012a; Sukholthaman et al., 2015).

Thus, this research aimed at assessing in parallel the sustainability of MSW management of BMA by applying Wasteaware benchmarking indicators, and investigating the key factors that influence waste separation intention among Bangkok population.

1.3. Objective of the Study

This research was composed of two main objectives as follows:

- To assess the effectiveness of MSW management of BMA using "Wasteaware" benchmarking indicators to obtain a comprehensive measurement of the situation of MSW management in Bangkok, Thailand.
- To investigate factors that influence household waste separation intention of Bangkok residents.

1.4. Scope of the Study

- This study focused on sustainability concepts related MSW management under Integrated Sustainable Waste Management framework.
- Wasteaware benchmarking indicators were applied using all criteria in order to assess sustainability of BMA solid waste management.
- This study also emphasized on the keys relevant factors influencing public participation in terms of waste separation at sources.

Thus the main stakeholders of this study were selected and separated into two groups which are BMA officers and Bangkok residents.

2. Literature Reviews

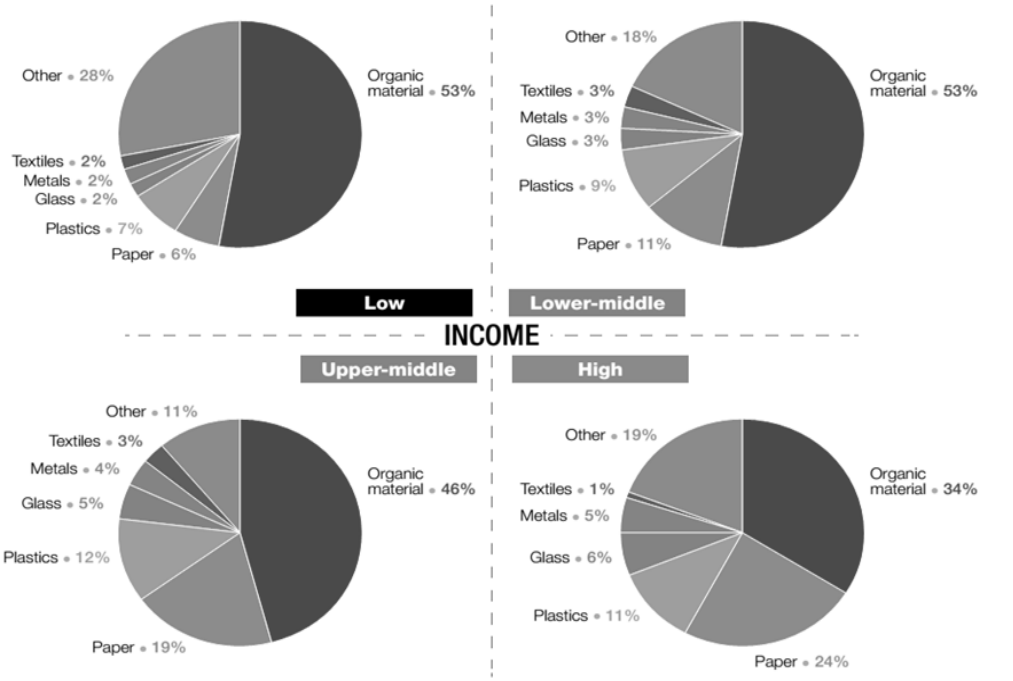
2.1. Municipal Solid Waste

The term of municipal solid waste (MSW) is normally applied to multiplex collection of waste generated in the city areas (UNEP, 2005). The exact definition of MSW is varies depending on sources and counties. However, the United Nations Human Settlements Program (UN-HABITAT) referred MSW 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". It also includes most commercial and business wastes, but excluding industrial process and other hazardous wastes. However, some sectors generate both MSW and other hazardous wastes at the same time. For example, hospitals generally generate at the same time hazardous waste, but also MSW through the use of equipment in the offices such as papers and food waste from employees or canteens(UN-Habitat, 2010).

The segmentation of MSW also differs between countries but generally MSW includes papers and cardboard (such as books, newspapers, magazines, so on), food or organic and kitchen waste, yard trimmings or leaves and wood, rubber or leather and textiles, plastics, metals, and others (EPA, 2012). Another study suggested that MSW is usually separated into four types, mainly organic waste, general waste, recycle waste, and hazardous domestic waste (Sukholthaman and Shirahada, 2015). However, when it turns into waste management process, MSW can be divided into three main groups which are composting waste (basically food waste or organic waste), landfill (general waste but particularly non-recycle waste), and recyclable waste such as recycle plastic, metal, glass, etc (BMA, 2014a).

The composition of MSW is different from place to place. This is depending on national or city living standard. According the Global Waste Management Outlook report, in low-middle income countries, the amount of organic waste is very high, in average between 46 to 53%; meanwhile there is only 34% in high income countries. On the contrary, the quantity of paper waste is much higher in high income countries

(24%) while it is between 11% to 19% in middle income countries and only 6% in low income countries. Other wastes are also differing depending on the income level of the countries as shown on figure below (ISWA, 2015):



Note: Based on data from 97 countries (22 in Africa; 14 Asia-Pacific; 35 Europe; 19 Latin America/Caribbean; 2 North America; 5 West Asia). Dates of the data vary from 1990 - 2009. "Other" means other inorganic waste

Figure 2. 1: Variation in MSW composition grouped by country income levels
Source: Adapted from International Solid Waste Association

The rapid economic expansion and the urbanization, together with the significant increase of population, are considered as the main drivers leading the increase of demand for food and other products and therefore waste generation. In the Asia-Pacific countries, the population represents over 60 % of the total world population, and urban population is particularly high. Several aspects lead people to increasingly move to the cities, inducing a rapid growth of urban population, at a rate of about 2.3% each year. In this regard, the global amount of MSW has strongly risen as stated by the World Bank in 2012; the global generation of MSW is approximately 1.3 billion tons annually or 1.2 kg per day per capita. However, MSW volume is estimated to be almost twice in 2025 (around 2.2 billion tons per year) with the expected generation rate per capita at 1.42 kg per day (Hoornweg and Bhada-Tata, 2012).

In Asia, MSW generation is particularly significant in cities areas. The level of MSW generation is about 760,000 tons per day but estimated to grow to 1.8 million tons per day in 2025. This signal is not only showing potential negative impacts on environment, but also on the economic development of the countries. According to the same report, MSW management represented a cost for city areas in Asia of approximately USD 25 billion annually. It is furthermore estimated to be double in 2025 (World Bank, 1999b).

For years, waste problem has become more and more serious creating numerous issues on environment and human well-being. MSW issue is also a huge challenge affecting many aspects of the development of the country, especially on the three dimensions of sustainable development; environmental, social, and economic. While the volume of MSW has been increased dramatically, waste is not really well managed as less than 70 percent of waste are collected in least developed countries. Furthermore, over 50 per cent of waste collected is disposed by open dumping or uncontrolled landfills and 15 per cent of waste are often recycled but with unsafe processes. However, establishing a good infrastructure or waste facilities in order to handle with MSW issue requires a huge investment both in terms of technology, but also management costs (UNDESA, 2012).

In the case of Thailand, the total waste generation of the country was 27.06 million tons in 2016. Besides, 4.20 million tons were generated in Bangkok (Pollution Control Department, 2016b). According to BMA, 87% of waste collected are disposed through landfills, while only 10% is composed and 3% is treated through incineration (BMA, 2016).

2.2. Impacts of Municipal Solid Waste

2.2.1. Environmental Impacts of MSW

The impacts of MSW on the environmental are several, but mainly on air pollution, water pollution and soil pollution. In addition, impacts of MSW on Climate Change Issue are also serious as follows:

- *Air Pollution*

One of the main sources of air pollution from MSW is linked to the burning of wastes. In most developing countries where waste-collection services are either not available or expensive, people burn their solid waste to get rid of it. Municipalities also often do the same, and burns them in open air. The first type of air pollution released by burning MSW is particulate matters (PM). A study made in Korea in 2013 stated that among the components of MSW burned, plastics generate particularly high emissions in terms of large PM (PM10), while burning paper has a higher impact on small PM (PM2.5). The same study also emphasized on the release into the air of heavy metals. Among the components of MSW, the burning of plastics releases the largest quantities of heavy metals (Park, 2013).

A significant impact on air pollution also comes from the transport of MSW. In particular, solid waste collection requires a large number of trucks in the cities, which brings additional transport related air pollution. Apart from greenhouse gases, the main air pollutants generated are particulate matters as well as nitrogen dioxide and carbon monoxide (Kirby, 1995)

Moreover, landfills themselves are also a contributor for air pollution: The degradation of MSW in landfills produces gases known as landfill gases (LFG), which are composed for more than half of methane, as well as carbon dioxide (CO_2), which are not direct air pollutants but was reviewed in the climate change impacts part. However, LFG also have some direct impacts on air quality as it contains in smaller quantities of other dangerous components, including non-methane organic compounds (Saquing et al., 2014). Depending on the type of gas generated, LFG have therefore an indirect effect either on environmental security, by contributing to global warming or

ozone depletion, or simply a direct effect on environmental and health security, when dangerous gases are inhaled by communities living next to landfills (Parizeau, 2014). In addition, landfill fires or explosions are common incidents, releasing high levels of hazardous gases. A huge fire in an abandoned landfill is Samut Prakan in 2014 was particularly significant example, with large emissions of sulphur dioxide and carbon monoxide (Frederikson, 2014).

- *Water and soil pollution*

Water is one of the most essential elements for all living organisms, especially for human being. Water pollution generated by MSW becomes bigger and bigger issue. In many cases, and in particular in developing countries, the MSW are kept in landfills and un-controlled dumping sites next to urban areas, and next to groundwater sources used by the population. The MSW is slowly decomposing in such sites and would ultimately contaminate the groundwater located below. At the same time, the water from rain running through solid waste gets contaminated and becomes leachate, which if not collected would further contaminates the soil and water. As an example, a recent study made in India next to an urban dumping side revealed levels of groundwater contamination well above the WHO maximum recommended. In terms of sulphates, the concentrations were in average 261.63 milligram per liter (mg/l) while the maximum WHO recommendation is only 150 mg/l. For nitrate contamination, the situation was even more worrying, with concentrations of 42.89 mg/l while WHO limit is 10 mg/l. The same goes for calcium hardness and magnesium hardness, with values far above WHO standards (Abdullah, 2012).

Also, the uncontrolled disposal of MSW in urban areas has a tendency to clog the wastewater drains. This is causing the water to stagnate in urban area, deteriorating the quality of the water, and generating health issues reviewed in next chapters. Furthermore, the linkage between MSW accumulation in urban areas and flooding is also noted in literature, as MSW will prevent the proper drainage of water in urban areas. (ISWA, 2015; UN-Habitat, 2010). This type of contamination is a significant factor inducing insecurity for communities living in those areas, as the consumption of contaminated water will directly affect their health, and can even compromise the

possibility to continue to live in affected areas, as no human life is possible without access to water.

Finally, significant levels of soil contamination are also to be taken into account, affecting both natural environment and human health. In particular, it has been demonstrated that MSW landfills are a major contributor to heavy metals pollution of the soil. Heavy metals are considered as a particularly dangerous pollutant as they are very persistent and toxic, and can damage human health as they accumulate in various organs in the body and cannot be eliminated. Depending on the type of heavy metal, kidney, liver, bones or brain can be affected. The risks of cancer are also significantly increased. (Adriano, 2001) In a study made in China next to landfill sites, very high levels of contamination by copper (Cu) and zinc (Zn) were noticed, confirming a long term contamination of the soil potentially affecting human health(Long, Shen, Wang, Lu, and Zhao, 2011).

Figure 2. 2: Groundwater contamination from a waste disposal site
Source: Canadian Environment Agency, 2014

- *Impacts on climate change*

MSW generates some significant direct and indirect impacts on climate change, mainly because of emission of two major of greenhouse gases (GHGs), which are methane (CH_4) and carbon dioxide (CO_2). According World Bank (2012), MSW

accounts for almost 5% of GHG total emissions on a global scale (Hoornweg and Bhada-Tata, 2012). As presented before, the first source of GHGs comes from the anaerobic decomposition of organic materials in landfills. Main components of LFG are CH_4 (50 to 55%) and CO_2 (45 to 50%). CH_4 is a particularly serious issue, as it is considered as 25 times more potent than CO_2 in terms of global warming potential (USEPA, 2015).

The incineration of waste also generates CO_2 emissions, even if the latest technologies such as gasification and pyrolysis presents lower emissions than previous technologies (UNEP, 2010)Also the burning process of MSW produces not only air pollution as mentioned before but yet greenhouse gases emission such as CO_2. This is the second largest source of GHG from solid waste just after landfills, and generated around 40 Mt CO_2-e in 2007, even if the latest technologies such as gasification and pyrolysis presents lower emissions than previous technologies (UNEP, 2010). Finally, other steps of the MSW management process have an impact through the release of GHGs. This includes the transport of MSW by trucks emitting CO_2, or the industrial processing of material recovery, aluminum smelting process also emitted Perfluorocarbons (PFLs)(Swenson, 2007). Moreover, organic waste or landfill are not only the main source of methane but also nitrous oxide (NO_2) particularly from the use of organic fertilizer and the combustion of solid waste (UNEP, 2010).

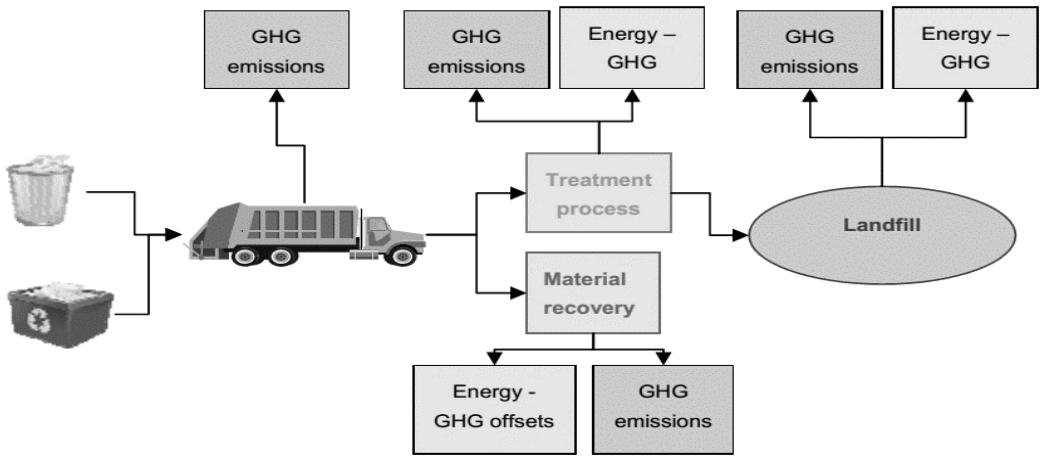


Figure 2. 3: Simplified schematic of waste management system and GHG emissions (applicable to urban waste management).
Source: United Nations Environment Programme

2.2.2. Social Impacts of MSW

From the description in the previous parts, MSW generates numerous impacts on environmental and therefore human well-being. The impacts of MSW on human or social are particularly significant on health issue through several diseases and also food security which will be described as follows:

- *Health effects related to direct contact with MSW*

In most developing countries, MSW is seen as a source of revenue for the poor, and the most vulnerable parts of the population. All over the third world countries, human beings are searching in the waste for materials which can be used or sold. This can take various forms, from collection of plastic and metal waste in the streets to direct collection on open air landfills. But the risks associated with MSW collection activity dramatically increase their health insecurity levels.

MSW from un-controlled landfills often contains dangerous materials such as lead-acid batteries causing burns, gas containers or cathode ray tube from old TV sets which can explode, or pesticide and chemicals which can generate poisoning, to cite only a few. Several studies showed that the effects on human health on these

populations are particularly significant, and include a wide variety of illnesses. As an example, a study made in Argentina on street recyclers showed a huge variety of health pathologies including respiratory issues, wounds and infections, digestive issues, cancers, etc. On top of physical issues, such populations also suffers from serious psychological affections such as depressions and anxiety (Parizeau, 2014). Another study made in Mexico showed a very important prevalence of Toxoplasma Gondii (a parasite infection weakening the human immunity system) within waste pickers. According to this study, more than 20% of the waste pickers' panel was infected. The study considers that one of the most common infection routes is by eating food products from the MSW. (Alvarado-Esquivel et al., 2008).

Moreover, not only people working with a physical contact to MSW are affected. The proximity to landfills can produce an added health insecurity too. As noted in a study made in 2000 in the U.K. on a population living next to a landfill, significant levels of babies with congenital malformations have been reported (Fielder, 2000).

- *Propagation of diseases through rodents and insects*

Another direct effect of the improper dumping MSW is the proliferations of several types of animals such as rodents, cockroaches and mosquitoes which feeds on the MSW and are vectors of specific diseases.

A case study made in Palestine in 2007 showed the link between the accumulation on MSW in the streets and the increase of rodents and mosquitoes populations, as rodents tend to feed and live in residual MSW, while mosquitoes benefit from stagnant water to proliferate (Al-Khatib et al., 2007). The effect of the proliferation of mosquitoes on health security is particularly significant. Increase of mosquito population due to MSW has a direct impact in the propagation of major diseases, including malaria, dengue fever, chikungunya and several types of encephalitis. Malaria is a particularly huge issue in many third world countries. According to WHO, malaria killed around 627,000 people around the world in 2012, and is transmitted by mosquito bites (WHO, 2014a). Dengue, although more seasonal,

is also a major issue in developing countries in Africa and Asia Pacific. Also according to WHO, dengue affects 50 to 100 Million people every year in the world, including over 500,000 cases of severe dengue requiring hospitalization, leading to death in 2.5% of cases (WHO, 2014b). The proliferation of rodents also plays a role in the spread of a large number of diseases either directly (through the bites of rodents) or indirectly (spread of parasites, water contamination by rodents' excrements, etc.). To cite only a few, deadly diseases such as plague can be spread through bites of rodents, or a contact with a dead animal. But some serious diseases such as rat-bite fever, leptospirosis or salmonellosis can be transmitted even more easily, by the consumption of water contaminated with fences or urine of such rodents (CDC, 2014).

- *Impacts of MSW on Food Security*

According to the Food and Agriculture Organization (FAO), one third of the food produced worldwide is wasted. At the same time, more than a billion people around the world suffer from hunger (FAO, 2014). There is therefore a direct linkage between food waste and food security, as part of this waste could be used to reduce food insecurity, for example through donations.

As stated before, a very significant part of MSW is composed of food waste, while part of it is still perfectly appropriate for human consumption. In developed countries, huge quantities of food are wasted through the industry, retail, hospitality industry and even households. A study made in 2008 estimated the total value of wasted food in the United States to USD 165 Billion, main components being meat and fish, vegetables and dairy products. This loss represents almost 10% of the amount spent on food in the US (Buzby and Hyman, 2012). Another study made on the food industry in Switzerland estimates that the two thirds of the food would be totally avoidable. Properly edible food is discarded because of shelf-life regulations, quality requirement, production methods or even consumption habits (fruits and vegetables with unusual shapes are difficult to sell) (Betz, Buchli, Gobel, and Muller, 2014). Moreover, at the final stage of the food chain, such as in restaurants or in households, there is huge quantities of food losses occurring, which at the same time increases the volume of

MSW and reduces global food security. A recent FAO report showed that in industrialized countries, a large part of the food waste is generated at consumer level, with a particularly significant portion in North America (Gustavsson, 2011).

Being from production, transport, retail or households, reduction of Food Waste becomes however a necessity to improve human security, as it would have positive effects on many factors, by reducing the volume of MSW and its adverse effects, by increasing the food safety of many through donations, but also by reducing adverse effects of over-production of food supplies which are finally discarded without being consumed.

2.2.3. Economic Impacts of MSW

The first level of economic impact of MSW is mainly about financial or the cost to manage it. According to UNEP, the cost of MSW collection varies from USD 20 to USD 250 per ton depending on the income of the country, while the cost disposal varies from USD 10 to USD 200 per ton depending on the income of the country and the technology used (ISWA, 2015). Depending on the country and the city, the cost of MSWM represents USD 0.66 to USD 106 per capita per year. Even if this amount could seem very high, it however generally does not represent more than 0.5% of the Gross National Product (GNP) per capita (World Bank, 1999b).

Several indirect economic impacts of the MSW issue also exist. In some countries which relies a lot on tourism industry, non-proper management of the MSW can lead to a loss of revenue as a clean and beautiful cities can attract tourists. A study made in Barbados showed the impact of bad MSW management in a country where the tourism accounts for 50% of the GDP and the employment. The study demonstrates that tourists who visit the place for the first time and see garbage on the beaches are less likely to come back. The economic impact of MSW on Tourism sector is therefore direct, and an inadequate management of the MSW leads to economic losses for a major economic sector (Schuhmann, 2011).

In addition, the health issues presented in the previous sector does not only represent a social issue, but also an indirect economic impact. As an example, an outbreak of plague epidemic in India in 1994 caused by uncollected MSW had huge

economic consequences beside the 56 deaths. The total cost reached USD 2 billion losses, because of about 45,000 tourists who cancelled their trips to India, but also the suspension of the cargo shipments from India to foreign countries to avoid the propagation of the disease (ISWA, 2015).

2.3. Municipal Solid Waste Management and Sustainable Frameworks

2.3.1. Municipal Solid Waste Management

Municipal Solid Waste Management (MSWM) is about collecting solid waste in urban areas, and processing these waste using various available methods. MSWM is the main element in reducing the diverse impacts of MSW issue; unfortunately, as mentioned in the previous paragraph, in many developing countries and least developed countries, the MSW is not fully well managed. On the other hand, implementing a good MSW management system requires a huge investment. However, as suggested by International Solid Waste Association (ISWA), doing nothing or little can generate huge costs for the society and the economy (ISWA, 2015).

- *Waste storage and waste collection systems*

Waste storage is one of the main problems reflecting waste collection issue in many developing countries. Waste generated by households are usually stored in communal containers, but most of the time, waste containers are either low quality or not matching waste generation rate, leading to waste overflowing issue, thus attracting rodents, flies, and so on. This is not only creating a problem of uncollected waste, but also creating a source of diseases for nearby population, and particularly waste collectors by the direct contact during collection (UNEP, 2005).

Waste collection is generally separated into four types of systems: the first is communal collection, which means generator should put their waste in a community container; second is block collection, generators are required to put their waste into the truck or waste transportation during the collecting time; third is kerbside collection,

send out the container when it's full and bring back after; and the last is door-to-door collection, for this system, waste collector will go to collect waste directly in the containers of each house and waste generators are not required to participate in collection process (UNEP, 2005).

The services are usually provided to local and city scales with the use of several types of vehicles for example trucks, boats or bicycles. Some technologies such as GPS and GIS are also used in order to optimize the system of waste collection. The effectiveness of waste collection service is very meaningful, as one of the most important parts of waste management is to have a regular waste collection service emphasizing on 100% waste collection each time. However, the performance on waste collection is different between cities, and depends on national circumstances or living standard of the country. As presented by the GWMO, in most of low-income counties, the average coverage of waste collection services is about 36%, while in lower-middle countries is 64%, upper-income countries 82%, and developed or high-income countries is reaching 100% of waste collected in urban areas. But if concentrating on regional scale, the ranges on waste collection would be different. For example, in Asia average waste collection coverage is between 50% to 90% while in Europe is about 80% to 100% (ISWA, 2015). Another issue is that between 30-60% of MSW is not collected in developing nations; furthermore, more than 50% of population have difficult or no access to solid waste collection services (World Bank, 2016b).

The use of technology in a suitable way is also important. According to the United Nations Environment Program, a common issue related to waste collection service is the inappropriate use of technology. For example, the vehicles used for cities that are low density rate and good infrastructure may not suit the areas where population density rate is high or having poor infrastructure such as narrow roads. Moreover, having low quality equipment or poor vehicles can induce an insufficient performance, but also costly collection process both in terms of maintenance and fossil fuel use (UNEP, 2005).

- *Waste disposal*

MSW can be managed through several methods of disposal such as through landfills, thermal treatment, or dumping. However, waste disposal management in each country is not the same. This is also depending on income or economic status of the country, as in high-income countries waste is generally disposed through controlled landfills and thermal treatment while open dumping is common in low-lower middle income countries, or landfills that are poorly operated in many middle income countries (Hoornweg and Bhada-Tata, 2012).

A controlled waste disposal practice is one the key elements for enhancing MSWM. However, according to the World Bank, in many developing countries where considering cost of waste disposal is still high, wastes are usually disposed through uncontrolled process such as open dump or open burning. But the worst is that these kind of practices become a norm in many developing countries (World Bank, 2016b). Unlike in high-income countries where waste disposal management seems very controlled as shown in the figure below:

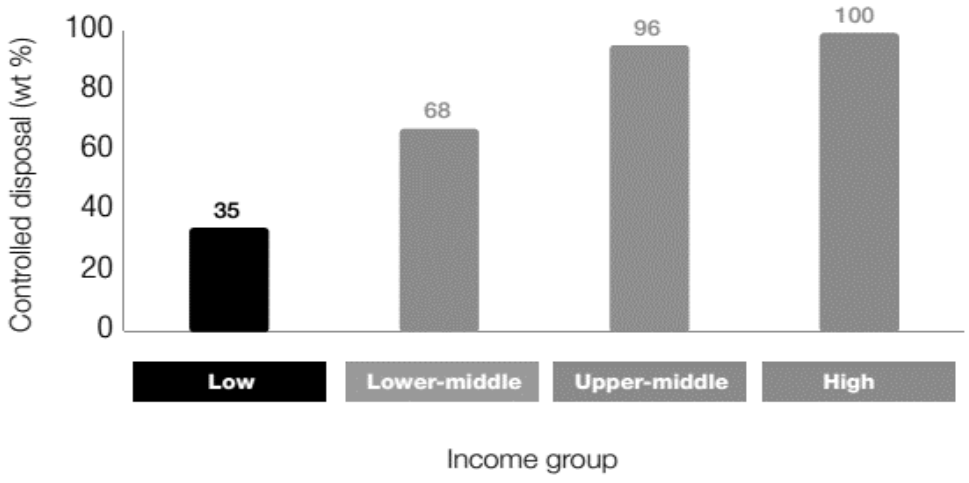


Figure 2. 4: Controlled disposal for selected cities by income level
Source: International Solid Waste Association, 2015.

2.3.2. Sustainable Solid Waste Management Frameworks

The terms of sustainable development or sustainability usually involves with the complexity of three dimensions which are social, economic, and environment (Brundtland, 1987). Sustainability can be applied to waste management. Sustainable MSW management concept usually refers to a system involving with minimizing waste, maximizing resources recovery, minimizing negative environmental impacts of the system, and maximizing its coverage (Manomaivibool, 2005). Moreover, sustainable waste management is part of the Sustainable Development Goals (SDGs). The SDGs were formally introduced at the United Nation Conference on Sustainable Development in 2012 (Rio +20). It is composed of 17 goals and 169 targets; it seeks to build a major improvement on the Millennium Development Goals (MDGs), and covers the integration and balancing the 3 dimensions of sustainable development: economic, social and environment. The term of sustainable consumption and production appears in the goal 12: *'Ensure sustainable consumption and production patterns'* which is directly related to waste issue. As stated on the 12.3, waste per capita should be reduced by half by 2030, and the point 12.4 focuses on environmental friendly waste management, and the reduction of MSW impacts on human health following international framework by 2020. Moreover, the point 12.5 insist on waste reduction through the implementation of 3Rs concept by 2030 (United Nations, 2015).

- *Reduce, Reuse, Recycle (3Rs)*

The 3Rs concept has initially be proposed during a Group of Eight (G8's) summit in 2004, with the head of state from France, United States, United Kingdom, Russia, Germany, Japan, Italy, and Canada. Five main initial objectives of the 3R Initiative were defined by the G8s (UNCRD, 2009).

- The first one was to reduce waste and reuse recycles products.
- The second was to reduce trade barriers in order to allow a better international flow of materials to be reused or recycled.

- The third was to allow a better cooperation between stakeholders, which, in the case of 3R, includes country governments, city authorities, nongovernmental associations, private sector and of course citizens.

- The forth focus was on the development of science and technology related to reducing, reusing and recycling.

- Finally the last element was cooperation between G8 members (developed countries) and developing countries to help them improve their recycling capacity.

The 3Rs initiative has then been refined during following G8s summits, and used as a reference in terms of sustainable MSW management by governments and institutions around the world. The objective of 3Rs concept is to propose a sustainable solution to waste management issue, by proposing priorities between the potential actions. Under 3Rs principle, the highest priority is to reduce the quantity of MSW, the second one is to re-use as much as possible instead of discarding, and the third one is finally to recycle what is actually discarded. A 4^{th} R, as a last priority, would be to recovering. Anything that cannot be reduced, reused or recycled should at least be recovered by composting (producing fertilizer) or converted to energy.

Reduce: as the most preferred option in the 3Rs principle, and can be performed by several methods. One of the key identified methods can be through the reduction of packaging, being paper, plastic or glass, which constitute a significant part of MSW. Stop using single use items, such as paper and plastic plates, cups, and so on also represents potential solutions to reduce. (Bouanini, 2013).

Reuse: the second most preferred option, when reducing is not possible. Reuse is preferred to recycle as does not require re-processing the item. Some well-known examples of reusing are the shopping bags or the refillable glass bottles. Some cities, such as San Francisco in USA, have taken some strong regulatory measures such banning the sale of bottled water, forcing the population to use reusable bottles (Jaffee and Newman, 2012). The implementation reusable bags in supermarkets, by systematically charging plastic bags, have also been implemented either by regulation such as in China, or by private sector initiative in Europe. But reuse also applies to more

sophisticated goods, by repairing instead of replacing. Several countries have been developed initiatives where repairing goods provide jobs, and at the same time opportunities to sell second hand goods for a low price and extend their useful life. (Bouanini, 2013)

Recycle: the third option of 3Rs principle. It consists in converting waste into a raw material to produce goods. The most common waste to be recycled is paper and cardboard, glass, and several metals. Recycling is the least preferred solution among the 3R as the industrial recycling process necessarily has a negative environmental impact, such as energy consumption or GHG emissions. However, the environmental impact of recycling is lower than sending MSW to landfills and producing new goods for raw materials. (Bouanini, 2013)

In Asia and the Pacific, the 3Rs concept has been promoted, and implemented in some places, for the past ten years. Japan had a pioneer role in establishing 3Rs concept, by launching a 3Rs Initiative at country level since 2005 (Visvanathan et al., 2007), but also by establishing in 2009 the 3Rs Regional Forum for the Asia and the Pacific, to promote 3Rs concept across Asia. (Ministry of the Environment Government of Japan, 2016). The objective of this forum is to bring together all major stakeholders form the region such as governments, international agencies, private sector or NGOs to promote 3Rs initiatives. However, except in some developed Asian countries, insufficient government regulations concentrate on 3Rs practices, and most of the 3Rs initiatives are from the informal sector, while formal MSW management does not enough to promote 3Rs implementation (Visvanathan et al., 2007).

- *Integrated Sustainable Waste Management*

The concept of Integrated Sustainable Waste Management (ISWM) was first introduced in 1995 during the Urban Management Program (UMP) Workshop on Municipal Solid Waste Management in Ittingen, Switzerland (World Bank, 1999a). The concept of ISWM has been developed by WASTE; Advisors on Urban Environment and Development with the purpose of addressing address some issues of municipal waste management in low and middle income countries. There are three main important dimensions of waste management recognized in ISWM; stakeholders, waste

management systems, and sustainability aspects. Policies and regulations related to environment issue is also a fundamental aspect of ISWM approach. Moreover, ISWM focuses on the promotion of technical appropriation and the development of waste management systems to be acceptable and suitable to social, economic, and environmental circumstances of the cities (Van de Klundert and Anschutz, 2001).

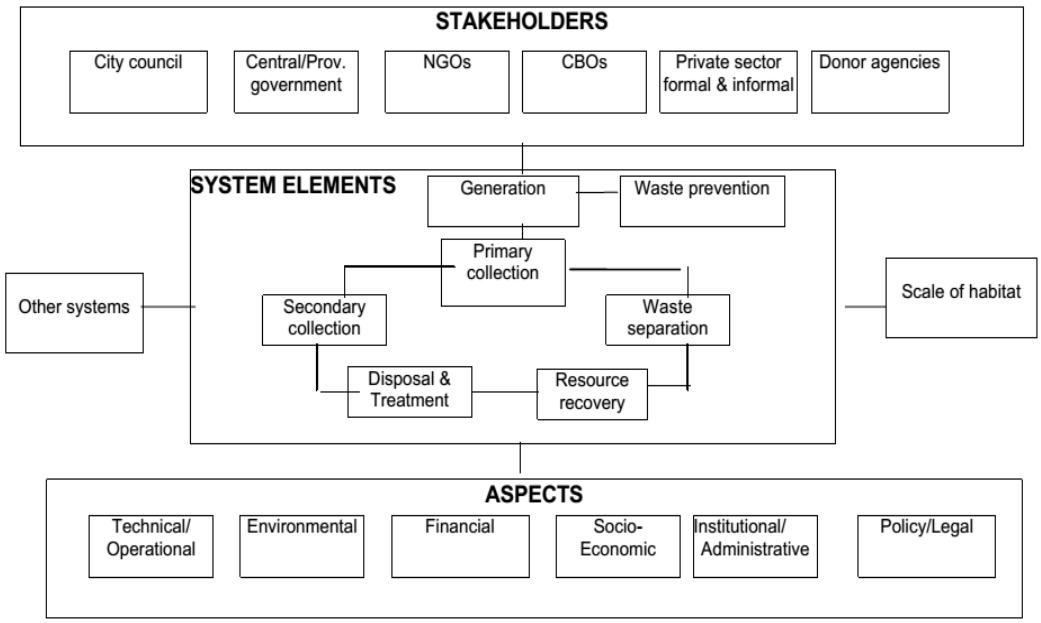


Figure 2. 5: Dimensions of Integrated Sustainable Waste Management
Source: The World Bank, 1999.

The framework of ISWM is composed of four main principles which are equity, effectiveness, efficiency, and sustainability.

Equity: an appropriate system on waste management is required to be used in communities. This is to prevent health issue to all citizens, as pollution generated by waste and some insects or rodents that are attracted by waste can create numerous diseases which may be very harmful to human health.

Effectiveness: this refers to the service related and to the material used on waste management system. This is concentrating on getting all waste fully collected or removed. All areas should be recovered, as sometimes in many cities where the service is limited, wastes are not fully managed. This is reflecting waste management system effectiveness.

Efficiency: the maximization on benefits, cost minimization, and optimizing the use of resources on waste management are taken into account in terms of equity, effectiveness and sustainability.

Sustainability: sustainable development dimensions as well as technical, financial, institutions and political perspectives which allows a waste management system which is suitable to local situations and maintaining itself over a long period of time. This is involving with equipment or resources that are used in waste management system.

2.4. The Theoretical Frameworks

2.4.1. The Theory of Planned Behavior

The Theory of Planned Behavior (TPB) was first introduced in 1985 by Ajzen. TPB was applied to modify the model of the Theory of Reasoned Action (TRA) which explained that "attitudes are multifaceted systems consisting of an individual's beliefs about specific object, feelings, and actions tendencies and developed over years". Also, attitude towards behavior is coming from intention that is a pre-requisite of behavior. It means people who have higher intention on something are more likely to perform their behavior. The TPB goes further, as beside attitude towards behavior and subjective norm, it includes perceived behavior control (PBC) as one of the potential determinants influencing people behavior (Ajzen, 1991).

The TPB identifies that human behavior is shaped by three factors, which are behavior beliefs (people usually behave based on their beliefs), normative beliefs (behavior that are influenced by the surrounding environment or people who are important for them), and control beliefs (the ability in doing something). Human behavior is also influenced by intention. Intention is basically involving with attitude towards behavior, subjective norm, and perceived behavior control. PBC refers to personal interest or belief of doing something based on the ability or difficulty in performing certain behavior.

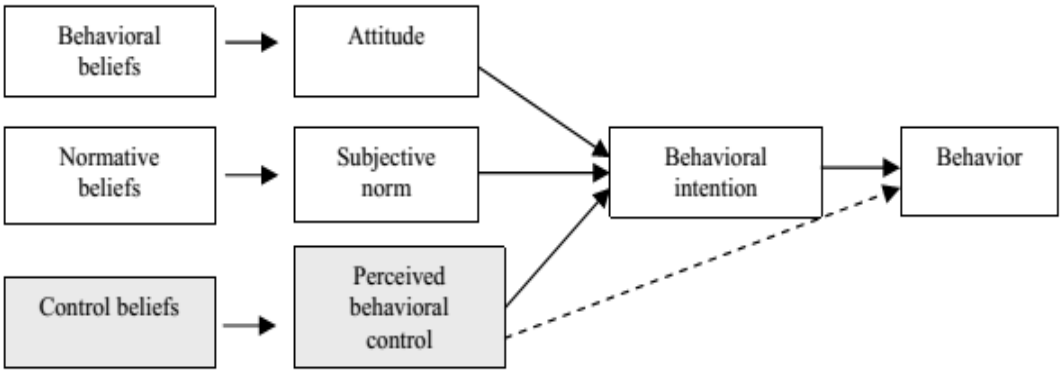


Figure 2. 6: The illustration of the theory of planned behavior
Source: Chaisamrej, 2006.

The TPB is generally used as a psychological theory explaining pro-environmental behaviors in order to predict recycling behavior in several aspects. Recently, TPB model has been applied in several research studies around the world. However, the results of some research on recycling behavior are remaining inconsistent (Chaisamrej, 2006) and suggested that some other important aspects such as habits or morale are not included in TRA and TPB models (Ittiravivongs, 2012a)

2.4.2. Matthies's Comprehensive Norm Activation Model

The Norm Activation Model (NAM) is also commonly used in studies related to environment issues. A key element of the Norm Activation Model is the study of personal norms and social norms as main elements of the motivation towards action. Social norms are considered on a general scale, not only subjective norm considered by TPB which refers mainly to family and friends, but more generally the whole society. A key element of this model is to predict a behavior on a succession of steps starting from awareness. It deeply studies the steps between knowledge and action, presenting that knowledge is not sufficient to trigger an action, but requires a motivation and evaluation stage in between (Welfens, Nordmann, and Seibt, 2016).

Matthies's Comprehensive Norm Activation Model (CNAM) is an extension of NAM. A main added element is to consider the habit as a potential influencer of several elements of the model. Habits can be a limitation to the decision process, as

people may just behave the way they are used to, not systematically thinking about benefits of a new behavior. It also influences the cost of behavior, as it is easier to do the way we are used to than to change a habit. The figure below represent the CNAM, and showed that habit can be influential at various stages of the process leading to a behavior (Matthies, 2005).

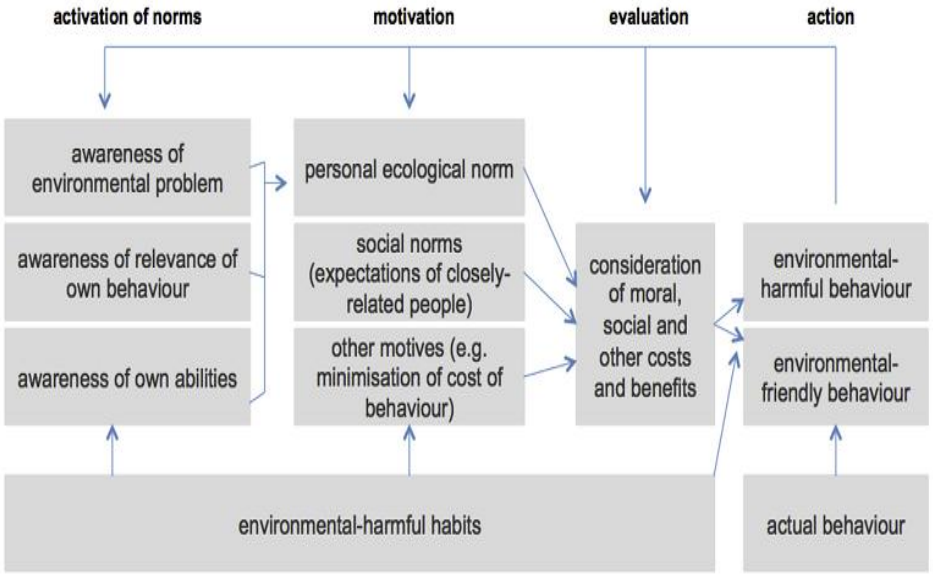


Figure 2. 7: Matthies's comprehensive norm activation model of environmentally friendly behavior.
Source: Matthies, 2005.

2.5. Influence Factors on Public Participation in Waste Separation and Recycling Worldwide

The review of several international papers which focuses on waste separation or recycling behavior give a good general overview of the main factors influencing waste separation or recycling.

- Demographic factors

First, importance of demographic data (considered or not as an external factor depending on the study) is very different from a study to another. While a research paper using meta-analysis study of 66 papers considers that demographic factors have a limited influence in the recycling behavior (Hornik, Cherian, Madansky, and Narayana, 1995), most other studies suggests that at least one demographic data is a major factor. In particular, most studies tend to show that age has a strong influence, as younger people have a lower tendency to separate or recycle waste (Arbués and Villanúa, 2016; Saphores and Nixon, 2014; Welfens et al., 2016). Education level is also recognized in several studies as an influential factor in the recycling behavior, but some studies sees it as a minor factor while others considers it as major. All studies who refer to education level at least agree that populations having the lowest level of education are less likely to recycle (Arbués and Villanúa, 2016; Hornik et al., 1995; Saphores and Nixon, 2014). Similarly, several studies agree that high income households are more likely to recycle than low income households, but on the other hand some argue that it is balanced by the fact that the useful life of equipment and appliances is longer in low income households (Arbués and Villanúa, 2016; Hornik et al., 1995; Nguyen, Zhu, and Le, 2015; Saphores and Nixon, 2014). The type of urbanization (large city or rural area) also seems to play a significant role even if this is not the most common parameter studied. The type of residence also seems to influence the recycling behavior, as people living in individual houses seems more likely to recycle than populations living in other types of housing (Hornik et al., 1995; Saphores and Nixon, 2014). Finally, a number of other demographic factors showed to

have some influence to a lower extend. A study suggests that woman have a higher tendency than men to recycle (Saphores and Nixon, 2014), the household size seems to influence the recycling behavior as families with children tends to recycle more (Arbués and Villanúa, 2016). Belonging to a specific ethnic group or nationality at birth also seems to have some impact in the studies made in Spain and in the US (Arbués and Villanúa, 2016; Saphores and Nixon, 2014).

- Internal factors

Internal factors are factors directly coming from the individual, for example related to emotions, habits, personal and social norms. These factors are generally well studied in papers related to waste separation and recycling behavior. These studies recognized the high importance of internal factors. Among them, personal norms seem to be one of the most important (Arbués and Villanúa, 2016; Nguyen et al., 2015; Saphores and Nixon, 2014; Welfens et al., 2016). However, most studies also recognized that influencing personal norms is a long process, and suggested for this reason to focus on education of the young generations. Other major internal factor is the perceived efforts or obstacles to recycle. Even if this is subjective (some people may perceive that the effort to recycle is very high while the facility is actually very close), literature suggested that both information and infrastructure can help increasing the separation / recycling behavior by reducing the perceived effort (Nguyen et al., 2015; Saphores and Nixon, 2014; Welfens et al., 2016). Concerns about environmental issues were also identified as a major factor by two studies (Arbués and Villanúa, 2016; Hornik et al., 1995). People who feel highly concerned on environmental issues are actually more likely to separate and recycle waste.

Another group of internal factors generally identified in the literature review are the ones related to personal knowledge and awareness. In particular, people who have knowledge of MSW environmental impacts seem to be more participating in recycling programs (Arbués and Villanúa, 2016; Nguyen et al., 2015; Welfens et al., 2016). But besides general knowledge, proper information on recycling programs and how to recycle seems to be a fundamental for enhancing waste separation level (Hornik

et al., 1995; Sheau-Ting, Sin-Yee, and Weng-Wai, 2016; Welfens et al., 2016). The literature review also showed that people sometimes do not participate in waste separation and recycling just because they do not know how to do, or are not aware that infrastructure and programs exists. Awareness about the transparency of the recycling process also seems very important in some cases, as some people may suspect that recycling benefits some kind of grey businesses such as re-selling mobile phones abroad, or getting personal benefits out of the recycle goods (Nguyen et al., 2015; Welfens et al., 2016).

- External factors

External factors are influencing factors that do not occur from the individual, but from other sources such as the surrounding environment, socio-economic background, or other persons. Regarding external factors, the highest level of agreement reached between the studies is on the impact of direct economic incentives for recycling. The economic incentive can take a number of different forms, as for example a refund for bringing back an empty bottle or free telephone credit while bringing back an old mobile phone. Several studies, including a meta study based on 67 papers, confirms that direct economic incentive is a factor having a high impact on recycling behavior (Hornik et al., 1995; Saphores and Nixon, 2014; Sheau-Ting et al., 2016). Other economic factors can have some influence to a lesser level, such as for example non-monetary incentives which can be lottery or games (Hornik et al., 1995; Sheau-Ting et al., 2016) , or at the contrary high prices of household waste management being a motivation to reduce or recycle (Saphores and Nixon, 2014). However, the high prices of MSW collection can also have some adverse effects such as illegal dumping.

Another category of external factor generally studied is the waste collection and recycling infrastructure. Among the elements studied, the most important seems to be by far the distance to recycling facility. This element is shown to be a major factor by multiple studies, as people are not willing to go too far to recycle. The closer the facility is, the higher the chance of recycling will be (Hornik et al., 1995; Saphores and Nixon, 2014; Sheau-Ting et al., 2016). To a lower extend, distribution of free materials

to recycle seems to have some impact, as for example giving free envelopes to send back old mobile phones, or giving bins to separate recyclable goods at home (Hornik et al., 1995; Welfens et al., 2016).

Finally, influence of policies and regulations are not so commonly studied in the literature, but seem to have some kind of influence when studied. In particular, the existence of strict regulations on recycling, coupled with a strong enforcement level and fines seems to be potentially a positive factor to encourage waste separation behavior (Saphores and Nixon, 2014).

2.6. Municipal Solid Waste Situation and Management in Bangkok

Thailand is considered as an upper-middle income country, with the population density of 132 people per km^2 and the total population is about 68 million in 2015 (World Bank, 2016a). According to the Thailand Environment Monitor by the World Bank, the total MSW generation in Thailand was 22 million tons per year but (World Bank, 2003) but increased to 27.06 million tons in 2016 (Pollution Control Department, 2016b). In this regard, Bangkok is one of the major contributors of those waste.

Bangkok is the capital of Thailand which located in the center of the country. According to BMA, the total population is about 5.7 million people (this is not including non-registered population) and the total number of households is estimated to 2.6 million (BMA, 2013). Bangkok Metropolis is a large city, covering over 1,568 km^2. However, the city's population is quite dense as the average density is approximately 3,726 persons/km^2. This city is separated into 50 districts and 154 sub-districts (UNEP, 2009a).

Bangkok is considered as a mega city with a very strong economic growth but facing the problem of MSW. The economic expansion as well as the rapid rise of population is generating significant impacts on waste generation. According to PCD, the total MSW generation in Bangkok is about 4.20 million tons in 2016 which showed a significant increase from 2009, as at that time Bangkok metropolis produced only about 3.2 million tons (Pollution Control Department, 2016a). In terms of MSW

generation per capita, an estimated figure of 1.09 kg/day can be calculated based on most recent figures of waste generation (4.2 million tons per year as per PCD) the latest Bangkok population (10.6 million inhabitants including non-registered population).

In terms of waste composition of MSW produced is different depending on the area and economy. However, in average, food waste or organic waste in Bangkok is the highest percentage (42.7%) compared to other types of waste, following by non-recyclable plastics (21.4%) and 12.4% of non-recyclable paper and others as showing on figure below:

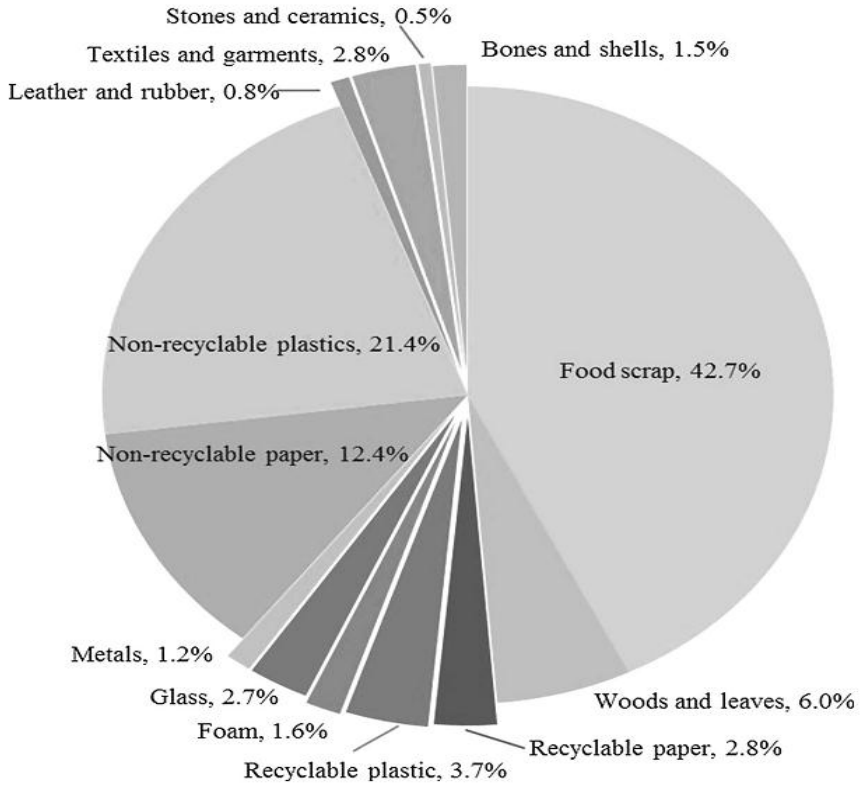


Figure 2. 8: MSW composition at transfer station
Source: (Sukholthaman, Chanvarasuth, and Sharp, 2015)

For waste collection services, BMA uses two main methods which are direct collection and indirect collection. Direct collection is used in areas where car or boat can access wastes. Waste is usually collected directly in front of households while for indirect collection, waste is collected at the areas whereas BMA has provided waste containers at specific point. To ensure this services, BMA has 66 boats and 1,856 vehicles (1,438 being rented and 418 owned) (BMA, 2014a).

The schedule of waste collection service differs depending on the type of waste. However, waste collection service usually start from 8:00 PM and should be completed by 6:00 AM. The BMA separates waste into 4 main types; general solid waste, organic waste, recycles waste, and hazardous waste. Waste collection service is provided every day for general solid waste and organic waste but only Sunday for recycle waste and only twice per month (the 1st and 15th) for hazardous waste (BMA, 2014a). After waste is collected, it is transferred to three main stations located in On Nuch, Nong Khaem, and Sai Mai districts. Then waste is transported and disposed through two main landfills in Chachoengsao and Nakonpathom provinces.

In 2016, 87% of total waste (10,130 tons/day) collected is disposed through sanitary landfills while 10% is composed at On Nuch waste transfer station, and 3% is disposed through thermal treatment at Nong Khaem facility (BMA, 2016). Due to the significant generation of MSW and the way waste is managed, some concerns remains on the diminishing surface of landfills and its impacts on society, community and environment such as ground water, water surface and soil contamination. Moreover, environmental change and the release of GHGs with particular methane is also a concerning issue. Apart from this, a better use of technology or vehicles as well as the need for effective MSW management plan and policies are considered as urgent in order to solve these issues (Sukholthaman and Shirahada, 2015).

2.7. Influence Factors for Public Participation on Waste Separation at Source in Bangkok

Several researches have been conducted over the past years related to MSWM in Bangkok. Some focus on factors influencing waste separation for recycling; some others are more generally oriented at studying the general management of MSW in Bangkok. Both were useful for this research, as the first question was oriented at MSW management, while the second one focused on waste separation intention.

For the studies focusing on elements influencing waste separation, the variety of factors is very wide, but can generally be divided in a few categories of internal and external factors, as for the international related papers review.

- External factors

Firstly, demographic factors are present in most studies which used questionnaire, with at least the gender and age of respondents, while some went much deeper in detail considering factors such as religion or number of tourists in the city. However, it is interesting to note that socio-demographic factors were not found to be significant factors that influence waste separation at source in Bangkok. Only one study notes that age has a negative correlation to the willingness to pay (WTP) for MSW recycling services, which means that younger people are more WTP for recycling services than older ones (Challcharoenwattana and Pharino, 2016). In Bangkok, the WTP for recycling services also seems to be correlated to the income of the household and the level of education (Challcharoenwattana and Pharino, 2016). Other factors such as the household size, the number of households or the income seems to have some influence and showed some correlation in the range of 0.65 with waste generation (Sukholthaman et al., 2015). But as a general comment, this showed that some basic demographic data demographic data such as age and gender are often collected in several studies related to MSW situation in Bangkok.

Economic data is also a variable studied by several papers. Economic incentive was found to be one of a significant factors that influence both the intention to recycle and behavior as many people can get income from the selling of recyclable waste (Ittiravivongs, 2012a; Sukholthaman and Sharp, 2016).

Infrastructure is also studied, mainly under the angle of the facility condition. A strong correlation is shown between the recycling facility condition and both the intention to recycle and the recycling behavior (Ittiravivongs, 2012a). Also, the general satisfaction towards MSW service is shown to be moderately correlated with WTP for recycling services (Challcharoenwattana and Pharino, 2016). However, distance to recycle bin or facility, which is an important factor in international literature, did not seem to be directly studied in Bangkok.

The influence of laws and regulations, as well as the level of enforcement were surprisingly quite absent from the factors used in previous researches. If the

existence of a regulatory framework or MSW management plans is referred to in the literature review of several papers, this element was not really used as an independent variable that may potentially influence recycling behavior (Muttamara and Leong, 2004; Sukholthaman et al., 2015; Sukholthaman and Sharp, 2016). However, a study on waste separation at source showed that over 70% of Bangkok residents considered that enforcement of waste collection, transportation and treatment laws would make waste management be more efficient (Sukholthaman and Shirahada, 2015).

- Internal factors

Research on internal factors influencing separation and recycling in Bangkok is quite limited. A few studies tended to show that in Bangkok, the influence of internal factors on recycling behavior is mainly indirect, contributing to the recycling intention. Regarding norms, it is interesting to note that subjective norms such as the influence of surrounding people or environment were found to be the key influential factors on waste recycling intention among Bangkok population (Ittiravivongs, 2012a, 2012b; Ittiravivongs. A, 2011).

Regarding WTP for recycling services, the main determinant internal factors in Bangkok population seems to be the willingness to recycle dry batteries, which slightly differs from smaller urban areas in Thailand where the most influential internal factor is more the concerns about MSW issue. Interestingly, the author suggested that this can be due to the fact that landfills are not located in Bangkok, so Bangkok residents are less directly confronted to the issue (Challcharoenwattana and Pharino, 2016).

Some Internal factors related to knowledge were identified to show a high potential influence on recycling behavior. This includes factors such as perceived recycling skills, attitude towards recycling, and the awareness of the recycling benefit (Ittiravivongs, 2012a). However, almost all papers conclude in the recommendations part that awareness is a key element to improve MSW management and recycling behavior. In particular, improve the education on recycling at source in order to improve population recycling skills is cited in 5 different papers (Challcharoenwattana and

Pharino, 2016; Ittiravivongs, 2012a; Muttamara and Leong, 2004; Sukholthaman and Sharp, 2016; Sukholthaman and Shirahada, 2015).

In conclusion, literature exists on sustainable municipal solid waste management in Bangkok, but few are specifically focused on intention to separate. The identified factors are also sometimes different or divergent compared with well documented international studies on the topic. This suggests the usefulness of this research, in order to evaluate statistically a number of factors which are not yet studied, or under-studied.

3. General Methodology

3.1. Research Framework

The objective of this research was firstly to assess the effectiveness of MSW management of BMA, and secondly to investigate factors that influence waste separation intention among Bangkok residents.

The measurement of MSW management effectiveness was mainly based on Wasteaware benchmarking indicators which allowed identifying weak and strong points, and enable to define strategies and priorities for the future management in terms of sustainable waste management.

The evaluation of influencing factors for waste separation intention was based on primary data collected through questionnaires, using Theory of Planned Behavior (TPB) and Matthies's Comprehensive Norm Activation Model (CNAM) as theoretical frameworks. The conceptual framework of this study is described in the figure below:

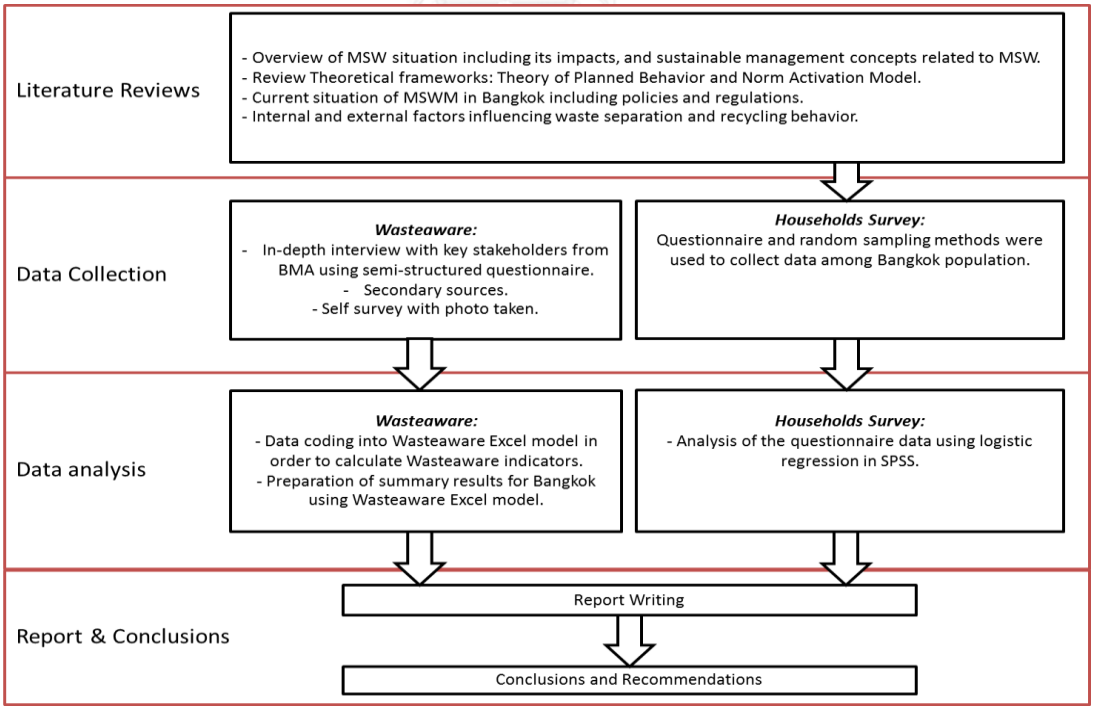


Figure 3. 1: Research conceptual framework

3.2. Scope of the Study

This study concentrated on Bangkok metropolis area. The city is covering an area of about 1,568 km^2 located in the center of Thailand, and is composed of 50 districts. According to the latest available BMA statistics, the total population is about 5.7 Million inhabitants, with an average population density of 3,625 persons per km^2. The total number of households is estimated to 2.6 Million (BMA, 2013).

This area is administrated by Bangkok Metropolitan Administration (BMA) which has the responsibility of the municipal solid waste management. The total waste generation of this city is about 4.20 million tons (Pollution Control Department, 2016b) but in terms of waste collection the total garbage collection by BMA represented 3.7 million tons in 2016, equivalent to 10,130 tons per day (BMA, 2016).

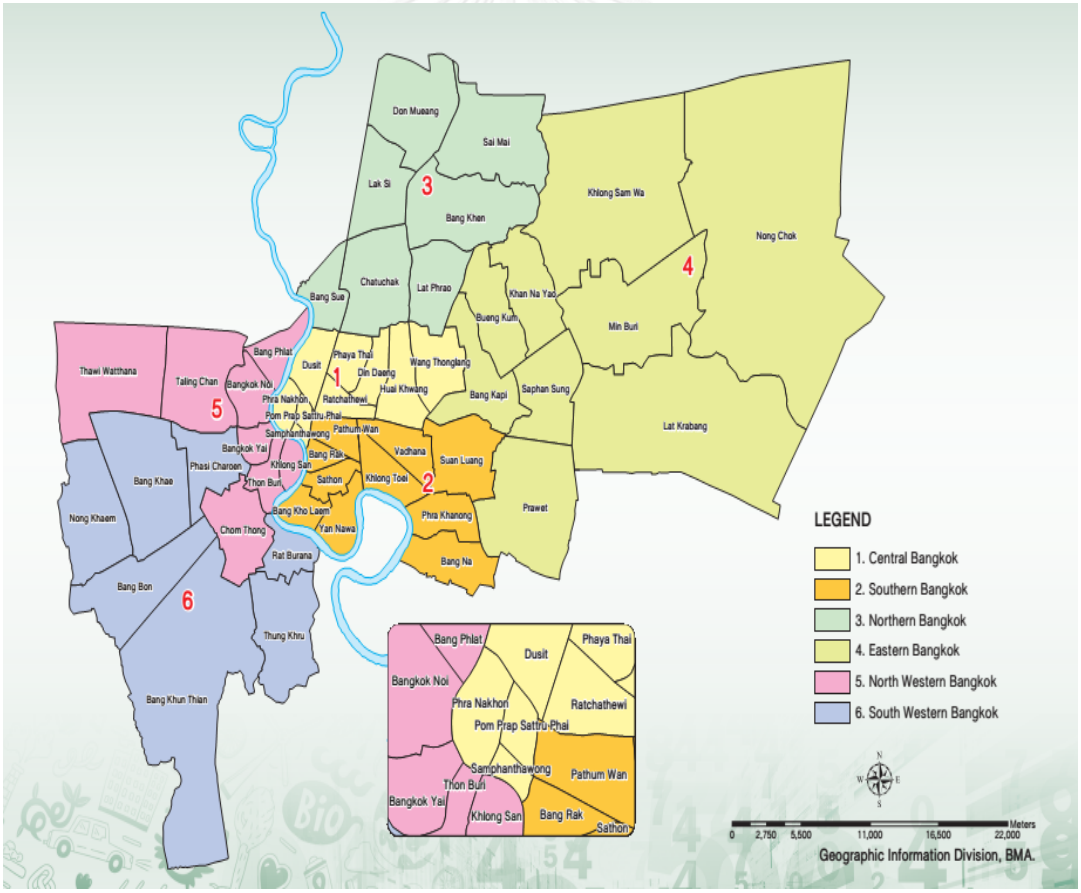


Figure 3. 2: Bangkok metropolis map and districts
Source: BMA, 2013.

4. Wasteaware Methodology and Analysis

4.1. Detailed Methodology

4.1.1. Wasteaware Benchmarking Indicators

This research was a qualitative research, applying Wasteaware indicators to answer the first question of this research by benchmarking Bangkok in terms of sustainability of MSW management. Wastaeware 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 (Wilson et al., 2015). The objective of Wasteaware indicators is to provide a single comprehensive tool to benchmark and compare cities or municipalities in terms of Integrated Solid Waste Management (ISWM) performance, regardless of their level of development. Wasteaware is one of the very important tools to assess sustainability of waste management in many cities around the world. It provides information to support on decision-making and allows getting a synthetic picture of the strong and weak points of MSW management system. Wasteaware does not only help to prioritize the keys issues that need to be improved or need to be addressed, but also to monitors changes overtime.

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 (UN-Habitat, 2010). However, Wasteaware revised the UN-Habitat factors in order to improve the analysis. New tools have also been developed in order to offer a relatively easy analysis, and a simple yet efficient "traffic lights" coding has been implemented to present the results (Wilson et al., 2015). Wasteaware is also based on the concept of ISWM, which uses three main dimensions to define waste management. One is the physical system, the second is sustainability aspects, and the third dimension is related to stakeholders. However, UN-Habitat study, as well as Wasteaware, are using a simplified version of this concept represented diagram hereafter.

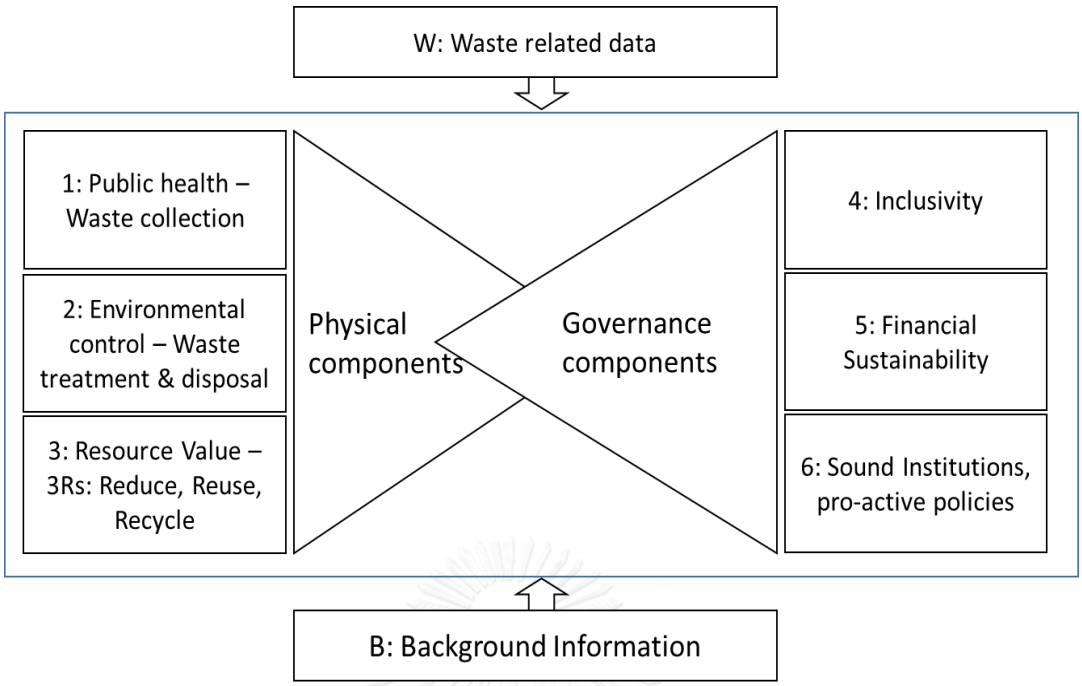


Figure 4. 1: The ISWM framework used by Wasteaware indicator set

The first set of data used by Wasteaware are general information such as city and user information (C), background Information (B) such as economic or demographic elements, as well as key waste related data (W), including quantification and composition. Then the indicators are divided in two parts, being "Physical Components" and "Governance Factors". Each of these parts is then divided in three categories. For "Physical Components", these categories are public health (1&1C), environment (2&2E) and resource value (3&3R). For "Governance Factors", the categories are inclusivity (4U&4P), financial sustainability (5F) and sound institutions (6N&6L). Finally, these categories are divided in a separate of indictors, which are either single indicators, or composite indicators calculated using a number of criteria as described in the table showed on next page.

Table 4. 1: Main Categories and Indicators used in Wasteaware model, as well as number of criteria used to build composite indicators.

Code	Category	Indicator	Nbr. of criteria
City			
C	City and User Information	City, user, dates, sources	N/A
Background Information			
B1	Country income level	World Bank income category, GNI / capita	N/A
B2	Population	Total population of city	N/A
B3	Waste Generation	MSW generation in tons/year	N/A
Key Waste Related Data			
W1	Waste Generation	MSW generation in tons/year	N/A
W2	Waste Composition	Organic, Paper, Plastic, Metals	N/A
Physical Components			
1.1	Public health- waste collection	Waste collection coverage	N/A
1.2		Waste captured by the system	N/A
1.C		Quality of waste collection service	6
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	N/A
2E		Degree of environmental protection in waste treatment and disposal	6
3	Resource management – reduce, reuse and recycle	Recycling rate	N/A
3R		Quality of 3Rs – Reduce, Reuse and Recycle provision	6
Governance Factors			
4U	Inclusivity	User Inclusivity	6
4P		Provider Inclusivity	5
5F	Financial Sustainability	Financial Sustainability	6
6N	Sound Institutions, proactive policies	Adequacy of national SWM framework	6
6L		Local institutional coherence	6

Source: Developed from data presented in Wasteaware Manual (Wilson et al., 2015)

This tool was basically developed to benchmark waste management system in any cities within or between countries worldwide and it was just fully adapted and applied to Bangkok Metropolitan area for the first time.

4.1.2. Detailed Data Collection for Wasteaware Indicators

The data collection for Wasteaware indicators was performed by different means, either through secondary or primary sources and also by self-survey with photos taken. The main collection method was based on the in-depth interview with BMA representative and sub-districts, using semi-structured questionnaire prepared in advance, in order to systematically cover all the criteria necessary for Wasteaware analysis. The interview with BMA was performed three times as first was in June 2016, second was on December 2016, and the last was in January 2017. All information collected through the interview were mainly used for Wasteaware indicator B3, W1, W2, 1.2, 1C, 2, 2E, 3, 3R, 4U, 4P, 5F, 6N.5 and 6L. For other indicators such as C1, C2, B1, B2, 1.1, 6N.1 to 6N.4, and 6N.6, where data is available from research papers and government reports, the data were collected through those secondary sources. In addition, for some indicators, information from self-survey on 1,076 households in Bangkok or photos taken in the fields were used to support the assessment. The following tables presents the detail of data sources and methodology by indicator. The detailed questions used during the interview to collect the necessary information are presented in Annex 1: Semi-structured questionnaire: first in-depth interview with BMA.

Table 4. 2: Sources of information for Wasteaware data collection in Bangkok city.

Code	Category	Indicator	Sub-Indicator	I	S	FS
Supporting Information						
C1	City and User Information	City	N/A		X	
C2		Country			X	

C3		Name of the person filling in indicator forms		-	-	-
C4		Sources of Information		-	-	-
C5		Date when indicator form completed		-	-	-
C6		Date to which indicators apply		-	-	-
C7		Previous application of the indicators			X	
C8		Date when indicators applied previously			X	
B1	Background Information	GNI / capita	N/A		X	
B2		Total population of city			X	
B3		Waste generation		X	X	
W1	Waste-related Data	Waste per capita	N/A	X	X	
W2		Waste Composition	*W2.1 Organic*	X	X	
			W2.2 Paper	X	X	
			W2.3 Plastics	X	X	
			W2.4 Metals	X	X	
			W2.5 Solid waste density	X	X	
			W2.6 Moisture Content	X	X	
Benchmark Indicator for Physical Components						
1.1	Public health (waste collection)	Waste collection coverage	N/A		X	
1.2		Waste captured by the system	N/A	X		
1C			*1C.1 Appearance of waste collection points*	X		X

		Quality of waste collection and street cleaning service	*1C.2 Effectiveness of street cleaning*	X		X
			1C.3 Effectiveness of collection on low income districts	X		X
			1C.4 Efficiency and effectiveness of waste transport	X		X
			1C.5 Appropriateness of service planning and monitoring	X		
			1C.6 Health and safety of collection workers	X		X
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	N/A	X	X	
2E		Degree of environmental protection in waste treatment and disposal	*2E.1 Degree of control over waste reception and general site management*	X		
			2E.2 Degree of control over waste treatment and disposal	X	X	
			2E.3 Degree of monitoring and verification of environmental controls	X		
			2E.4 Efficiency of energy generation and use	X		
			2E.5 Degree of competence in the planning, management and operation of treatment and disposal	X		

			2E.6 Occupational health and safety	X		
3	Resource management – reduce, reuse and recycle	Recycling rate	N/A	X		
3R		Quality of 3Rs – Reduce, Reuse and Recycle provision	*3R.1 Source separation of "Dry Recyclable"*	X		X
			3R.2 Quality of recycled organic materials	X		
			3R.3 Focus on top level of the waste hierarchy	X	X	
			3R.4 Integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system	X	X	
			3R.5 Environmental protection in recycling	X	X	
			3R.6 Occupational health and safety	X		X
Benchmark Indicator for Governance Factors						
4U	Inclusivity	User Inclusivity	*4U.1 Equity of Service Provision*	X		X
			4U.2 The right to be heard	X	X	
			4U.3 Level of public involvement	X		X
			4U.4 Public feedback mechanism	X		
			4U.5 Public Education and Awareness	X		
			4U.6 Effectiveness in achieving behavior change	X	X	X
4P		Provider Inclusivity	*4P.1 Legal Framework*	X	X	

			4P.2 Representation of the private sector	X	X	
			4P.3 Role of the "informal" and community sector	X		
			4P.4 The balance of public vs. private sector interests in delivering services	X		
			4P.5 Bid Process	X	X	
5F	Financial Sustainability	Financial Sustainability	*5F.1 Cost Accounting*	X		
			5F.2 Coverage of the available budget	X		
			5F.3 Local cost recovery – from households	X		X
			5F.4 Affordability of user charges	X		
			5F.5 Pricing of disposal	X		
			5F.6 Access to capital for investment	X	X	
6N	Sound Institutions, proactive policies	Adequacy of national SWM framework	*6N.1 Legislation and regulations*		X	
			6N.2 Strategy / Policy		X	
			6N.3 Guidelines and implementation procedures		X	
			6N.4 National institution responsible for implementing solid waste management policy		X	
			6N.5 Regulatory control / enforcement	X		

			6N.6 Extended Producer Responsibility (EPR) or product Stewardship (PS)		X	
6L		Local institutional coherence	*6L.1 Organizational structure/coherence*	X		
			6L.2 Institutional capacity	X		
			6L.3 City-wide solid waste management & plan	X	X	
			6L.4 Availability of quality of solid waste management data	X	X	
			6L.5 Management control and supervision of service delivery	X	X	
			6L.6 Inter municipal (or regional) co-operation	X		

Note: I = primary data collected through the interviews with BMA and sub-districts; S = data collected from secondary sources; FS = field survey (including households survey and photos taken) in Bangkok areas.

4.1.3. Methodology on Wasteaware Analysis

- **Data analysis**

The complete data have been entered in the MS-Excel format developed by Wasteaware project. The coding aims at converting both the qualitative and quantitative data collected into 5 level "traffic lights". Exact coding instructions are given by the Wasteaware manual, for each indicator. For fully quantitative indicators, the coding is quite simple, as specific numerical range is converted to a color code. For example, waste collection coverage between 0 and 49% are coded Red, Red/orange between 50% and 69%, orange between 70% and 89%, orange/green between 90% and 98%, and green if coverage is 99% to 100%.

For more qualitative data, the manual also gives very precise coding instructions. For example, the level of control of a landfill are coded Orange/Red (Low) if it is staffed, in a designated area and has some equipment. It was coded Orange/Green (Medium High) if it is an engineered landfill using daily cover material, having some level of leachate containment and a collection system for landfill gas.

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 scoring between 0 and 20 of the 6 indicators used: C=$\sum_{i=1}^{n} Si$(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= $\frac{\sum_{i=1}^{n} Ci}{20n} x100$ (where N is normalized score). This percentage was then be color coded as indicated in the manual.

- **Data presentation**

The Wasteaware excel tool allows to generate automatically a summary matrix presenting the results of the benchmarking. This matrix uses 5 level "traffic lights" coding for easy interpretation of the main indicators.

In addition to the summary matrix, as suggested by Wasteaware, radar graphs were prepared to allow a visual interpretation of the level of sustainable MSW management in Bangkok.

4.2. Wasteaware Analysis

The criteria defined by Wasteaware are divided in three main parts; one is the background information and key waste related data, the second is about physical components, and the third is related to governance factors. The Wasteaware model was fully applied to Bangkok Metropolitan area, which allows getting a synthetic picture of both strong and weak points of MSW management system in Bangkok. The analysis and results here is presented under three parts as follow:

4.2.1. Current Situation of Waste Management of BMA

Benchmark Indicators B - Background Information on MSW Management by BMA

According to BMA, waste management in Bangkok includes waste collection and disposal services. Solid waste is generally daily collected and then transported to waste transfer stations located in On nuch, Sai mai and Nong khaem. BMA separates waste into 4 main types which are general solid waste, organic waste, recyclable waste, and hazardous waste. BMA also reported that 87% of total waste collected per day (10,130 tons) in 2016 is disposed through sanitary landfills located in Chachoengsao and Nakonpathom provinces. While 10% of waste remaining is composed at On nuch waste transfer station, and 3% waste to energy treatment at Nong khaem. The process of waste disposal by sanitary landfills is conducted through first of all, from the transfer station, transporting waste into waste belt and then compacted using high pressure of hydraulic machine. The compacted waste is then attached by using wire tie to prevent waste from dropping or falling apart. A pack of waste size is about 1 cubic meter or 1 ton. The capacity of waste transportation is about 47 tons per trailer. Finally, waste is

covered by canvas or burlap before transporting to landfills. For composting, waste is generally weighed as the first step, then separated by workers before putting in the drum rotating which takes 7 days to intermix or cut into small pieces. Waste are then transported into sieving machine and composted. In terms of waste to energy, 2 stroker type is being used (250 tons/stroker) with burning temperature not less than 1,000 Celsius. BMA reported that there is pollution control system before emitting the exhaust gases to the air, and that the electricity generated by this method is about 5 MW as minimum.

Following Wasteaware methodology, some parts of background information on the current situation of MSW managed by BMA was collected from secondary sources.

Based on Wasteaware manual, the data on Gross National Income per capita was suggested to be collected from World Bank report. And according to the latest World Bank estimation, the Thailand GNI per capita is 5,720 USD while GNI per capita in China is 7,930 USD and Malaysia is 10,570 USD (The World Bank, 2015). This data is quite in line with the national statistical data which available in 2015 the GNP per capita in Thailand was 192,812 Thai baht equivalent to 5,266 USD (Bank of Thailand, 2017). Based on the same reports mentioned, Thailand is considered as an upper-middle income economies country with total population of 68,261,443 people.

Bangkok is the capital of the country, the total of registered population in this city is about 5.7 million people in 2016. However, if include non-registered population the total residents in Bangkok is approximately 10.6 million people (BMA, 2015; CCAC, 2015). In terms of waste generation, the total waste generated of the city was 4.20 million ton in 2016, which is equivalent to 11,507 tons per day (Pollution Control Department, 2016b). However, as per Wasteaware manual, the estimation on waste generation per year may be different in each city, as this is depending on the definition of solid waste which is used, or how they define the composition of solid waste. Therefore, it is important to provide the local definition of waste to demonstrate waste generation of the city. In the case of Bangkok, according to one year action plan “Thailand without waste” 2016-2017 report, solid waste is referred to "organic waste, recyclable waste, hazardous waste, and general waste". Organic waste refers to waste which is easily biodegradable such as food waste, plants, vegetables, fruits etc.

Recyclable waste refers to waste that can be either reused or recycled such as glass, paper, plastics, metals, tire, etc. Hazardous waste refers to waste that can be dangerous or containing dangerous components such as electric and electronic equipment, batteries, spray cans containing chemicals, inks, lamps, etc. General waste refers to waste which is not easily biodegradable or recyclable or not worth recycling such as plastic or paper wrapping, foam, coffee capsules, etc. (Ministry of Public Health, 2016). In this regard, BMA reported that waste collected by BMA is only 10,130 tons/day.

The production of MSW per capita in kg is also very different depending on the source used. The Department of Local Administration and Pollution Control Department estimates Bangkok MSW per capita at 1.89 kg/capita / day (Department of Local Administration and Pollution Control Department, 2016). However, this figure seems over estimated and does not match with BMA data. I therefore use a value of 1.09 kg / capita based on calculation using figure presented in indicators B2 which identify the total population in Bangkok and B3 waste generation per year of the city (11,507,000 kg of MSW/day divided by 10,600,000 inhabitants).The MSW per capita in kg per year is therefore resulted as 396 (4,200,000,000 kg / 10,600,000 inhabitants)

In terms of waste composition, the waste that collected by BMA is composed of a large portion of organic waste (48.29%), which includes food waste as well as branches and leaves. Following by plastics which represents 25.68%, this is including both recyclable and non-recyclable plastics. Finally, metals represents only 1.57% of collected waste (BMA, 2014a).

The waste density of MSW collected by BMA is estimated to 380 kg per cubic meter in average (BMA, 2011), while the moisture content is about 50% to 60% (Hongyon, 2007).

4.2.2. Benchmark Indicators for Physical Components

Benchmark indicators for physical components is composed of three main groups of indicators: first is “benchmark Indicators 1 & 1C: Public Health – Waste Collection”, second is “Benchmark Indicator 2 & 2E – Environment (Waste Treatment and Disposal)”, and the last is “Benchmark Indicator 3 & 3R – Resources Value – 3Rs - Reduce, Reuse and Recycle”.

Benchmark Indicators 1 & 1C: Public Health – Waste Collection

Indicators 1.1, 1.2 were used to give a quantitative assessment of the access of waste collection as well as how efficient is street swapping system. And 1C is composite indicator, made up of 1C.1 to 1C.6, focus on qualitative assessment of the quality on waste collection as well as the quality of street cleaning service.

1) Indicator 1.1 - Waste Collection Coverage.

Waste collection coverage is about the percentage of households that receive waste collection service from the city authority and informal sector. In terms of quantitative assessment of waste collection coverage, the percentage of households in Bangkok receiving waste collection service is 90% as stated in the BMA’s report on “Bangkok state of environment 2013-2014” (BMA, 2014a). This corresponded to Medium/High (orange/green) rating as per the Wasteaware coding. Waste collection services that the households received in this city includes door-to-door waste collection service and by deposited into a community container or waste collection points. According to the interview with BMA in December 2016, the frequency of mixed waste collection service is daily while, recycle waste is every Sunday. BMA also confirmed during the interview that this figure does not include waste collection service from informal sector.

2) Indicator 1.2 - Waste Capture by Solid Waste Management and Recycling System.

This is about the percentage of the actual collection of waste generated that is actually delivered to official treatment or disposal facility, and recycling factory by waste management system.

The total waste generated in Bangkok was 11.507 tons per day, while BMA collected 10,130 tons per day, this means BMA collected around 88% of the total Bangkok MSW. BMA also claims that 100% of the waste they collect is delivered to an official treatment or recycling facility (87% is delivered to controlled landfills, 10% to engineered compost and 3% to engineered thermal facility). At the same time, 1,348 tons per day were collected by informal recycling sector and recycled (Pollution Control Department, 2016b). It is therefore rated as high as per Wasteaware manual, as 100% of the waste captured by the system is either treated or recycled.

3) Indicator 1C – Quality of Waste Collection and Street Cleaning Service.

As mentioned this is composite indicator made up of criteria 1C.1 to 1C.6 and focusing on qualitative assessment or effectiveness of the waste collection and street cleaning service.

For qualitative composite indicator, the normalized score given by Wasteaware analysis was 50% which correspond to medium level, or orange traffic light coding.

- *1C.1 Appearance of waste collection point*

The focus on the appearance of waste collection points was not only an immediately after waste collection service but also two hours after waste was collected. The analysis of this indicator showed medium incidence of waste accumulation.

Even though the BMA answered to questionnaire that there was "very low incidence of littering and overflowing bins", this was based on the situation immediately after waste was collected, not one or two hours later or longer. So based on the site survey with photos taken, it was identified that there's some littering after waste collection services both immediately and few hours after waste was collected.

This is due to several reasons; one is from the service itself as some collection points, waste were not fully collected and also the population in several areas litter their waste out of time scheduled as BMA set the time and allow residents to litter their waste only from 8PM until 3AM. However, some people were still not aware or didn't really pay attention on this rule causing waste accumulation after collection service as per the interview with BMA.

Note: Photos taken from Silom, Sathorn, and Bangrak roads in January 2017

Figure 4. 2: Waste collection points, immediate situation, and few hours after waste collection service.

- *1C.2 Effectiveness of street cleaning*

This focuses mainly on the presence of litter and overflowing bins around city center or main roads and popular places where people gathers. From the analysis of on Wasteaware system, the effectiveness of street cleaning in this city was considered as average.

Based on both site survey and interview with BMA, the littering or overflow bins on the main roads and city center were pretty low but in some places where people gather, overflowing bins were sometimes found. Thus the score given was rated as "medium incidence".

Note: Photos taken from Silom and Narathiwat roads in December 2016

Figure 4. 3: Overflowing bins in Silom area

- *1C.3 Effective of collection in "low income districts"*

In terms of waste collection service in "low income districts" (consider or not as per Wasteaware manual), the situation of waste seems to be more problematic, with a pretty high incidence of accumulated waste, illegal dumping or open burning were sometimes found. According to BMA, waste collection service does not depend on income. However, in some areas particularly in high density areas where roads are sometime very narrow and not allowing door-to-door collection by vehicle, waste collection service is not provided daily. Moreover, illegal dumping occurred in many areas in Bangkok this is including dumping into watercourses and drains. The score given was therefore rated as "high incidence" as per Wasteaware manual.

Figure 4. 4: Evidence of illegal dumping of waste in Klongtoey district, Bangkok.
Source: Bangkok Post, April 18th, 2017

- *1C.4 Efficiency and effectiveness of waste transport*

Regarding the efficiency and the effectiveness of waste transport, the Wasteaware rating was resulted as medium/high. As the focus of this criterion is on transporting waste to final disposal or treatment facilities, using appropriate or well maintain vehicles to transport waste is very important. In this regard, BMA answered to the questionnaire that all MSW vehicles were contained, well maintained, includes precautions from windblown litter, liquid spilling, and the transfer stations have sufficient capacity. However, similarly to 2E.1 the procedures related to windblown litter, flies, vermin, birds, and mud on truck wheels have not been clarified. In addition, based on site survey with photo taking, some trucks used for waste collection services in the city were not contained and did not present protections from wind.

Figure 4. 5: Waste transport that is uncontained and not protected from wind.

- *1C.5 Appropriateness of service planning and monitoring*

In terms of appropriateness of service planning and monitoring, Wasteaware evaluation also showed medium/high compliance. BMA answered to questionnaire that the contracts with private operators exist, with detailed specification of service, and over 80% of trucks were rented from private sector. But in terms of waste collection service, all waste collectors were employed by BMA. However, in terms of waste disposal or landfill, private sector was processing by themselves. Also, monitoring procedures of MSW operation by private or public sector was under the responsibility of each district office as well as BMA office in order to check their services whether they were well performed.

- *1C.6 Health and safety of collection workers*

Finally, in terms of health and safety of collection workers, a low compliance was noted according to Wasteaware criteria. The focus in this indicator was on the appropriate use of personal protection equipment of waste collectors during working and receive a regular health-checks.

According to BMA, they confirmed that waste collection workers were all provided with necessary tools such as boots, gloves, and overalls or visibility vests during waste collection services, and receive also a general health check every year. However, vaccinations were not provided to BMA collection staff, and some workers don't really apply several equipment during working time. For example, it was identified based on field survey with photo taking that gloves and overalls were not often used, due to humidity and hot weather.

Benchmark Indicator 2 & 2E – Environment (Waste Treatment and Disposal)

The set of indicators under this aspect concentrate on the degree of environmental protection of waste treatment and disposal processes. This part is composed of two main indicators: indicator 2 is a quantitative assessment of the percentage of controlled treatment and disposal, while composite indicator 2E is a composite indicator which is composed of criteria 2E.1 to 2E.6, aiming at evaluating the quality of environmental protection and waste treatment and disposal.

1.) Indicator 2 - Controlled Treatment and Disposal

The degree of controlled treatment and disposal was rated high (green traffic light) as according to BMA interview and published reports (BMA, 2014a) as well as interview with BMA, all collected waste was disposed in controlled treatment facilities, being either controlled landfills (87%), engineered compost (10%), and thermal treatment (3%). The processes on waste disposal by sanitary landfills was conducted by transporting waste into waste belt and compacted using high pressure of hydraulic

machine. Then attached the compacted waste by wire tie to prevent waste dropping or fall apart and before transporting to landfills, waste were covered by canvas or burlap this to prevent waste falling or dropping during transpor. For composting, waste was generally weighed and was then separated by workers before putting in the drum rotating which takes 7 days to intermix or cut into small pieces. After that waste were transported into sieving machine and composted. In terms of waste to energy, a new incineration facility opened in 2016 in Nong Khaem. A 2 stroker type was being used (250 tons/stroker) with burning temperature not less than 1,000 Celsius. The electricity generated by this method was about 5 MW minimum. In this facility, the truck load was checked, the leachate were treated in a sewage treatment, ashes were collected and sent to dedicated landfills, and BMA also reported that there's pollution control system before exhausting to the air and confirmed the clean process of treatment.

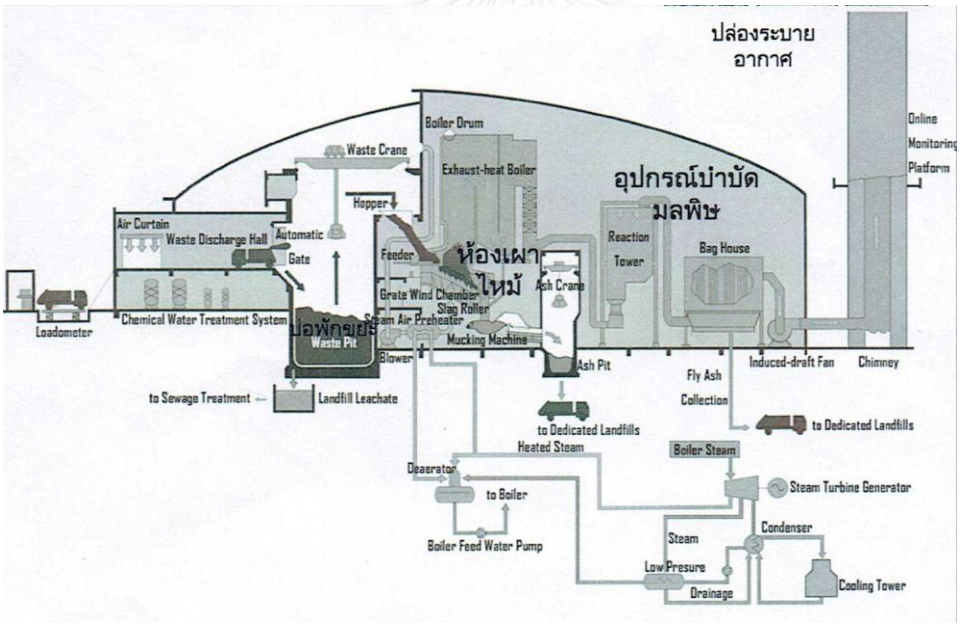


Figure 4. 6: Schematic diagram of Nong Khaem waste-to-energy facility
Source: BMA, 2016

2.) Indicator 2E – Quality of Environmental Protection of Waste Treatment and Disposal

On a qualitative point of view, the environmental protection of waste treatment and disposal was rated as medium/high (orange green as per was as per Wasteaware traffic light color coding), with a normalized score of 75% this evaluation is based on the following criteria:

- *2E.1 Degree of control over waste reception and general site management*

The degree of control over waste reception and general site management was rated medium/high. BMA declared during the interviews that landfills have clean and large access roads, with traffic management procedures, fences, access control, log of trucks, and supervision of unloading. Procedures in case of accidental fires exist. Only the procedures related to windblown litter, flies, vermin, birds, and mud on truck wheels have not been clarified.

- *2E.2 Degree of control over waste treatment and disposal*

The degree of control over waste treatment and disposal was considered medium/high for all three methods of disposal used, based on the technical elements defined by Wasteaware manual. For landfills, as mentioned 87% of waste collected in Bangkok is disposed through 2 main landfills located in Khampangsan, Nakornpathom province and Phanomsarakham, Chacheongsao province. In this regard, BMA confirmed that both landfills were staffed, daily covered by soil, waste was compacted using hydraulic press, leachate containment and LFG collection systems exists, and a post-closure plan also exists when the site is full. For thermal treatment which is located in Nong Khaem, BMA also confirmed that there were particulate emissions control, management of ashes, systems in place to capture acid gas and toxin, and the full process was temperature controlled. For biological treatment which is located in On nuch, incoming materials were hand and magnetically sorted, the process was

temperature controlled, there was leachate collection and treatment, odors were controlled by spraying, and clear procedures exists. This was also in line with the regulations and guidelines of municipal solid waste management issued by Pollution Control department (Pollution Control Department, 1998). However, at the same time, a previous research noted insufficient level of control from BMA, and referred to Administration Court case related to unsanitary operation of Rajatheva landfill in Samut Prakarn province causing negative effects on the environment (Manomaivibool, 2005).

- *2E.3 Degree of monitoring and verification of environmental controls*

The degree of monitoring and verification of environmental controls was rated as medium/high. According to the interview with BMA, they confirmed that all official sites have a permit to operate and complies with local regulations. The surface water near sites, leachate and landfill gases were controlled, liquid from biological treatment were also controlled but not gases, and compost was tested by a laboratory. However, for thermal treatment moisture content and calorific values were not controlled

- *2E.4 Efficiency of energy generation and use*

The focus in this indicator was on the purpose of efficiency used for energy recovery facilities. In the case of Bangkok, the waste to energy facility exists and opened recently. However, the capacity of this facility was not significant as it processes only 500 tons of waste per day. Thus as this is an “optional” criterion I have decided not to use it and rated as N/A.

- *2E.5 Degree of technical competence in the planning, management and operation of the treatment and disposal*

The degree of technical competence in the planning, management and operation of the treatment and disposal was rated medium/high. Based on BMA interview, their management staff has appropriate educational background, and BMA provides regular training to its own staff. However no confirmation was given for any training of the staff of private operators (including landfills).

- *2E.6 Occupational health and safety*

Finally, in terms of occupational health and safety of staff working at treatment and disposal sites was rated medium/high. BMA declared that staff of private operators follows safe operation procedures, and all necessary protection material was used, but did not provided additional details. This also applied to private sector employees.

3&3R – Quality of Resource Management – Reduce, Reuse and Recycle

Quality of resource management in terms of 3Rs is composed of indicator 3 which is a quantitative assessment of the recycling rate (percentage of total MSW generated that is recycled), and a composite indicator 3R which is comprised of criteria 3R.1 to 3R.6, aiming at evaluating the quality of resource management in terms of reduce, reuse and recycle.

1.) Recycling Rate

On a quantitative point of view, Wasteaware analysis waste gives a "low/medium" rating (orange traffic light) in terms of recycling rate. According to PCD, 0.48 million tons per year (1,315 tons/day) were recycled in Bangkok, excluding composting (Pollution Control Department, 2016b). At the same time, 10% of waste collected by BMA (10,130 tons/day) was composted at On nuch district and 3% was disposed through thermal treatment at Nongkhaem, which represents about 11% of total waste. Based on this data, we can therefore identify that the recycling rate was about 23%, while the national recycling rate was about 21% (Pollution Control Department, 2016b). This showed that recycling rate has improved over time, as a study performed in 1994 was giving an estimate around 7.5% (Muttamara, 1994). However, as per Wasteaware manual, the range of recycling rate from 10-24% is considered as low/medium.

2.) Quality of Resources Management 3Rs – Reduce, Reuse, and Recycle.

On a qualitative point of view, composite indicator 3R was rated medium (traffic light orange) with a normalized score of 42%. The criteria described below led to this rating.

- *3R.1 Source separation of "dry recyclables"*

The analysis showed that clean source separation of "dry recyclables" was not fully sufficient, with a medium rating. Similarly to the previous indicator, BMA does not have precise statistics available as this is done either directly by households, or by informal sector. In addition, our survey made on 1,076 Bangkok residents showed that 65.8% of households declared that they separate at home. Moreover, 33.1% of respondents declared that they separate UHT Packaging. This showed that about 33.2% to 65.8% of respondents make a clean source separation of dry recyclables. As per Wasteaware manual, an estimated rate of clean-source separated materials between 26% and 65%, which corresponds to a score of 10.

- *3R.2 Quality of recycled organic materials*

The quality of recycled organic materials was also rated medium. As per Wasteaware manual, this focused on how much organic materials were recycled and on the standard of separation at sources such as household, restaurant or commercial. In the case of Bangkok, the segregation of food waste does not exist at household level but some commercials such as shopping malls, restaurants or canteens do separate and then sell it to farmers. Moreover, a good level of separation was done at the composting facility, as both magnetic and manual sorting was done before composting. However, as per Wasteaware manual, a score of 15 cannot be given as it requires all organic materials to be separated at source, but a score of 10 was selected as organic materials were thoroughly separated from other mixed waste at treatment facility.

- *3R.3 Focus on top levels of the waste hierarchy*

The focus on top levels of the waste hierarchy, which is to favor reduce first, then reuse, then recycle (Diaz, 2011) was also not very sufficient, rated medium as per Wasteaware criterion. According to the estimation in this research, waste generation in Bangkok is currently about 1.09 kg/person/day. Wasteaware manual defines that over 1 kg/person/day, is a higher waste generation city, and should concentrate on waste reduction / reuse activities in the evaluation. Interview with BMA confirmed that BMA have policies and promotion activities related to reuse of second hand products, including awards for students and general population. The 5 year plan exists with a target to reduce household waste by at least 7% in 5 years based on 3Rs principles. However, no information on extension of useful life by improved design or organized repair and refurbishment could be found and in terms of practice, and waste generation is still increasing recently. Moreover, the lack of financial allocation for promoting 3Rs is a key issue at district level.

- *3R.4 Integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system*

In terms of integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system. According to BMA interview, policies exist to include IRS in the waste management plan. The new public health act which was drafted by Ministry of Health formally allow private sector to collect MSW under specific conditions. IRS workers have access to some waste separated at source, and there are some forms of cooperation between BMA employees and IRS. For example, BMA declared that IRS is always invited to participate in community events related to MSW in terms of buying recyclables. BMA also make specific efforts to inform and get general public participation through communication and events, such as recycling awards. In addition, even though BMA have recognized the importance of IRS, there's up to now no program to promote or upgrade informal sectors in order to encourage waste separation at source. Moreover, BMA do not cooperate with IRS in terms of WEEE collection and did not allocate budget to district offices so they could

not promote community sectors unless they can find external support from other organizations. For these reasons the rating was low as per Wasteaware manual.

- *3R.5 Environmental protection in recycling*

The environmental protection in recycling was rated medium. As per BMA interview, the collection of recyclables and the collection of waste electric and electronic equipment (WEEE) is currently done by IRS. This process is not structured as it is done by independent operators. A regulation is currently under development to ensure private sector recalls their products after use, but this is not implemented yet. Regarding the clean steps of recycling process including collection and separation, some large operators such as Wongpanit exists for the processing of high value recyclables (PET, paper, WEEE...). This company claims to operate in compliance with all national as well as international regulations (Wongpanit, 2017). However, there are many junk dealers or recycle shops in Bangkok that are not in a good condition nor environmental sound.

Figure 4. 7: Local dealers or recycle shops in Bangkok area

- *3R.6 Occupational health and safety*

Finally, the occupational health and safety related to recycling activities is quite low. As confirmed during interview and on site survey, there is a partial compliance from BMA employees, as they generally receive appropriate clothing and equipment as well as basic health checks. However, some workers don't really use those equipment during working hours. Moreover, this does not apply to IRS workers and generally they collect recyclables waste with bare hands or with very limited protection.

Note: Photos taken in South Sathorn and Saladaeng roads on January 2017

Figure 4. 8: Evidence of waste collectors in Bangkok (both formal and informal sectors) working without personal protection equipment.

4.2.3. Benchmark Indicators for Governance Factors

The benchmark indicators under this component focus on the governance strategies to ensure that the waste management system is properly functioning system. It is composed of three major benchmark indicators; the inclusivity which includes indicator 4U – user inclusivity and indicator 4P – provider inclusivity. It focuses on the contribution and benefits of stakeholders in terms of service user as well as service provider. Second indicator is financial sustainability, this is to ensure that the services and activities of solid waste management are affordable and cost-effective. And the last is sound institutions and proactive policies.

1.) Benchmark Indicator for Inclusivity: 4U – User Inclusivity

Indicator 4U is a composite indicator that made of criteria 4U.1 to 4U.6, aiming at evaluating the degree to which the users of solid waste services have access to the services, but also are involved and can influence the way the services are planned and implemented.

Waste management of BMA could also be improved under this aspect. As per Wasteaware analysis of this composite indicator, an "Orange" (medium) traffic light qualitative assessment showed, equivalent to a normalized score of 42%.

- *4U.1 Equity of service provision*

In terms of equity of service provision, the rating was pretty low. As based on the field survey performed on a representative sample of 1,076 Bangkok respondents, the evaluation of satisfaction of respondents with the BMA solid waste collection service was performed using a 5-point Likert scale (1 = very dissatisfied, 2 = dissatisfied, 3 = unsure, 4 = satisfied, 5 = strongly satisfied). The average score was 2.86 (SD = 0.99), showing a slight dissatisfaction from Bangkok Residents. In addition, the interview with BMA explained that due to the narrow roads in high density areas, door-to-door service is not available and collection is not always done daily. Also, BMA does not provide any containers or bins to these area but request local residents to have their own.

- *4U.2 The right to be heard*

Concerning the right to be heard, the score rating was average. According to BMA, a law exists which requires participation of citizens (Public Health Act). But in practice, only main stakeholders who are relevant to the issue are invited to participate in decision making process of MSW. In addition, this survey showed that the population was generally not aware of BMA activities related to MSW but they can lodge their opinions on BMA service through hotline 1555 or directly at the local authority offices.

- *4U.3 Level of public involvement*

The level of public involvement was also rated medium in terms of public involvement in the decision making related to planning and implementation process of solid waste management. According to BMA interview, all appropriate tools and procedures exists to ensure a proper involvement of general public such as; the involvement representatives from public which includes woman, youth, and unions; also solid waste management committees, taskforce or working groups are established and meeting regularly. However, in terms of practice, only 19.9% of the respondents to our field survey declared being aware of a BMA activity in their neighborhoods in the past year. Moreover, from the survey of BMA officials, they do work with the registered communities but not cover the entire Bangkok population which means residents in the areas that are not registered as communities have lower chance to get involve in BMA activities.

- *4U.4 Public feedback mechanisms*

Regarding public feedback mechanisms, the rating was medium. A hotline exists to report issues on any metropolitan service and get feedback from the population. The hotline is easily accessible by dialing 1555. However, this is not dedicated to only waste, but a general hotline for all BMA services. In addition, the population in Bangkok can also notify any problems related to waste directly at the local authority offices in their communities. But again there is no clear evidence whether the feedback from citizen or their opinions affect choices or decisions making.

- *4U.5 Public education and awareness*

In terms of public education and awareness, the rating was medium. Based on the interview with BMA in June 2016, BMA do invest on communication and awareness which is managed jointly by communication and environmental departments of BMA. The budget for education and awareness which is including public relations is basically about 100 million Thai baht, or not more than 150 million Thai baht annually. This includes communication campaigns and community events related to waste separation and recycling, or related to city cleanness. However, in the latest fiscal

year the budget was reduced to 20 million Thai baht. This budget is quite low compared to the budget for waste collection and disposal which is about 6,000 million Thai baht per year. Moreover, the budget on public education is not provided to district offices.

- *4U.6 The effectiveness in achieving behavior change*

Finally, the effectiveness in achieving behavior change was evaluated to be low. Based on the field survey, it seemed that campaigns or activities related to waste increased a bit the waste separation behavior. 63% of respondents who declared being unaware of campaigns or activities related to waste do separate at source, while 77.8% of those who were aware do separate waste at source. There was a statistically significant relationship at 0.05 level between awareness of waste related activity and separation behavior as presented in the crosstab analysis in Annex 4: Household survey elements used in Wasteaware analysis, Table 3, X^2 (1, N = 1,076) = 16.10, p = .000. Also, the BMA's report claimed that the MSW volume has been increased recently but still lower than JBIC predictions, which is mainly due to the effectiveness of campaigns promoting the participation of citizens (BMA, 2014b). However, as previously mentioned, even though the waste generation volume is lower than the estimation, but in reality the quantity of waste is still increasing each year. And regarding to waste separation at source, it is still considered as low as most of most of source separation is done for high value recyclables only such as pet bottles, cans, papers or metals but not for food waste. And following 4U.5 indicator, due to a low budget on public education and awareness, it's hard to identify an obvious change in behavior of population regarding their practices on waste handling.

2.) Benchmark Indicator for Inclusivity: 4P - Provider Inclusivity

Indicator 4P is a composite indicator made of criteria 4P.1 to 4P.5, which objective is the evaluation of the degree to which service providers (including formal private, community, and informal sectors) are included in the planning and implementation of MSW and recycling services and activities.

This composite indicator showed a medium performance, with a yellow traffic light, for a score of 50%. In order to evaluate this indicator, this study considered

that service providers in Bangkok were mainly private sector contracted by BMA for several types of services, which includes the rental of collection trucks, operation of landfills or operation of engineered compost (BMA, 2014a), but also private sector and Informal Recycling Sector operating in the field or Recyclable Waste, from collection to sorting and processing.

- *4P.1 Legal framework*

The first element considered by Wasteaware to calculate this composite indicator is legal framework. This assessment was medium. According to the interview with BMA, they confirmed that there's a regulation related to public private partnership that's been applied to MSW management with a clear guideline of service contracts. However, BMA also confirmed that there is no national or local regulation related to private sector participation (PSP) or community based organizations (CBO) that apply to MSW management. The Public Health Act includes a clear provision allowing municipalities to use private sector to fulfil their duty in terms of waste management (UNEP, 2009b). The Regulation and Guidelines of Solid Waste Management by PCD also gives details on requirements for private sectors operators (Pollution Control Department, 1998). However these guidelines does not include guidance for service contract itself.

- *4P.2 Representation of the private sector*

The second criterion reviewed within this composite indicator is the representation of the private sector, which was medium. According to BMA interview, regular meetings are organized with private sector companies involved in waste management such as truck rentals or landfill management. However neither literature review nor interview gives evidence of a formal process involving all private sector stakeholders.

- *4P.3 Role of informal and community sector*

Thirdly, the review of the role of IRS and community sector was low. As per interview, BMA recognized that the informal sector is "quite important" in terms of

waste collection, recycling and reuse. They also recognizes this role by giving access to recyclable materials separated at source, and letting informal sector to collect WEEE. However, similarly to 3R.4 indicator, BMA do not concentrate on promoting or upgrading informal sectors in order to support and enhance waste separation at source. Moreover, as BMA allows IRS to collect WEEE by themselves, it is also important that BMA give more focus or control on both collection and separation as WEEE is regarded as hazardous waste. In terms of promoting community sectors at district level, BMA did not allocate budget to local authority so they could not promote community sectors unless they can find external support from other organizations.

- *4P.4 The balance of public vs. private sector interests in delivering services*

The fourth element of this category is the balance of public vs. private sector interests in delivering services. This is quite subjective, but the assessment was medium. According to BMA interview, it is complicated to consider the balance between public and private sector interest in delivering services. The best service is sometimes not affordable, therefore the service provider selection is usually based on BMA's budget.

- *4P.5 Bid processes*

Finally, the bid processes used for provider selection. The focus here was to ensure that there was no corruption during the bid processes, thus the whole processes should be transparent and open for all sectors. And as per Wasteaware manual, it was rated medium as BMA did not respond on this part during the interview. However, according to a 2005 published paper, there is a bid process for the attribution of treatment facilities and landfills. But the researcher gives the example of the tender process for Chachoengsao landfill bidding which was under heavy lobbying, causing that only former contractors submitted and won the bids (Manomaivibool, 2005). This tended to confirm that if formal Bidding Process exists, significant improvements were possible in this field. Also a recent article from Thai online newspaper stated that a cement company (TPI) wanted to buy MSW from BKK for energy recovery in its cement kiln which would cost about 134 million Thai baht. However, for some reasons

BKK didn't want to sell them and chose to pay disposal costs (which is much higher, 531 million Thai baht) to landfill operators. This is still remaining as a very questionable issue. (Manager Online, 2016).

3.) Indicator 5 - Financial Sustainability

Indicator 5 is also composite indicator made of criteria 5F.1 to 5F.6. This indicator evaluated to which degree the city's solid waste management service was financially sustainable.

The Wasteaware analysis showed that financial sustainability is relatively adequate in terms or MSW management in Bangkok. The normalized score for this category was 71%, which correspond to "orange green" traffic light code for Medium/High.

- *5F.1 Cost accounting*

Firstly the cost accounting, as BMA waste management is clearly defined and controlled, which allows a "high" rating. The total cost of waste management in BMA was about 6,500 million Thai baht (or over 184 million USD) in the year 2015 but they can get it back from waste fees only 7%, as confirmed during interview. BMA also indicated that their accounts were public and audited by independent authority.

- *5F.2* Coverage of the available budget

Secondly, the coverage of the available budget was medium/high. This budget seemed to be sufficient to mostly cover BMA operation costs as well as some improvements. According to BMA interview, the current budget fully covering current operation costs. Some improvements have been recently implemented, such as the opening of the first thermal treatment facility. However BMA indicates that budget restraints forces to select contractors (disposal, transport) based on cost more than on quality.

- *5F.3 Local cost recovery from households*

The local cost recovery from households was rated high. Based on Wasteaware manual, the focus of this indicator is on the number of households that is using and paying for primary waste collection services. According to our survey made on 1,076 Bangkok residents, over 84% declared paying a waste collection fee to BMA. Based on the interview with BMA together with their yearly report, BMA declared that the total percentage of waste collection fees covered only 7% of the waste management costs. Considering waste collection fee, it is particularly low compared to total waste management cost. However, as this indicator is more focusing on percentage of total number of households that actually pay for waste collection service fee and NOT the percentage of total cost, therefore the score given here was maximum as per Wasteaware manual, 75 to 100% should be rated for 20.

- *5F.4 Affordability of user charges*

A negative point was however about the affordability of user charges. Rating in this case was 0 (None), as according to BMA interview there is currently no system to subsidy or reduce waste collection fees for users that can least afford it. Also in the case of Bangkok, the waste collection fee itself is already very low, only 20 baht (less than 1USD) per month per household, which actually can be affordable by the general public.

- *5F.5 Coverage of disposal costs*

The coverage of disposal costs gets maximum rating of 20 under Wasteaware evaluation grid. For landfill, a fee charged by ton is paid to the private operators and depends on the contract with the operator. In 2014, it was 438 to 535 THB / ton (12-15 USD), depending on the landfill site (Manomaivibool, 2005). This was believed to be sufficient as it was proposed by the private operator himself by bidding process. Composting is also charged using a similar principle. The obligation to have closure plans is also an obligation for the private sector operator as per PCD regulations

(Pollution Control Department, 2016a); it is therefore believed that this is included in the price per ton offered by private sector bidders.

- *5F.6 Access to capital investment*

Finally, the access to capital investment gets an average score of 10. BMA declared having adequate funds to invest new infrastructure but not to extend coverage of service. The source of these funds are mainly from private sector investment and BMA budget, but does not benefit from grants or government investment. In addition, potential projects using Carbon Development Mechanism related to MSW have been studied such as anaerobic digestion and gasification (Siriratpiriya, 2014). Also landfill gas recovery in Kampangsaen is under CDM project but as there is no more Kyoto protocol, there is no CDM projects getting carbon credits.

4.) Benchmark Indicator for Sound Institutions and Proactive Policies: 6N - National SWM Framework

Indicator 6N is a composite indicator that made of criteria 6N.1 to 6N.6. This indicator assesses the adequacy of the national solid waste management framework as well as its degree of implementation.

The overall evaluation of the National solid waste management framework was medium, with a normalized score of 50%.

- *6N.1 Legislation and regulations*

In terms of national legislation and regulations, Wasteaware scoring was medium, in particular because Thailand has currently no approved national law or regulation specifically dedicated to MSW. Provisions related to MSW are included in other regulations such as Public Health Act B.E 2535 (A.D 1992), the Cleanliness and Orderliness Act B.E 2535, the National Environment Quality Act B.E 2535, Royal Factory Act 2535. A new National Cleanliness and Orderliness Act, under the Ministry of Interior, has been enforced in 2016 (Ministry of Interior, 2016). This Act was amended to deal with municipal solid waste, but not cover other types of waste (industrial waste, infectious waste, household hazardous waste).

- *6N.2 Strategy and policy*

The analysis showed an above average situation in terms of strategy and policy, as the MSW issue is cited in national plans such as the 12th National Economic and Social Development plan 2017-2021 which plans to increase the capacity of community waste management by 75% (National News Bureau of Thailand, 2016). Also, an Integrated Waste Management Roadmap from August 2014 and a National Waste Management Master plan exist. A yearly action plan, called "Thailand without waste" also exists for year 2016-2017 (Department of Local Administration and Pollution Control Department, 2016), and the implementation of the roadmap is regularly reviewed at Prime Minister office level (Royal Thai Government, 2015).

- *6N.3 Guidelines and implementation procedures*

Regarding guidelines and implementation procedures, Wasteaware scoring was also average. According to secondary data, this research found that some guidelines for local authorities on how to implement the law and strategy exist. For example the Waste Management Roadmap includes some detailed actions for "crisis provinces" (Phra Nakhon Si Ayutthaya, Nakhon Pathom, Saraburi, Lopburi, Pathum Thani, and Samut Prakan) such as landfills closure plans, or development of feasibility studies for new waste to energy sites. There is also clear guidelines for EIA that exists, as it is compulsory for all types and all sizes of waste treatment plant or buried garbage, and a single agency is in charge of reviewing these EIA: The Environmental Impact Evaluation Bureau (EIEB) (Thailand Board of Investment, 2014). But ~~we have~~ no information on guidelines to extend the collection services, the increase of recycling rates, and the improvement of environmental standards. Also no information on how requests from “Not In My Backyard” (NIMBY) movements were treated.

- *6N.4 National institution responsible for implementing solid waste management policy*

Also Thailand is clearly missing a single institution responsible for implementing solid waste management policy, and this element was rated medium/low according to Wasteaware criteria. The responsibilities are shared between several

departments from six different ministries, namely the Ministry of Natural Resources and Environment, the Ministry of Industry, the Ministry of Public Health, the Ministry of Interior, the Ministry of Energy and the Ministry of Sciences and Technology (Pollution Control Department, 2009a).

- *6N.5 Regulatory control and enforcement*

In terms of regulatory control and enforcement, the absence of a single institution in charge of waste was also a reason why this element was rated as average. According to the interview with BMA, there is a well-organized department in charge of environmental regulation enforcement. However, in terms of practice across the whole country or efficiency of this department in permitting and inspecting waste disposal and treatment site, BMA gave an average rating during interview.

- *6N.6 Extended producer responsibility (EPR) or product stewardship (PS)*

Finally, the national regulatory framework is also lacking regulations involving private manufacturers in the waste management of their products. An extended producer responsibility regulation is currently under development but not implemented yet. A few local partnerships exists with private sector, such as for example Chatuchak District Recycle 360 project in collaboration with Coca Cola Foundation, however these PPP projects are not clearly based on EPR or PS principle. (BMA, 2014a).

5.) Benchmark Indicator for Sound Institutions and Proactive Policies: 6L - Local Institutional Coherence

Indicator 6L is a composite indicator that made of criteria 6L.1 to 6L.6. This indicator is similar to indicator 6N, but focusing on Local level, also this indicator assesses the institutional strength and coherence municipal solid waste management functions.

As a result from Wasteaware analysis system, local institutional coherence was also rated medium (orange traffic light) with a normalized score of 50%.

- *6L.1 Organizational structure/coherence*

In terms of organizational structure, the score given was average as per Wasteaware manual. BMA has quite clear structure but lack a single organization or department responsible for solid waste management as it is split into two main departments. Solid waste management planning is under the responsibility of the Environmental Department for the central administration and the Public Cleaning and Parks subdivision in 50 districts for districts administration, waste collection and 3Rs promotion. So the organization structure is quite clear. In addition, the budget for solid waste management does not fall into a single organization, but is split between the departments in charge.

- *6L.2 Institutional capacity*

In terms of institutional capacity, our assessment was also average. According to BMA interview, a clear organization chart of the departments in charge exists, and BMA declared that all functions were currently staffed. However, no evidence was given by BMA that the educational background of the staff in charge is appropriate. Similarly, BMA provides yearly training of their staff both in classrooms and in the field, but no evidence on the training results was provided. BMA also declared during interview that career progression plans exists.

- *6L.3 City-wide solid waste management strategy and waste plan*

A clear city-wide strategy and waste management plan also exists at local level, both a 20 years plan as well as a five years plan exist and were still valid. According to BMA interview, these plans were in line with national strategy. The BMA also confirmed that they have sufficient funds and staff to implement this plan. However, as stated in indicator 3R.4, 4U.5, and 4P.3, local level still lack budget allocation on several elements including the promotion on waste reduction activities and separation. Thus, the score given was medium as per Wasteaware manual.

- *6L.4 Availability and quality of solid waste management data*

In terms of availability and quality of solid waste management data, the situation is assessed average. BMA confirmed that Management Information System (MIS) is in place and the data on waste management is regularly collected, measured, and monitored. There is a daily monitoring quantity of waste collected and quantity of waste treated. For waste composition, there is a monthly monitoring which is done at transfer stations. However, the date of latest dataset provided by BMA is from 2014, while a recent dataset is the key element of scoring following Wasteaware methodology, resulting in an average scoring.

- *6L.5 Management, control and supervision of service delivery*

The management, control and supervision of service delivery were also a mix of positive and negative elements resulting in medium rating as per Wasteaware assessment. BMA only confirmed during the interview that timing and position of trucks were controlled by GPS and by an online messaging system, but it seems that the quality of waste collection service is not. BMA also declared having staffed dedicated to check if landfills operate according to the law. However, other research suggests that the control of privately owned landfills by BMA is sometimes insufficient, citing an Administrative Court judgment blaming BMA for insufficient supervision of the operation of their contractor (Manomaivibool, 2005).

- *6L.6 Inter-municipal co-operation*

Finally, from the interview with BMA relates inter-municipal co-operation. A good working relationship with government bodies in charge of MSW management exists. Regulation, policy and planning on solid waste management is clear. However, the cooperation with government agencies is mainly related to MSW regulation and public communication but not funding or control and enforcement issues. As per Wasteaware manual, the score given in this criterion was medium.

4.2.4. Summary and Discussion

Regarding the assessment of Wasteware analysis related solid waste management in Bangkok, the overall results highlighted the strong and weak points under both physical and governance components. The most significant weak points for physical components were on the quality of resources management, the promotion of 3Rs and waste collection services. The good points were however demonstrated on waste capture by system, control treatment and disposal. While the most significant issues on governance factors related to waste management were inclusivity and sound institution proactive policies. In terms of financial sustainability, the analysis did not identified any significant problem, suggesting that this was not a key issue related to waste management by BMA.

- ***Physical components***

Some good points were highlighted under this components. Waste collection coverage, as well as the waste captured by the system were generally satisfactory in Bangkok. The waste treatment, even if the major part is landfill a relatively strong point as adequate technologies were in place to minimize the impacts on the environment. However, even if less critical than the governance part, some weak points were identified under physical components. This is in particular the case of resource management, both on quantitative and qualitative point of view. Quantitatively, the management of resources recovery has been improving but regarding the recycling rate in Bangkok, it is still considered as low. While waste volume has been increasing each year, the waste to energy remains marginal, and composting is only 10% of the waste collected by BMA. This key issue is due to a lack of separation at source, and in particular the segregation of organic waste. Qualitatively, the resources management under 3Rs principle also gets a relatively low rating with a score of 42%. This is in particular due to the low integration of the IRS into the formal waste management system, and some weak points have been found in terms of occupational health and safety of both BMA staff and IRS. While BMA waste collectors only very partially use basic safety equipment, IRS workers mostly work without any protection and collect

waste with their bare hands. On this elements, significant improvements can come from BMA, by imposing the use of safety equipment, enhancing the quality of social welfare and also building awareness on waste related healthcare issues. Moreover, cooperating much more closely with IRS is also important.

Another weak point was also on quality of waste collection services, showing some room for improvement. Even though the scoring result was average (50%), several elements still need to be improved. While waste transport is relatively good, the quality of street cleaning and the appearance of waste collection points can be significantly enhanced. Concentrating on waste accumulation, overflow bins and illegal dumping have been found particularly significant in high density areas. Waste should be fully captured by waste collectors each time, and providing more frequent collection service to such areas could be a solution.

- ***Governance components***

Based on Wasteaware analysis, the score of user inclusivity and the provider inclusivity was respectively at 42 and 45%. Regarding user inclusivity, this study showed that improvements were necessary on a number of elements, in particular by bringing an equal quality of service to all users. This is particularly true in some areas of Bangkok especially in high density areas, where door-to-door or daily service were not always available causing waste accumulation and therefore illegal dumping or open burning which may affect the environment and population health. In terms of user inclusivity, a key point needing improvement is the effectiveness in achieving a behavior change. The study noted that while communication and training actions related to solid waste from BMA exists, a large part of Bangkok residents were unaware of it, and this does not allow to reduce the waste generation, which continue to increase every year. One reason is the lack of specific financing support, in particular at district offices level, which limits the effectiveness of such actions.

Regarding provider inclusivity, this analysis also showed some significant issues requiring improvements. The most critical point under this category is the role of informal and community sector. As this is the case in many countries, the informal sector plays a central role in recyclable waste management. However, in Bangkok, even

if some form of cooperation exists, in particular at field level between formal and informal sector workers, not enough focus is given by BMA on supporting and controlling informal sector in order to improve waste separation. Moreover, enhancing the level of cooperation between BMA and IRS in terms of collecting hazardous waste is very important as currently BMA allows IRS to collect those waste by themselves.

The institutions and proactive policies related waste management, at both local and national levels, were also rated average with score of 50%, showing space for improvement. Regarding national institutions, while some legislative and regulatory framework exist, the analysis reveals that the weakest element comes from the lack of single institution in charge of waste management. Responsibilities were divided between numerous departments, which could limit the efficiency. Also, no regulatory framework exist to involve private manufacturers in waste management, and the Extended Producer Responsibility (EPR) regulation under development is not yet implemented. Regarding local institutions, the assessment was average on all criteria, which does not point out a specific key improvement, but more a necessity to strengthen the whole local institutional coherence.

Finally, it is very interesting to note that financial sustainability was not the main issue, and rather more a positive point with a scoring of 71%. Even if waste collection fees is very low and does not cover service costs, BMA have a budget to maintain the current quality of service, and to improve it under some aspects. The overall analysis results is presented in the below table:

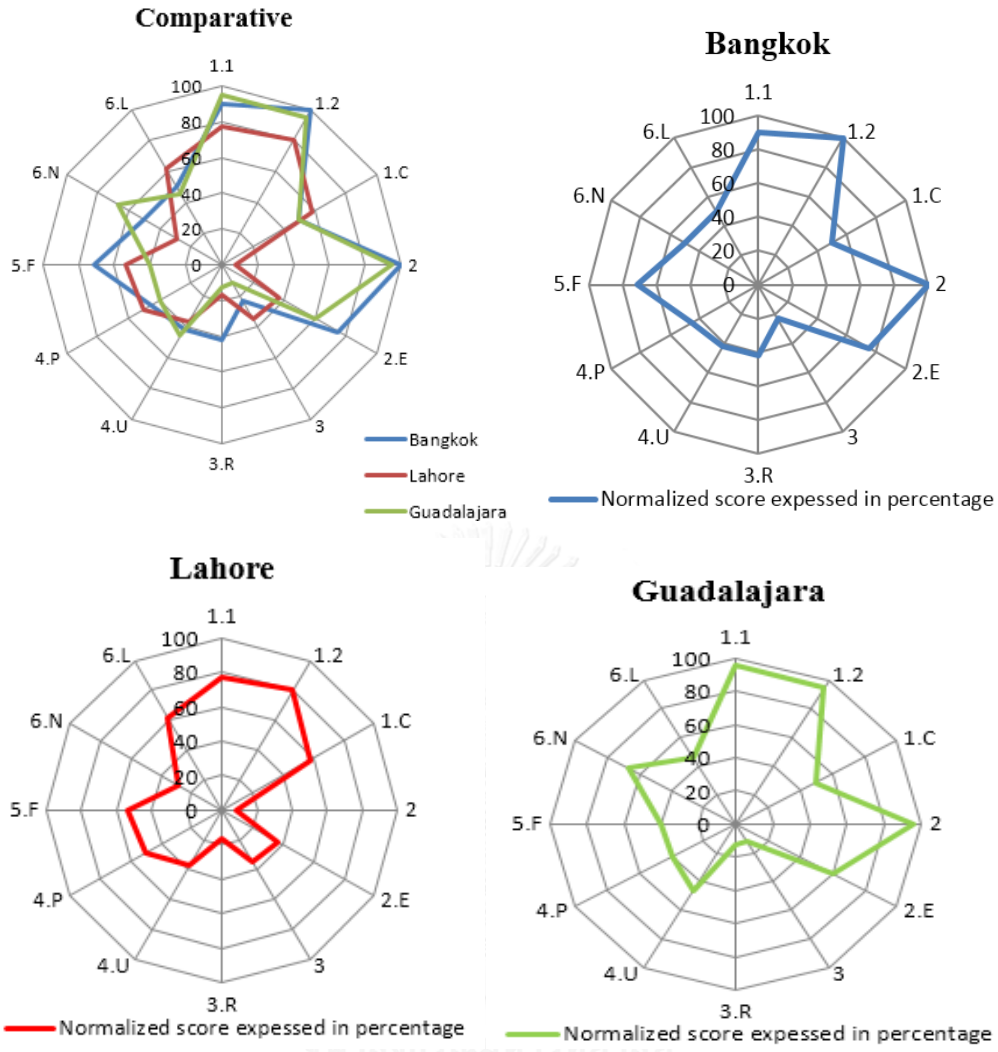
Table 4. 3: Wasteaware summary table for Bangkok

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			
		Upper Middle Income Economy	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	-	-	
		MSW per capita – 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			

- ***Comparasion with other cities***

Based on Wasteaware analysis results in Bangkok compare to other cities with similar level of development such as Lahore and Guadalajara, we can see that in middle income cities most of time the focus on 3Rs is much lower than other elements. However, it is interesting to note that while the recycling rate in Bangkok and Guadalajara is very low (23% in Bangkok and 12% in Guadalajara), the recycling rate in Lahore is quite high reaching 35% of total recycling rate. Meanwhile, Bangkok and Guadalajara have high focus on waste collection coverage, disposal, and environmental protection and waste treatment, Lahore seems to have much lower emphasizment on these elements particularly on control treatmeant and disposal which represent only 8% of controlled and 37% of environmental protection. In addition, the financing sustainability on waste management in bangkok is hightlighted to be a positive point, this element in Guadalajara is found to be a weak point (resulted 40% on Wasteaware assessment) as well as in Lahore (54%).

In this regard, to ensure the sustainabilty of MSW management in developing countries, the key elements that need to be improved are mainly on resource management, secondly inclusivities, and the last is sound institution proactive prolicies. Based on Wasteaware analysis, the comparasion of overall results of each cities are presented in the below radar graphs:



Physical Components
1.1 – Waste collection coverage
1.2 – Waste captured by the system
1C – Quality of waste collection service
2 – Controlled treatment and disposal
2.E – Quality of environmental protection and waste treatment.
3 – Recycle rate
3.R – Quality of 3Rs
Governance Factors
4.U – User inclusivity
4.P – Provider inclusivity
5.F – Financial sustainability
6.N – Adequacy of national solid waste management framework
6.L – Local institutional coherence

Figure 4. 9: Radar graph presenting Wasteaware analysis results for each indicator, for Bangkok and comparison to Lahore and Guadalaraja.

5. Households Survey on Factors Influencing Waste Separation Intention in Bangkok.

5.1. Detailed Methodology

5.1.1. Questionnaire Design

The collection of data related to factors influencing waste separation and recycling intention among Bangkok people was conducted through questionnaire. Full questionnaire is presented in Annex 3: Household survey questionnaire

In order to have the best understanding from the respondents, the questionnaires were designed using local language which is Thai language. The answers were collected using different methods, such as close-ended questions and through Likert 5 point scale as this is one of the most common models, ensuring a good understanding from the respondents with the midpoint that allows to express the idea of neutrality on a specific question (Russell Bernard, 2013).

The construction of the questionnaire was largely based on TPB and the CNAM. Both models have been widely used by previous studies and were considered as efficient to explain environment related behavior. The questions were therefore designed in order to evaluate the various parameters identified by both theories as being precursors of a pro-environmental behavior.

5.1.2. Case Study Selection and Sampling Design

To collect data on factors influencing waste separation intention among Bangkok population, this study determined the sample size by using Taro Yamane formula for calculating sample of the known population ($n = N / (1 + N^2)$) at the confidential level of 95% or a precision of ±5% (G.D. Israel). For the population of Bangkok, according to the National Statistical Office, 2015, the registration of the population was 5,692,284 people and the number of household was 2,672,423 in 2014. The calculated sample size would therefore be 400 samples at a confidence level of 95% as presented in Annex 5: Sample size calculation using Taro Yamane formula.

However, if include non-registered people, the total population in Bangkok would be about 10.6 million people (BMA, 2015; CCAC, 2015). In order to have a better reflection among Bangkok population, this research has set the sample size of 1,100 households.

For the areas selected, the researcher used stratified sampling method by first of all, selecting the six most representative areas (of 50 districts) with the highest number of homes in each neighborhood group. Then the sample selected were surveyed based on the number of households in each selected area as showing in the table below:

Table 5. 1: Selected Bangkok areas for households survey

Group of areas	**Selected areas**	**Number of households 2014**	**Number of questionnaires**
Bangkok Central Group	Huai Khwang District	65,131	143
Southern Bangkok Group	Suan Luang District	65,869	198
North Bangkok Group	Chatuchak District	99,740	212
Eastern Bangkok Group	Bang Kapi District	97,866	241
Northern Krung Thonburi	Chom Thong District	63,846	142
Southern Krung Thonburi	Bang Khun Thian District	80,667	164
Total		473,119	1,100

After the survey areas were set, the proportion of questionnaires were also determined to be distributed to both inside and outside of the established communities. This was to ensure that it covers the Bangkok population as much as possible.

The term "community" is referred to a group of people living together continuously and having similar lifestyle. The 2012 Regulation has divided the community into six categories as follows: high density community, urban community, suburban community, housing community, tall building community and housing estate community. In 2014, there were 2,060 established communities in Bangkok with the

total population of 2,097,727 people (37% of the total population) and 472,601 households (18% of total housing units in Bangkok). This research determined to survey 37% of the selected communities randomly in each area. The highest density areas that can represent low-income population were selected and housing estate communities represent middle to high income population. However, the team faced the difficulty of distributing questionnaires during the weekdays, where most people go out to work. Some of the questionnaires (15%) were distributed at the Bang Khun Thian Land Office and the Chom Thong District Office, where people went to contact the government, which allowed the research team to distribute more questionnaires.

The distribution of survey questionnaires was conducted from August 28, 2016 to September 13, 2016, on weekdays and weekends. Before doing survey, the distribution team was trained to get a deep understanding of the questions. In terms of data collection method, the self-administered survey was used to reduce the bias that may be caused by the interview. However, if the sample groups were pretty old or having poor eyesight, the team helped reading and filling out the questionnaire. From the total of 1,100 questionnaires, 1,090 questionnaires were returned but there were 14 questionnaires that were incomplete, thus the total questionnaire with full answers was 1,076 sets.

5.1.3. Definition of Assumptions for Data Analysis

In order to identify the factors influencing waste separation intention among Bangkok households, several assumptions have been defined. These assumptions were based on significant factors identified by several research papers presented in literature review part, both in Thailand, worldwide, and the factors defined by TPB and CNAM

The first assumption was based on most significant demographic and economic variables which influence waste separation behavior, according to international studies presented in literature review. This study was trying to confirm that the same applies to Bangkok population.

The following assumptions (assumption2, 3, and 4) were based on TPB model, and intends to confirm the influence of attitude, perceived behavioral control

and subjective norm in the waste separation intention. It was also based on literature review, as TPB is commonly used in papers related to MSW.

The four last assumptions were related to other predictors found in the literature review to commonly influence the intention to separate. This includes situational factors such as past behaviors and recycling infrastructure availability, trust in the MSW collection service, perceived information level and knowledge about local MSW situation.

Assumption 1 Socio demographic factors have a significant influence on waste separation intention.

Assumption 2 Attitude, such as general concerns about environmental or MSW issues, increases waste separation intention.

Assumption 3 Perceived behavioral control, such as know on how to separate, or sufficient space to separate influences waste separation intention.

Assumption 4 Subjective norm, such as separating because of the influence of family, friends, neighbors, or because of feelings of responsibility and guilty, increases separation intention.

Assumption 5 Situational factors, such as past waste separation behavior at home or workplace, and recycling infrastructure, increase waste separation intention.

Assumption 6 Trust in MSW service, knowing that collection staff will not dump separated waste together, increases waste separation intention

Assumption 7 Perceived information level, such as waste separation knowledge acquired from school, medias or authorities, increases the waste separation intention.

Assumption 8 General knowledge about waste situation, such as knowing the quantity of collected waste daily or the location of landfills, increases the waste separation intention.

5.1.4. Analysis Methodology

In order to analyze all factors that influence waste separation intention, the collected data were run using SPSS Statistics 22 software under Windows 7 environment, after coding several variables into dummy variables. Descriptive statistics were extracted for demographic variables, including mean, standard deviation and frequency distribution of demographic factors. In addition, some main reasons to separate and not separate also were described and presented using graphs.

Logistic regression analysis was then used to estimate the significance of the explanatory variables. Logistic regression fits well this study as it is designed to be performed with a binomial dependent variable, and several independent variables which can be binomial or continuous (scales). It allowed to model the chances of an outcome, such as an intention to separate, depending on several factors (Sperandei, 2014). Direct logistic regression was preferred to sequential logistic regression as this research does not indicate any order of importance between the assumptions. All the predictors (independent variables) were therefore entered in the equation at the same time. The potential predictors that were related to this research assumptions were first selected from the questionnaire. The first list of predictors was composed of both demographic categorical variables, and ordinal variables presented in Likert 5 point scales. For socio-demographic variables, the ones that appeared to be most significant according to literature review were kept as predictors of the logistic regression.

In order to reduce the number of predictors in this model, the researcher grouped some questions into components thus, new variables were created by computing several variables into composite variables using mean values. This allowed to build a final model, mixing the statistically significant socio-demographic variables

and the components created. The model was then tested by various means. A first test was to check if the sample (N=1,076) was large enough to accommodate the number of factors in the regression by using the "rule of thumb" for logistic regression which states that the sample size should be at least equal to 50 + 8n where n equals the number of independent variables (C. Wilson and Morgan, 2007). An omnibus test of the model coefficients was also used to test the improvement of the model compared to the null model. Also, a Goodness-of-fit test was performed using the Hosmer & Lemeshow test. In the case of a logistic regression, a non-significant Hosmer & Lemeshow test where $p>0.05$ suggests that the model was fit to the data well (Peng, Lee, and Ingersoll, 2010). Nigelkerke R^2 was finally applied to check the goodness-of-fit of the model, and check the overall statistical significance of the variables at a level of 0.05.

In order to test the statistical significance of the regression coefficients (β),Wald Chi Square was used and the statistical significance was tested at 0.1 level, 0.05 level and 0.01 level. The influence of each statistically significant predictor on the dependent variable was finally commented.

5.2. Data Analysis Results

5.2.1. Descriptive Analysis

Gender

From 1,076 valid survey questionnaires, the respondents were well balanced between male and female (51% female, 49% male). Male seems however a bit over-represented in this research sample compared with the latest BMA statistical data, female being 53% while male is only 47% of Bangkok registered population (BMA, 2014b).

Age

The age of respondents ranged from 18 years old and a maximum of 82 years old (M = 41.0, SD = 17.07). To ease presentation, age were grouped into three main categories of dummy variables. The first group was "Age_young" which represents the respondents who were aged from 18 to 24 years old, second was "Age_middle" which

represents people who were 25 to 49 years old, and the last group was “Age Old” which represents the age of respondents from 50 years old and over. This grouping is similar to the ones used in other MSW related research (Nguyen et al., 2015; Saphores and Nixon, 2014), and was selected to match the official grouping of BMA statistics, allowing an easy comparison (BMA, 2014b).

The sample group however did not seem to present an appropriate representation on Bangkok population as 25 to 49 years old range was over-represented (58.2%) compared with Bangkok statistics data (38.0%) (BMA, 2014b). This was mainly due to the fact that this research only selected respondents who were above 18 years old. In addition, another element can come from the fact that BMA statistics only includes Bangkok registered population, which may have a different age profile compared to the total population.

Marital status and education

Over half of the respondents were married or divorced (58.3%) and 57.7% were having level of education under bachelor degree. This figure was in line with Bangkok average years of educational attainment at 12 years.

Employment

In order to reduce the number of variable under job categories, this research performed some grouping using dummy variables before analyzing. All respondents’ profession were grouped into three main variables. The first was “employees” which represents government workers, private company workers, employees, labor and maids. Self-employed, seller and farmer were grouped under “Small Business”, while students and retired or unemployed people were grouped under “Unemployed” category. From the analysis result, 61.7% of respondents were employees while 28.3% were in small business category, and 9.5% were in the unemployed category.

Household size

The household size was also grouped using dummy variables into three groups representing small, medium and large. The small group is referred to households which have member from 1 to 3 people, while medium group is households that were having member from 4 to 6 people, and large group represents households with over 6 members. Based on the analysis, small households represented 48.9% of respondents, while medium households was 41.6%, and large households was 9.5%. The households size of respondents ranged from 1 to 20 persons (M = 3.9, SD = 2.2) and households which had kid ranged from 1 to 5 children per household (M = 0.6, SD = 0.9).

Household income

Based on questionnaire design, the household income was grouped into three main groups before an analysis. The first group represents households that earned lower than THB 30,000 per month as "low income households", while second group "middle income households" is referred to households that earn from THB 30,001 – 60,000 per month, and the last group is "high income household" earning between THB 60,001 – 80,001 and over. Based on the analysis, it showed that over half or 56.3% of the respondents earned below THB 30,000 per month which equivalent to USD 850 (the two most represented groups being people who earned between THB 10,001 to 20,000 per month and THB 20,001 to 30,000 per month). The households with an income comprised between THB 30,001 and 60,000 represented 24.5% of the sample, while households earning more than THB 60,001 per month represented only 19.1% of respondents. This figure did not seem to be in line with official Bangkok statistics, as the average households income of Thai people is about THB 40,000 per month (BMA, 2014b). Knowing that the mean number of members is 3.9 persons, low income households seem over-represented in this sample. This could be due to the fact this is self-declared and respondents were reluctant to give their actual income. It could also come from a confusion from the respondent, giving their personal income rather than the household income.

Type of housing and housing ownership

Single house and townhouse were grouped in one category as "House / Townhouse", while apartments, buildings, flats or condominium were grouped under "Building / Apartment / Condominium" category. From the analysis, the majority of respondents which represent more than half or 54.3% were living in a house or a townhouse, while 45.6% of respondents were living in a building, an apartment or condominium. Also most of them (59.8%) were owning their houses while 39.9% were renting.

Number of years in the community

The sample groups selected were in their communities with the average year of living about 16 years. The minimum was 1 year, and the maximum was about 79 years (M = 16.0, SD = 14.4). The number of years in the community was also grouped using dummy variables into four groups: first is less than 2 years, second is 2 to 5 years, third is 6 to 10 years, and the last is over 10 years. The analysis showed that a large number of the respondents representing 48.4% had lived in their communities for over 10 years. For the remaining respondents, 8.4% lived in their communities for less than 2 years, 22.7% from 2 to 5 years and 20.5% between 6 to 10 years.

Ownership of a vehicle

The large majority of households who responded in this survey owned a vehicle, being either a car or a motorbike (83.8%).

Table 5. 2: Demographic information of respondents after grouping (N = 1,076)

Variable	**Categories**	**Percentage**
Gender	Male	49.0
	Female	51.0
Age	Under 25 years old	10.6
	25 – 49 years old	58.2
	50 years old and over	31.2
Marital status	Single	41.7
	Married and divorced	58.3
Education	Less than bachelor	57.7
	Bachelor and higher	42.3
Job	Employees	61.7
	Small business	28.3
	Unemployed	9.5
Household size	1 to 3 persons	48.9
	4 to 6 persons	41.6
	Over 6 persons	9.5
Household income	0 – 30,000 THB	56.3
	30,001 – 60,000 THB	24.5
	60,001 THB and over	19.1
Type of housing	House / townhouse	54.3
	Building / apartment / condominium	45.6
Housing ownership	Own	59.8
	Rent	39.9
Years in the community	Less than 2 years	8.4
	2 to 5 years	22.7
	6 to 10 years	20.5
	Over 10 years	48.4
Own a vehicle	Do not own vehicle	16.2
	Own vehicle	83.8

Main reasons to separate waste

In addition to the socio-demographic characteristics, the reason why people separate waste or not to separate waste during the past year have been studied using descriptive statistics. In this regard, the analysis results showed that large number of respondents (65.8%) declared that they separated their waste regularly at home during the past year. And the reasons to do so were mainly based on economic incentive or sales revenue (310 respondents), followed by environmental reason with the willingness to preserve the environment (285 respondents) and about 100 respondents declared they did waste separation to assist people with low income, or for other reasons. For convenience of interpretation, the answers are presented in the graph below.

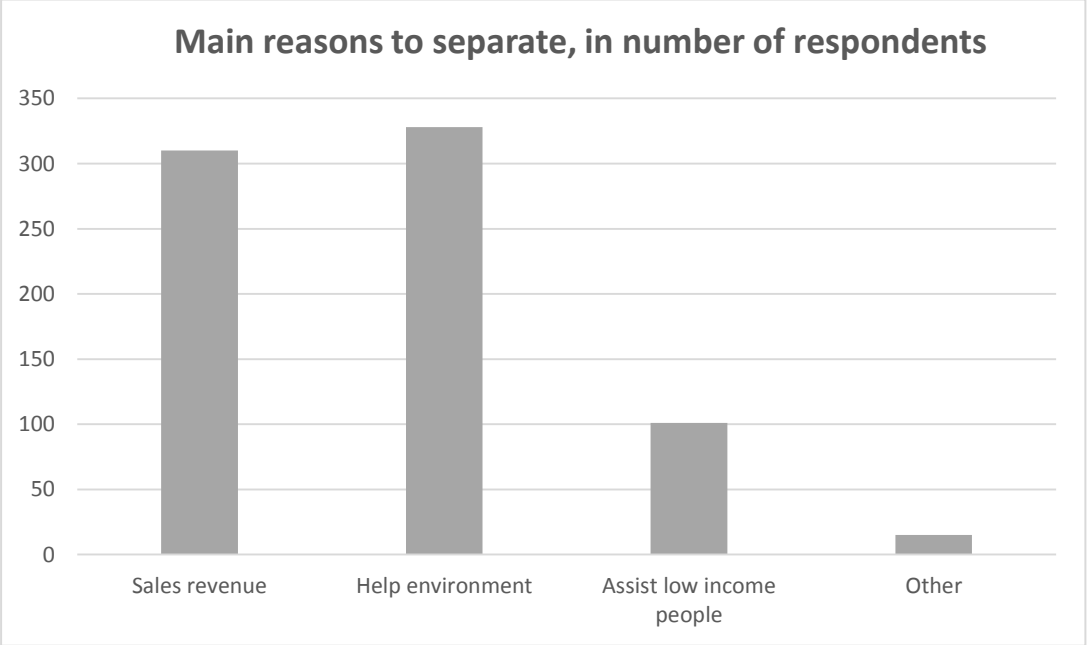


Figure 5. 1: Main reasons for separating MSW at home during the past year

Main reasons not to separate

From 1,076 respondents, 34.2% declared that they did not separated their waste regularly at home during the past year. And the reasons of not doing so were mainly due to the lack of space (127 respondents), and the lack of infrastructure or waste segregation bins at home (126 respondents). Another interesting reason is that 121 of respondents declared that they did not separate waste because of either being

lazy, not interested or had no time and other reason was due to the lack of knowledge on how to separate waste.

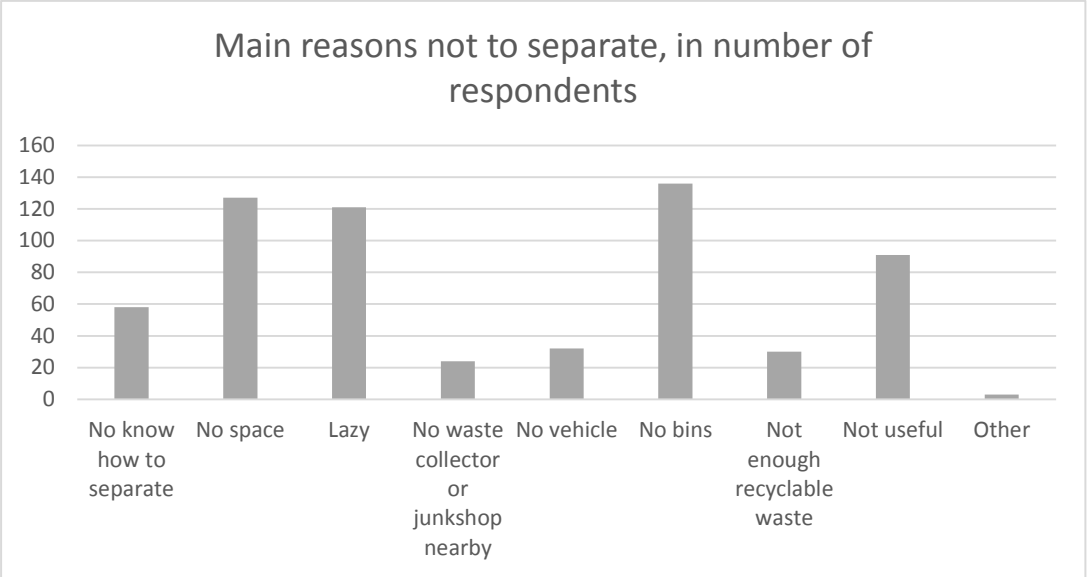


Figure 5. 2: Main reasons for not separating MSW at home during the past year

5.2.2. Variable Selection for Logistic Regression

A traditional approach when building a model to perform a logistic regression is to try to reduce the number of variables to ensure the model is more stable (Hosmer, 2000). However, as the sample group in this research was relatively large (N=1,076), this research model can accommodate a significant number of independent variables. The "rule of thumb" for logistic regression is that the sample size should be at least equal to 50 + 8n where n equals the number of independent variables, which means that this model could theoretically include up to (1,076 – 50)/8 = 128 independent variables. (C. Wilson and Morgan, 2007). Thus, the predictors used in logistic regression were selected based on the following steps: first, by selecting all questions that relevant to the assumptions from the questionnaires. Secondly, some ordinal variables evaluated on Likert 5 point scales were grouped into components based on TPB and CNAM using mean values.

- Selection of dependent variable

To test the intention on waste separation, question 2.9 of the questionnaire was selected, which gives an indication on the short-term intention to separate, in the coming month: “In the future (1 month), will you separate your waste on a regular basis at home or not?” This variable was coded into a new dummy binary variable called “Intention_yes” where “Yes” =1 and “No”=0.

- Selection of socio-economic independent variables

As the first assumption of this study is that socio demographic factors have a significant influence on waste separation intention, therefore, the first step was to transform all data when necessary into dummy variables. Then the most common socio-economic variables found significant in other studies were selected to be used as predictors of the intention to separate in the regression model. This included the seven following variables:

Based on the analysis result in the above table, five variables were selected to be used as predictors of intention to separate in the regression, as follows:

- “Gender_Female”, a binomial variable where female respondents were coded 1, and others 0.
- “Age”, a scale variable expressing the age of the respondent in years.
- “Marital_Married_Divorced”, a binomial variable coded 1 for respondents who answered Married or Divorced, and 0 for all other respondents.
- “Edu_Bachelor_over”, a binomial variable coded 1 for respondents who graduated from bachelor degree or higher, and 0 for all other respondents.
- “Household_Income”, an ordinal variable with 9 groups of household income from “less than 10,000 baht” to “80,001 bath up”
- “Housing_House”, a binomial variable where answers “single house” and “townhouse” were coded 1 and all other types of residence were coded 0.
- “Period”, a scale variable expressing the number of years of residence in the neighborhood.

- Definition of composite variables

In order to reduce the number of predictors in the logistic regression, several ordinal factors were grouped into composite variables using means as follows:

Table 5. 3: Variable grouped into Components, using mean.

Component 1.1 : ATTITUDE – Attitude towards environmental problems	
3.1.1	We are approaching a point where the natural resources cannot support the world's population anymore.
3.1.2	If human continue behaving this way, we will soon face an ecological catastrophe.
3.1.6	Even if the environment is getting worse, I still think that economic issues are more important than environmental issues. [(a)]
Component 1.2: ATTITUDE – Attitude towards climate change issue.	
3.1.3	Climate change or global warming is a serious problem and a very actual issue.
3.1.4	We should give priority to solving the problem of global warming. Even though the solutions that will impact negatively on economic growth and employment (For example increasing taxes on products generating carbon emissions will result in higher prices for goods and services).
3.1.5	I'm willing to pay more for goods and services that helps help reduce global warming. (For example having to pay an additional150. Baht per month for electricity or fuel from clean energy).
Component 1.3 : ATTITUDE - Attitude towards waste problems	
3.2.1	Solving the issue of pollution related to MSW is the responsibility of the government and local authorities, not mine.[(a)]
3.2.2	I think the issue of country waste is getting more and more serious and will impact on the environment and human health.
3.2.3	If we all participate to reduce and separate waste, It will help to solve the country MSW issue.
3.2.4	Waste separation helps reduce global warming.

3.2.7 Waste separation is a waste of time / useless.[a]

Component 2: PERCEIVED BEHAVIORAL CONTROL

3.2.6 Waste separation is easy and close.

3.2.8 Waste separation is difficult and complicated.[a]

3.2.9 Segregating requires storage space. It makes it inconvenient to separate waste. [a]

3.2.11 I know how to separate waste very well. (I know which type of waste can or cannot be recycled).

Component 3 : SUBJECTIVE NORM - Influence of surrounding social environment

3.2.13 Waste separation is the duty/responsibility of everyone

3.2.14 I feel that waste separation is an important responsibility for me

3.2.15 I feel guilty if I do not separate waste as the way it should be.

3.2.16 I feel that the people around me (family, friends) expect me to separate waste.

3.2.17 If I see my neighbor's separating waste, I will do.

Component 4.1: Situational factor: Infrastructure

2.8 During the past one year. Did the district office of BMA provide waste separation bins (garbage, recycling, solid waste, hazardous waste) in your village / community / neighborhood or not? [b]

Component 4.2: Situational Factor: Influence of past behavior at home

2.1 During the past year, did you separate recyclable waste such as plastic bottle, paper, etc. at your residence often or not? [b]

Component 4.3: Situational Factor: Influence of past behavior at workplace

2.6 At your workplace, are there any waste separation bins, and does the employees / organization supports waste separation or not?(Types of waste separation bins, biodegradable / organic waste, recyclable waste, general waste (other waste) and hazardous waste - Recycling bins may be classified by type of recyclable materials, such as paper, plastic, aluminum, glass). [b]

Component 5: Trust in MSW service
3.2.10 Even if I separate, the collection staff will dump it together. [(a)]
Component 6: Perceived information level
3.3.1 How much knowledge did you acquire on waste reduction and separation (Organic waste, general waste, recyclable waste, hazardous waste) from the school where you studied?
3.3.2 How much knowledge did you acquire on waste reduction and separation, including separation of the hazardous waste, from the district office? (Such as through announcements, brochures, banners, PR).
3.3.3 How much knowledge did you acquire on waste reduction and separation, including separation of the hazardous waste, from the television / radio / newspapers?
3.3.4 How much do you think that the public relations of BMA in the past (through various means) helped to gain better knowledge on waste reduction and separation, including the separation of hazardous waste?
Component 7: General knowledge about waste issue
4.1 6. The current waste generation in Bangkok is up to 9000 tons per day, which is equivalent to 9000 cars per day, and most of the waste is disposed in Landfills at Chachoengsao and Nakhon Pathom.[(b)]

(a) As the question have a negative meaning, this variable has been re-coded by inverting the Likert scale before calculating the mean.
(b) This is a categorical variable. It has been recoded into a dummy variable where Yes=1 and No=0.

5.2.3. Logistic Regression Analysis

a) Summary of Logistic Regression Predicting Intention to Separate

A eighteen-predicator model based on research hypotheses and individual variables testing was fitted to the data, in the objective of testing the relationship between likelihood of a respondent was to express intention to separate, and the predicators. The logistic regression was performed using IBM SPSS version 22 in the Windows 7 environment. The full SPSS output of the regression is presented in Annex 6: SPSS output of Logistic Regression analysis

All variables in the model were entered in a single step as this study has no specific information about any hierarchy between the predicators.

Table 5. 4: Estimated regression coefficients of the logistic regression model predicting intention to separate.

Predictors	**β**	**Sig.**	**Exp(β)**
Socio-demographic			
Gender (female)	-0.001	0.612	0.999
Age	0.007	0.471	1.007
Marital status (married)	0.000	0.886	1.000
Education (bachelor and over)	0.003	0.278	1.003
Household income	-0.043	0.382	0.958
Housing (house)	0.002	0.289	1.002
Years in the neighborhood	-0.005	0.540	0.995
Attitude			
Attitude towards environmental problems.	-0.032	0.867	0.958
Attitude towards climate change issue	-0.090	0.617	0.914
Attitude towards waste problems	-0.078	0.740	0.925
Perceived behavioral control	0.737***	0.001	2.089
Subjective norm	0.611***	0.001	1.842
Situational factors			
Availability of recycling infrastructure	-0.032	0.911	0.968
Influence of past behavior at home	2.854***	0.000	17.354
Influence of past behavior at workplace	0.799***	0.001	2.181
Trust in MSW service	0.389***	0.000	1.476
Perceived information level	0.180	0.191	1.197
General knowledge about waste	0.723***	0.006	2.060

Dependent variable = Intention to separate (1= Yes, 0 = No)

Exp (β) = Exponentiated β

Statistically significant at *0.1, **0.05 and ***0.01 levels.

b) Evaluation of the Logistic Regression Model

The evaluation of the logistic model was made using different techniques. It was first noted that the variables entered in this model showed an improvement compared to the null model, as the model correctly classifies 86.4% of the sample (92.9% of respondents with intention to separate, and 61.0% of respondents with no intention to separate). The overall model was evaluated using an Omnibus test of the model coefficients, which was significant. X^2=428.02; p=0.00 < 0.05 showing an improvement of the model compared to the null model. A Goodness-of-fit test was also performed using the Hosmer & Lemeshow test. The test was insignificant, X^2=7.34; p=0. as p>0.05, suggesting that the model was fit to the data well (Peng et al., 2010). The Nigelkerke R^2 test showed a result significant result of 0.52, which means that the model is explaining about 52% of the variation.

c) Predictors of Intention to Separate and Discussion

The model allowed to identify a number of predictors of the recycling intention. To do so, the statistical significance of the regression coefficients (**β**) was tested using Wald Chi Square. Statistical significance was tested at 0.1, 0.05 level and 0.01 level (Table 5.7). After testing, assumptions one, two and seven were not found significant and were rejected, while all other assumptions were found very significant and accepted

- *Socio demographic*

The analysis results in this study showed that none of the socio-demographic predictors were statistically significant at 0.1 level after running the logistic regression. In the case of Bangkok, demographic factors did not seem to significantly influence the intention to separate waste of households. Therefore, the first assumption of this research was rejected.

- *Attitude*

The second assumption of this research was also rejected, as the attitude towards environmental problems (**β**=-0.032;p=0.887), climate change issue (**β**=-0.090;p=0.617) or waste situation (**β**=-0.078;p=0.740) did not appeared to be a significant predictors of waste separation intention.

- *Influence of perceived behavioral control*

Perceived behavioral control was found to influence very significantly the intention to separate, which allowed to accept the third assumption of this research. This predictor is significant (**β**=0.737; p=0.001). This component was grouping into several elements, related to the perceived knowledge on how to separate, but also to the space required to separate, as lack of space may make waste separation uneasy. Regarding knowledge on how to separate, this finding is coherent with several previous research which demonstrated that education and training are necessary elements to improve the separation skills, which is not at all an obvious thing for households. Regarding space, as the question had a negative meaning, the Likert scale was reverted before calculating the mean of the component and using it in the regression, so the positive **β** value means that respondents expressing a concern about space required for separating have less intention to separate. The issue of space is clearly central for waste separation at source, as already noted by other studies. It is also coherent with Figure 5.2 presented in descriptive analysis part, as the lack of space is one of the main reasons for respondents not to separate waste. Having several waste bins at the same time in a tiny space can be strong limit for urban populations. However, adequate infrastructure can probably help to mitigate this limitation. Frequent collection service, associated with availability of separation bins close to residence areas (or within buildings) may help residents to discard their waste more frequently, and therefore use less space in their residence.

- *Influence of subjective norms*

Also, subjective norms were found highly significant, and the fourth assumption of this research was therefore accepted. The attitude of family, friends and neighbors, as well as a feelings of guilt and responsibility influences positively the intention to separate in a very significant manner (**β**=0.611; p=0.001). People were clearly influenced by the attitude and behavior of their direct social environment, such as family, friends or neighbors. This means that the more recycling becomes a social norm, the easier it will be to convince households to separate at home. Changing social norms is of course not an easy task and requires time. As mentioned by several other studies, emphasis on young generations' education, such as waste separation programs in school, communication in media and social networks may help to change the attitude of the society about waste separation over time.

- *Influence of situational factors*

Situational factors tested in the regression were the influence of past waste separation behavior, at home or workplace, and the influence of nearby recycling infrastructure. The findings allowed only to partially accept the fifth assumption of this research, which was that situational factors, including past behavior and recycling infrastructure, influences the intention to separate. This is because only past behavior was found significant, but not the nearby recycling infrastructure.

The influence of nearby recycling infrastructure was tested, and found not significant at a level of 0.1 (**β**=-0.032;p=0.911).

However, as suggested by the Matthies's CNAM, separation habit (past behavior) has been found to be the most significant predictor of the separation intention. As a part of situational factors, the researcher tested the relationship between the intention to separate and the past waste separation behavior at home and at the workplace. The analysis showed that both the past behavior at home (**β**=2.854; p=0.00) and the past behavior at the workplace (**β**=0.799;p=0.001) influence positively the intention to separate. This means that the respondents who had been separating waste regularly in the past year either at home or at their workplace showed a much higher intention to separate waste at home in the coming month than those who were not

separating regularly. For this reason, in order to improve the recycling behavior among Bangkok population, it is necessary to encourage people to separate at home regularly. However, changing habits is a long term process, and it has to be done through various other factors such as education, information, awareness and so on. When the separation behavior is part of the daily routine, this becomes a habit and people are more likely to continue to perform it over time.

- *Trust in waste management services*

The trust in the MSW service, which means knowing that the recyclable waste will not be dumped together by waste collectors, was also found to strongly influence the intention to separate (β=0.389; p=0.00), which confirmed that the sixth assumption of this research was accepted. As respondents were asked about their agreement to a question having a negative meaning, the Likert scale was reverted before running the regression. The positive **β** value then means that the trust in the MSW service (considering that waste collection staff will not dump everything together) influences the intention to separate. This finding was already identified by another research made in Hanoi, and tends to demonstrate that BMA should better communicate with all stakeholders, including households, to demonstrate the efficiency and usefulness of recyclable collection service, either by BMA staff or in cooperation with informal sector.

- *Perceived information level*

Also, the seventh assumption of this research, which was related to the perceived information level was rejected. The perceived information level received from school, medias or authorities not seems to significantly influence the intention to separate waste (**β**=0.180;p=0.191).

- *Influence of general knowledge related to waste issue*

Finally, testing the influence of general knowledge about MSW in Bangkok on the intention to separate was significant (**β**=0.723; p=0.006), which allowed to

accept the eighth assumption of this research. Respondents that declared knowing the daily waste generation in Bangkok, as well as the location of landfills have a higher intention to separate than others. This tends to show that precise information on local MSW situation could help to get a better understanding of a “close to home” issue, and could motivate them to take action to solve the issue.

6. Conclusion and Recommendations

6.1. Conclusion

In conclusion, regarding Wasteaware analysis related to solid waste management in Bangkok, both strong and weak points have been found in this study. some good points were identified under physical components such as indicator 1.1 with a high degree of waste coverage, 1.2 as all waste collected is disposed through controlled treatment, 2 and 2.E with good degree of control and monitoring of environment protection in waste treatment facilities. The weak points under this component were however found in indicator 1C with average quality of collection service as waste accumulation, illegal dumping and overflow bins were sometimes found, particularly in high density communities, 3 and 3Rs as recycling rate is low and 3Rs principles were not enough promoted. For governance component, a good point was identified in indicator 5F as BMA claimed to have enough budget to ensure current service. However, negative elements were noted in both indicator 4U and 4P as users are not enough included in waste management decision making, cooperation between formal and informal sectors was found insufficient. Another significant issue was also identified in indicator 6N & 6L as a single institution controlling waste management and some regulations such as EPR are missing. 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 been increased each year with no increase in manpower and low level of waste reduction promotion, which could affect the financial sustainability and its collection service in the long run.

Apart from several issues related to the city waste management that have been defined based on Wasteaware benchmark indicators, other important elements related to public participation in terms of waste separation intention were also investigated in this study. Based on the survey of 1,076 households in Bangkok, this research found that the intention to separate is mainly influenced by a few factors. The most important element found is the influence of habit. People who regularly separated solid waste, either at their home or at the office, tend to have a higher intention to separate in the future. Another key factor identified was the importance of perceived behavioral

control, as respondents who fell to have sufficient skills and space showed a higher intention to separate. Subjective norms played also an important role in the intention to separate waste, as respondents were clearly influenced by their families' or neighbors' behaviors. This research also showed that some kind of mistrust in the MSW service had a negative influence of the intention to separate, as some respondents believed that separated waste would always be dumped together with other waste by waste collection staff. Finally, general knowledge on Bangkok waste situation, such as the quantity of waste collected and the landfill sites, also appeared to increase the intention to separate.

In this regard, the findings above showed that TPB is applicable for the study of waste related issues in Thailand. However it should be extended to cover the influence of past behavior as suggested by Matthies's CNAM, as this is the major predictor of the intention to separate waste in Bangkok. Also some other factors need to be taken into account, such as the trust in MSW collection service, and the general knowledge about waste situation.

6.2. Recommendations

The outcome of this study allowed to identify some key recommendations which could have a positive effect to enhance the sustainability of waste management in Bangkok, including the increase of public participation in waste separation at source.

- Improve the promotion of waste separation at source.

Several findings of this research supports the idea that education and skills improvement related to waste separation are a key element to increase recycling rates. First, Wasteaware analysis showed the average efficiency and coverage of BMA actions on promoting recycling, as many people were not aware about it. One of the key issue is the lack of waste separation at source. At the same time, the household survey revealed that perceived knowledge on how to separate, as well as general knowledge on the MSW situation in Bangkok, were a strong predictors of the intention to separate.

More frequent and focused actions, at district and community level, to train and increase knowledge to the population on how to separate waste can strengthen waste separation at source and therefore waste reduction. Moreover, the Bangkok households' survey of this research also identified that habit and subjective norms were strong predictors of the intention to separate. Therefore, long term education programs toward the young generations, for example in schools, can also help improving waste separation. This could make not only the separation behavior becoming a habit (daily waste separation at school) but it could also influence households via subjective norms as children would promote the separation at home later on.

- Enhance recyclable waste separation infrastructure in Bangkok

Quality of recycling infrastructure is a key element to promote waste separation. The household survey part of this research found that the lack of space at home was a limit to the intention to separate. Even if authorities cannot directly address this issue, ways can be found to make it less critical. Providing more recycling facilities such as drop-off points, waste separation bins, or promoting waste buyer and junk shops to pick up recyclable waste more often would allow people to discard their separated waste regularly, thus using less space at home. In this regard, the new application named "O.K. Recycle" developed by TIPMSE could be a good tool to encourage waste separation as it puts in relation households which want to sell recyclables with potential buyers. For the population living in building, having access to separation bins at each floor level, could enhance separation behavior.

- Enhance quality of waste collection service in some areas of Bangkok

The analysis of household survey showed a rather low satisfaction from Bangkok residents about BMA waste collection service. At the same time, Wasteaware analysis revealed that the lack of frequent door-to-door service in high density areas generated significant issues, including waste accumulation, illegal dumping and poor street cleanness. A focus should therefore be given to such areas either by providing more community containers within walking distance of households or emphasizing on hire someone to pull the waste to waste collection points. Another alternative can also

be through enhancing the awareness of population on waste related issues by promoting 3Rs activities or providing more information about waste to the areas mentioned. Moreover, frequent and convenient collection services could also encourage households to regularly separate their waste. In addition, the analysis of household survey revealed that the lack of trust on waste collection service affects the intention to separate waste. Therefore, BMA should arrange daily collection of separated recyclables using a dedicated compartment of the collection truck, to ensure that separated waste is actually conveyed to recycling facilities.

- Promote better integration of IRS

IRS plays a central role in waste collection, transport and processing of recyclable waste in Bangkok. However, Wasteaware analysis showed an insufficient collaboration between municipal waste services and IRS, as well as a lack of IRS integration into the general waste management framework. Several elements such as a clear regulatory framework related to the role, rights and obligations of IRS could be used to enhance this situation. To strengthen the cooperation with IRS, a better assistance from BMA can also be by providing information and training on collecting waste properly and safely as well as controlling on the collection of some dangerous waste.

- Strengthen waste management related institutions and regulatory framework, both at local and national levels

Another weak point identified by Wasteaware analysis was the lack of single institution in charge of waste management, leading to some limitations in terms of decision making decision as national level, and also lack of efficiency of local management. Therefore allowing a single institution, in change of all waste management related issues and empowered to enforce regulations may help to develop and apply coherent plans and regulations. Furthermore, improving regulatory framework to get private manufacturers involving in waste management could also be an alternative to improve recycling level and hazardous waste management of the country.

6.3. Limitations of the Study

1) Even if all efforts were made to confirm BMA answers collected during interview using secondary sources, some elements of the Wasteaware analysis are mainly based on BMA declarations, either during interview or included in the official reports. The lack of independent information sources for some elements may therefore be a limitation of this study.

2) The behavior studied in the field survey is self-reported by respondents. This may bring a bias in the answers, as for example some respondents may be reluctant to admit that they do not separate waste at all.

3) The field survey was performed in a single step, which does not allow to study the influence of separation intention on separation behavior. To do so, a second survey on the same sample would have been necessary one month later, to test if the intention to separate is a predictor of separation behavior as suggested by Theory of Planned Behavior. This could be a topic for future research.

APPENDIX

REFERENCES

References

Abdullah, S. I., M.A. Ilyas, M. Shejule, K.B. Rehana, A. (2012). Groundwater Pollution ar Beed, Maharashtra as an Effect of MSW Dumping. *Bulletin of Environment, Pharmacology and Life Sciences, 1*(12), 43-46.

Adriano, D. C. (2001). Ecological and Health Risks of Metals *Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability, and Risks of Metals* (pp. 133-165). New York, NY.

Ajzen. (1991). the theory of plan behavior *ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES, 50*, 179-211.

Al-Khatib, I. A., Arafat, H. A., Basheer, T., Shawahneh, H., Salahat, A., Eid, J., and Ali, W. (2007). Trends and problems of solid waste management in developing countries: a case study in seven Palestinian districts. *Waste Manag, 27*(12), 1910-1919. doi: 10.1016/j.wasman.2006.11.006

Alvarado-Esquivel, C., Liesenfeld, O., Márquez-Conde, J. Á., Cisneros-Camacho, A., Estrada-Martínez, S., Martínez-García, S. A., . . . García-Corral, N. (2008). Seroepidemiology of Infection with Toxoplasma gondii in Waste Pickers and Waste Workers in Durango, Mexico. *Zoonoses and Public Health, 55*(6), 306-312. doi: 10.1111/j.1863-2378.2008.01133.x

Arbués, F., and Villanúa, I. (2016). Determinants of behavior toward selective collection of batteries in Spain. A bivariate probit model. *Resources, Conservation and Recycling, 106*, 1-8. doi: 10.1016/j.resconrec.2015.11.004

Bank of Thailand. (2017). Thailand's Macro Economic Indicators. from http://www2.bot.or.th/statistics/BOTWEBSTAT.aspx?reportID=409&language=ENG

Betz, A., Buchli, J., Gobel, C., and Muller, C. (2014). Food waste in the Swiss food service industry - Magnitude and potential for reduction. *Waste Manag*. doi: 10.1016/j.wasman.2014.09.015

BMA. (2011). Bangkok State of Environment 2010 - 2011. In BMA (Ed.). Bangkok.

BMA. (2013). Statistical Profile of Bangkok Metropolitan Administration: Strategy and Evaluation Department of BMA.

BMA. (2014a). Bangkok state of environment 2013-2014.

BMA. (2014b). Statistical Book 2014.

BMA. (2015). *Bangkok Waste Managemnet Master Plan 2015-2019*. Bangkok Metropolistan Administration: Retrieved from http://bangkok.go.th/environment.

BMA. (2016). Key factors in implementing Integrated Waste Management Policy.

Bouanini, S. (2013). The Importance of the 3R Principle of Municipal Solid Waste Management for Achieving Sustainable Development. *Mediterranean Journal of Social Sciences, 4*(3).

Brundtland, G. H. (1987). Report of the World Commission on Environment and Development: Our Common Future: UN.

Buzby, J. C., and Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy, 37*(5), 561-570. doi: http://dx.doi.org/10.1016/j.foodpol.2012.06.002

CCAC. (2015). Solid Waste Management City Profile, Bangkok, Thailand.

CDC. (2014). Diseases from Rodents. from http://www.cdc.gov/rodents/diseases/

Chaisamrej, R. (2006). The integration of the theory of planned behaviour, altruism, ans self-construal: Implications for designing recycling campaigns in individualistic and collectivistic societies. *University of Kentucky Doctoral Dissertations, 318*.

Challcharoenwattana, A., and Pharino, C. (2016). Wishing to finance a recycling program? Willingness-to-pay study for enhancing municipal solid waste recycling in urban settlements in Thailand. *Habitat International*, 23-30. doi: 10.1016/j.habitatint.2015.10.008

Department of Local Administration and Pollution Control Department. (2016). *Action plan "Thailand without waste", guidelines "civil state" for one year (2016-2017)*

Diaz, L. F. (2011). *The 3Rs as the Basis for Sustainable Waste Management: Moving Towards Zero Waste*. Paper presented at the Third Regional 3Rs Forum in Asia and the Pacific, Singapore.

http://www.uncrd.or.jp/content/documents/Text%20for%20Keynote%20Address%20for%203rd%20Regional%203R%20Forum_Luiz%20Diaz.pdf

EPA. (2012). *Municipal Solid Waste Generation, recycling nad Disposal in the United States: Facts and Figures for 2012*. Retrieved from http://www.epa.gov/epawaste/nonhaz/municipal/pubs/2012_msw_fs.pdf.

FAO. (2014). Food Loss and Food Waste. Retrieved 2016, July 12, from http://www.fao.org/food-loss-and-food-waste/en/

Fielder, H. M. P. P. K., C.A.; Palmer, S.R.; Moss, N.; Coleman, G. (2000). Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis. *BMJ, 320*(7226), 19-23.

Frederikson, T. (2014). Landfill fire battle not yet won, *Bangkok Post*. Retrieved from http://www.bangkokpost.com/learning/learning-news/400425/battle-to-put-out-landfill-fire

G.D. Israel. *Determining Sample Size*. University of Florida. Retrieved from https://edis.ifas.ufl.edu/pdffiles/PD/PD00600.pdf

Gustavsson, J. C., C.; Sonesson, U. (2011). Global Food Loss and Food Waste. In FAO (Ed.). Rome: FAO.

Hongyon, C. (2007). National Report, Thailand. In A. P. Organization (Ed.), *Solid Waste Management: Issues and Challenges in Asia* (pp. 274-297). Tokyo: Asian Productivity Organization.

Hoornweg, D., and Bhada-Tata, P. (2012). WHAT A WASTE A Global Review of Solid Waste Management (March 2012, no. 15 ed.): The World Bank.

Hornik, J., Cherian, J., Madansky, M., and Narayana, C. (1995). Determinants of recycling behavior: A synthesis of research results *THE JOURNAL OF SOCIO ECONOMICS, 24*.

Hosmer, D. (2000). *Applieed Logistic Regression*. New York: Wiley.

ISWA, U. (2015). Global Waste Management Outlook. Retrieved 2016, July 01, 2016, from http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/GWMO%20report/GWMO_report.pdf

Ittiravivongs, A. (2012a). Household Waste Recycling Behavior in Thailand: The Role of Responsibility

Ittiravivongs, A. (2012b). The Reason behind Lack of Household Recycling Participation A Bangkok Metropolis Case Study. *Global Journal of HUMAN SOCIAL SCIENCE Arts & Humanities, 12*.

Ittiravivongs. A. (2011). Factors influence household solid waste recycling behaviour in Thailand: an integrated perspective *Sustainability Today, 437*. doi: 10.2495/

Jaffee, D., and Newman, S. (2012). A Bottle Half Empty: Bottled Water, Commodification, and Contestation. *Organization & Environment, 26*(3), 318-335. doi: 10.1177/1086026612462378

Kirby, C. (1995). Urban Air Pollution. *Geography, 80*(4), 375-392. doi: 10.2307/40572712

Long, Y. Y., Shen, D. S., Wang, H. T., Lu, W. J., and Zhao, Y. (2011). Heavy metal source analysis in municipal solid waste (MSW): case study on Cu and Zn. *J Hazard Mater, 186*(2-3), 1082-1087. doi: 10.1016/j.jhazmat.2010.11.106

Manager Online. (2016). "Waste Cheat Guide". Retrieved 2017, May 03, from http://www.manager.co.th/AstvWeekend/ViewNews.aspx?NewsID=9590000033547

Manomaivibool, P. (2005). *Municipal Solid Waste Management in Bangkok: The cases of the promotion of source reduction and source separation in Bangkok and in Roong Aroon School.* (Master), Lund University, Lund, Sweden. Retrieved from https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1327677&fileOId=1327678

Matthies, E. (2005). A modified model of moral decision as a new influence for the environmental friendly behavior. *Umweltpsychologie, 9*(1), 62-81.

National Act on Cleanness and Orderness (2016).

Ministry of Public Health. (2016). *Action Plan "Thailand without waste" Guideline "Civil State" 1 year (2016-2017).* Retrieved from http://bangkok.go.th/environment.

Ministry of the Environment Government of Japan. (2016). Regional 3R Forum in Asia and the Pacific. from http://www.env.go.jp/recycle/3r/en/index.html

Muttamara, S. (1994). Solid Waste Recycling And Reuse In Bangkok. *Waste Management & Research, 12*(2), 151-163. doi: 10.1006/wmre.1994.1005

Muttamara, S., and Leong, S. T. (2004). *The Evolution of Solid Waste Management in Bangkok: Implications for the Future.* Asian Institute of Technology, Bangkok.

National News Bureau of Thailand. (2016). NESDB pushes forward 12th Plan and Sufficiency Economy Philosophy. from http://nwnt.prd.go.th/CenterWeb/NewsEN/NewsDetail?NT01_NewsID=WNECO5907230010005#sthash.xVJISMZH.dpuf

Nguyen, T. T. P., Zhu, D., and Le, N. P. (2015). Factors influencing waste separation intention of residential households in a developing country: Evidence from Hanoi, Vietnam. *Habitat International, 48*, 169-176. doi: 10.1016/j.habitatint.2015.03.013

Parizeau, K. (2014). When Assets are Vulnerabilities: An Assessment of Informal Recyclers' Livelihood Strategies in Buenos Aires, Argentina. *World Development, 67*, 161-173. doi: 10.1016/j.worlddev.2014.10.012

Park, Y. K. (2013). Release of Harmful Air Pollutants from Open Burning of Domestic Municipal Solid Wastes in a Metropolitan Area of Korea. *Aerosol and Air Quality Research*. doi: 10.4209/aaqr.2012.10.0272

Peng, C.-Y. J., Lee, K. L., and Ingersoll, G. M. (2010). An Introduction to Logistic Regression Analysis and Reporting. *The Journal of Educational Research, 96*(1), 3-14. doi: 10.1080/00220670209598786

Regulation and Guideline of Municipal Solid Waste Management (1998).

Pollution Control Department. (2009a). Project of Drafted Master Law for the Promotion of Waste Reduction Reuse and Recycling.

Pollution Control Department. (2009b). *Thailand State of Pollution Report 2009*. Ministry of Natural Ressources and Environment Retrieved from http://infofile.pcd.go.th/mgt/Report_Eng2552.pdf?CFID%20%C2%BC2302577&CFTOKEN%20%C2%BC73460820,.

Pollution Control Department. (2016a). Pollution Prevention and Mitigation Policy 1997 - 2016. from http://www.pcd.go.th/info_serv/en_reg_polwaste.html

Pollution Control Department. (2016b). State of municipal solid waste of Thailand 2016. Retrieved 2017, May 16, from

http://www.pcd.go.th/public/Publications/print_report.cfm?task=wsthaz_annual59

Royal Thai Government. (2015). Report on Government Strategy Implementation - Waste and hazardous waste management roadmap from http://www.thaigov.go.th/index.php?option=com_k2&view=item&id=90027%3A90027&Itemid=398&lang=en

Russell Bernard, H. (2013). *Social Research Methods Edition 2*. Los Angeles: SAGE.

Saphores, J.-D., and Nixon, H. (2014). How effective are current household recycling policies? Results from a national survey of U.S. households. *Resources, Conservation and Recycling, 92*, 1-10. doi: 10.1016/j.resconrec.2014.08.010

Saquing, J. M., Chanton, J. P., Yazdani, R., Barlaz, M. A., Scheutz, C., Blake, D. R., and Imhoff, P. T. (2014). Assessing methods to estimate emissions of non-methane organic compounds from landfills. *Waste Manag, 34*(11), 2260-2270. doi: 10.1016/j.wasman.2014.07.007

Schuhmann, P. W. (2011). Tourist perceptions of beach cleanliness in Barbados: Implications for return visitation. *Études caribéennes (Online), 19*. doi: DOI : 10.4000/etudescaribeennes.5251

Sheau-Ting, L., Sin-Yee, T., and Weng-Wai, C. (2016). Preferred Attributes of Waste Separation Behaviour: An Empirical Study. *Procedia Engineering, 145*, 738-745. doi: 10.1016/j.proeng.2016.04.094

Siriratpiriya, O. (2014). Municipal Solid Waste in Thailand: Challenges and Strategic Solution *Municipal Solid Waste Management in Asia and the Pacific Islands*. Kuala Lumpur: Springer Singapore.

Sperandei, S. (2014). Understanding logistic regression analysis. *Biochem Med (Zagreb), 24*(1), 12-18. doi: 10.11613/BM.2014.003

Sukholthaman, P., Chanvarasuth, P., and Sharp, A. (2015). Analysis of waste generation variables and people's attitudes towards waste management system: a case of Bangkok, Thailand. *Journal of Material Cycles and Waste Management*. doi: 10.1007/s10163-015-0456-x

Sukholthaman, P., and Sharp, A. (2016). A system dynamics model to evaluate effects of source separation of municipal solid waste management: A case of

Bangkok, Thailand. *Waste Manag, 52*, 50-61. doi: 10.1016/j.wasman.2016.03.026

Sukholthaman, P., and Shirahada, K. (2015). Technological challenges for effective development towards sustainable waste management in developing countries: Case study of Bangkok, Thailand. *Technology in Society, 43*, 231-239. doi: 10.1016/j.techsoc.2015.05.003

Swenson, D. (2007). Economic Impacts of Recycling in lowa.

Thailand Board of Investment. (2014). Thailand Board of Investment Guide on Environmental Regulations.

The World Bank. (2015). GNI Per Capita, Atlas Method. Retrieved 2017, January 14, from http://data.worldbank.org/indicator/NY.GNP.PCAP.CD

UN-Habitat. (2010). Solid Waste Management in the World's Cities *The Water and Sanitation in the World's cities series*.

UNCRD. (2009). National 3R Strategy Development - A progress report on seven countries in Asia from 2005 to 2009.

UNDESA. (2012). Chapter 5 – Municipal Solid Waste Managmenent - Turning waste into ressources *Shanghai Manual: A Guide for Sustainable Urban Development in the 21st Century*.

UNEP. (2005). Solid Waste Management.

UNEP. (2009a). Converting Waste Plastics into Fuel - Report on Situation Analysis of Existing Solid Waste Management System for Bangkok Metropolitan Administration.

UNEP. (2009b). Policy and Regulations Bangkok Metropolitan Area *"Converting Waste Plastics into Fuel - Report on Situation Analysis of Existing Solid Waste Management System for Bangkok Metropolitan Area"*: UNEP.

UNEP. (2010). Waste and Climate Change.

United Nations. (2014). World Urbanization Prospects The 2014 Revision Highlights.

United Nations. (2015). UNITED NATIONS TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT.

USEPA. (2015). Landfill Gas Energy Basics. In EPA (Ed.), *LFG Energy Project Develop,ent Handbook*.

Van de Klundert, A., and Anschutz, J. (2001). Integrated Sustanable Waste Management - the Concept. In A. Scheinberg (Ed.): Waste.

Visvanathan, C., Adhikari, R., and Prem Ananth, A. (2007). *3R practices for municipal solid waste management in Asia*. Paper presented at the The Second Baltic Symposium on Environmental Chemistry, Kalmar, Sewden. http://faculty.ait.ac.th/visu/public/uploads/Prof%20Visu's%20CV/Conferance/3/Visvanathan_Kalmar07.checked.%20Latested%20submitted.pdf

Welfens, M. J., Nordmann, J., and Seibt, A. (2016). Drivers and barriers to return and recycling of mobile phones. Case studies of communication and collection campaigns. *Journal of Cleaner Production, 132*, 108-121. doi: 10.1016/j.jclepro.2015.11.082

WHO. (2014a). 10 Facts on Malaria. from http://www.who.int/features/factfiles/malaria/en/

WHO. (2014b). Dengue and severe dengue factsheet No. 117. from http://www.who.int/mediacentre/factsheets/fs117/en/

Wilson, Rodic, Cowing, Velis, Whiteman, Scheinberg, . . . Oelz. (2015). 'Wasteaware' benchmark indicators for integrated sustainable waste management in cities. *Waste Manag, 35*, 329-342. doi: 10.1016/j.wasman.2014.10.006

Wilson, C., and Morgan, L. (2007). Understanding Power and Rules of Thumb for Determining Sample Sizes. *Tutorials in Quantitavive Methods for Psychology, 3*(2), 43-50.

Wongpanit. (2017). Wongpanit Environmental Policy. from http://www.wongpanit.com/wpnnew/eng/abountme.php

World Bank. (1999a). Integrated Sustainable Waste Management.

World Bank. (1999b). Solid Waste Management in Asia. In U. D. S. Unit (Ed.). Washington D.C., USA.

World Bank. (2003). Thailand Environment Monitor 2003.

World Bank. (2016a). Thailand - Country at Glance. from http://www.worldbank.org/en/country/thailand

World Bank. (2016b). Urban Solid Waste Management. Retrieved 2016, July 07, from http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEV

ELOPMENT/EXTUSWM/0,,menuPK:463847~pagePK:149018~piPK:149093~theSitePK:463841,00.html

Annexes

Annex 1: Semi-structured questionnaire: first in-depth interview with BMA

Information about Interview and Respondent:

Interviewer:_____

Date of Interview:_____

Place:_____

Name of Interviewee:_____

Position:_____

Organization:_____

W2 - Waste Composition

- Date of last measurement? *(Latest data found is BMA 2013-2014 State of Environment Report*)

____/____/_____

- Frequency of measurement?

_____ Times every week / month / year (circle correct one)

- Are seasonal variations taken into account?

□ Yes □ No

- Time series data if available (previous data)?

□ Not Available □ Available (if available, please attach previous data)

- Place of measurement (you can choose more than one)?

□ At Collection site; Name of sites _____

□ At Transfer station; Name of station _____

□ At treatment site; Name of sites _____

□ At Landfill; Name of landfill _____

- If at disposal site, is there a correction for materials removed before this step?

□ Yes □ No

- Could you attach the full data set on waste composition, as an annex or excel file?

- What is the percentage of organic waste (including garden waste from public parks and roads, and excluding any packaging papers, cardboard, textiles, leather, and

wood from packaging and furniture)? _____% *(50.2 % - BMA 2013, to be confirmed)*

- What is the percentage of Paper waste (including cardboard, but excludes laminated materials such as drink cartons)? _____% *(15.2 % - BMA 2013, to be confirmed)*
- What is the percentage of Plastic waste? _____% *(25.1 % BMA 2013, to be confirmed)*
- What is the percentage or metal waste? _____% *(1.2 % BMA 2013, to be confirmed)*
- What is the solid waste density? _____
  - How this data was collected? _____
  - When this data was collected? _____
  - Where was it collected? _____
- What is the moisture content of MSW? _____
  - How this data was collected? _____
  - When this data was collected? _____
  - Where was it collected? _____

1 Benchmark Indicators on Public Health (Waste Collection)

1.1Waste Collection Coverage

- Percentage of households receiving a reliable collection service? _____%

(90.42 % - BMA 2013, to be confirmed)

- What is the frequency of collection for mixed waste?

_____ Time per hour / day / week (*1 time per day to be confirmed)*

- What is the frequency of collection for separated waste?

_____ Time per day / week / month *(1 time per week on Sunday to be confirmed)*

1.2 - Waste captured by the solid waste management and recycling system

- What is the percentage of Bangkok waste collected by BMA and disposed or recycled (including waste recycled by informal sector, but excluding waste illegally burned, dumped or buried)? _____%

1C.1 - Appearance of waste collection points

- How would you rate the presence of accumulated waste around collection points 2 hours after collection:

□ Very High incidence of littering

□ High incidence of littering

□ Medium incidence of littering

□ Low incidence of littering

□ Very low incidence of littering

1C.2 - Effectiveness of street cleaning

- How would you rate the effectiveness of street cleaning in terms of presence of litter and overflowing bins in the city centre of Bangkok *(field investigation suggest medium, to be confirmed)*

□ Very High incidence of littering and overflowing bins

□ High incidence of littering and overflowing bins

□ Medium incidence of littering and overflowing bins

□ Low incidence of littering and overflowing bins

□ Very low incidence of littering and overflowing bins

1C.3 - Effectiveness of collection on low income districts

- How would you rate the effectiveness collection in low income districts:

□ Very High incidence of littering

□ High incidence of littering

□ Medium incidence of littering

□ Low incidence of littering

□ Very low incidence of littering

- Is there any illegal open burnings in low income districts?

□ Yes □ No

- Is there any illegal dumping in low income districts?

□ Yes □ No

- Does MSW sometimes block drains and watercourses in low income districts?

□ Yes □ No

1C.4 - Efficiency and effectiveness of waste transport

- Are all vehicles used for MSW transport contained? *(field research suggests No)*

□ Yes □ No

If yes please describe: _____

- Are there precautions to prevent windblown litter? *(field research suggests No)*

□ Yes □ No

If yes please describe: _____

- Are there precautions to prevent liquid spilling on street?

□ Yes □ No

If yes please describe: _____

- Are the vehicles well maintained?

□ Yes □ No

- Is the vehicle capable of mechanical discharge?

□ Yes □ No

- What is the number of trucks reaching daily the transfer station from collection points to transfer stations? _____ Trucks

- What is the average capacity of a collection truck? _____ Tons *(1.5 / 2 / 5 / 6 / 8 Tons to be confirmed)*

- What is the maximum daily capacity of each transfer station? _____ Tons

- What the number of trucks daily from each transfer station to treatment sites? ____ Trucks
- What is the average capacity of a truck from transfer station to treatment? _____ Tons
- Is the capacity of current transfer sites enough, or does the waste quantity sometimes exceeds the capacity?

□ Enough □ Not Enough

1C.5 - Appropriateness of service planning and monitoring

- Is there contract between BMA and private operators?

□ Yes □ No

- Is the detailed specification of service described?

□ Yes □ No

- Is there a clear service planning (both private &BMA)?

□ Yes □ No

If yes please describe: _____

- Are there monitoring procedures and tools?

□ Yes □ No

If yes please describe: _____

1C.6 - Health and safety of collection workers

- Are the operators receiving regular health checks?

□ Yes □ No

- Are the operators receiving vaccinations?

□ Yes □ No

- Do the operators use boots? *(field research suggest yes but not properly used)*

□ Yes □ No

- Do the operators use gloves? *(field research suggest yes but not properly used)*

□ Yes □ No

- Do the operators use overalls? *(field research suggests no, to be confirmed)*

□ Yes □ No

- Do the operators use high visibility vests? *(field research suggests yes, to be confirmed)*

□ Yes □ No

Benchmark Indicators 2&2E – Environment (Waste treatment and disposal)

2 - Controlled treatment or disposal

- What is the percentage of total MSW treated in an engineered thermal facility?_____%
- What is the percentage of total MSW treated in an engineered compost?_____%
- What is the percentage of total MSW treated in controlled landfills?_____%

2E.1 - Degree of control over waste reception and general site management

- Do the landfills / treatment facilities have a large clean access road, free of mud?

□ Yes □ No

- Are there traffic management policies to access these sites, to limit truck queues and limit impact to neighbors?

□ Yes □ No

- Are these sites secured by fences, with access control?

□ Yes □ No

- Is there a log of the reception, with staff checking and weighting all incoming trucks?

□ Yes □ No

- Is the unloading supervised and controlled by staff?

□ Yes □ No

- Is there control procedures for following nuisances:
  - Windblown litter □ Yes □ No
  - Flies □ Yes □ No
  - Vermin □ Yes □ No

- Birds □ Yes □ No
- Mud on truck wheels leaving □ Yes □ No

- Is there control of fires:

Is there routine burning of waste? □ Yes □ No

Are there frequent wild fires? □ Yes □ No

Procedures in case of accidental fires? □ Yes □ No

2E.2 - Degree of control over waste treatment and disposal

Questions about Landfills:

- Are there staff working at the landfills? □ Yes □ No
- Is the waste covered (with earth)? □ Yes □ No
- If Yes, How often?_____
- Is the waste compacted using equipment? □ Yes □ No
- Is there any leachate containment system? □ Yes □ No
- If yes please describe_____
- Is there any landfill gas collection system? □ Yes □ No
- If yes please describe_____
- Is there final cover and post closure plan in place for closing the site once full?

□ Yes □ No

Questions about thermal treatment, or Waste to Energy:

- How many staff works at the site? _____ persons
- Are there systems to control particulate emissions? □ Yes □ No
- If yes please describe_____
- Are the ashes properly managed? □ Yes □ No
- If yes please describe_____
- Are there systems to capture acid gas and dioxin? □ Yes □ No
- Are time and temperature controlled? □ Yes □ No
- Is the facility compliant with strict norms such as EU GHG emissions norms?

□ Yes □ No

Questions about Biological Treatment (Compost):

- Are incoming materials controlled to avoid hazardous waste? □ Yes □ No
- Is processing temperature controlled? □ Yes □ No
- Are there clear retention time and mixing procedures? □ Yes □ No
- Are atmospheric emissions controlled including odors? □ Yes □ No
- Is there leachate collection and treatment? □ Yes □ No

2E.3 - Degree of monitoring and verification of environmental controls

- Have an Environmental Impact Assessment (EIA) been conducted for each processing / dumping site?

□ Yes □ No

- Do all sites have an up to date permit issued by the authorities to operate?

□ Yes □ No

- Do all sites comply with Thai regulations on environment?

□ Yes □ No

- How long did it take to get the authorization to build the recent waste to energy processing site?_____ weeks / months / years
- Are weights, volumes and categories of waste systematically controlled on each site?

□ Yes □ No

- Is ground and surface water near landfills regularly controlled?

□ Yes □ No

- Are leachate and landfill gases regularly controlled?

□ Yes □ No

- For thermal treatment, are moisture content and calorific values of waste controlled?

□ Yes □ No

- Are gas emission monitored?

□ Yes □ No

- For biological treatment, are liquid and gases controlled?

□ Yes □ No

- Is the quality of the final product controlled by a laboratory?

□ Yes □ No

2E.4 - Efficiency of energy generation and use

- Is the energy generated by waste to energy plant mainly used for internal process purposes?

□ Yes □ No

- Is the energy generated regularly exported to the electricity grid?

□ Yes □ No

- Is the heat collected and used all the year?

□ Yes □ No

- Is there a steady user of the heat located close to the facility?

□ Yes □ No

2E.5 - Degree of competence in the planning, management and operation of treatment and disposal

- Do technical and management teams in charge of disposal / treatment facilities have a related academic background?

□ Yes □ No

- If Yes, describe most common academic backgrounds_____

- Does BMA provide training to management staff in charge of treatment and disposal?

□ Yes □ No

If yes, please give details_____

- Does BMA provide training to management staff in charge of treatment and disposal?

□ Yes □ No

If yes, please give details_____

2E.6 - Occupational health and safety

- Does BMA staff follows safe operation procedures?
- □ Yes □ No
- Are these procedures enforced?

  □ Yes □ No
- Does it apply to private sector / contractors workers?

  □ Yes □ No
- Does employees of waste to energy uses heat protection?

  □ Yes □ No
- Do they use respiratory protection?

  □ Yes □ No

3 - Benchmark Indicators 3 & 3R – Resource Value – 3Rs – Reduce, reuse, recycle

3 - Recycling Rate

- What is the recycling rate of total Bangkok MSW (including biological treatment, but excluding waste to energy)? _____%
- What is the percentage recycled by informal sector? _____%
- What is the percentage recycled by formal sector? _____%

3R.1 - Source separation of "Dry Recyclable"

- What is the percentage of materials collected for recycling that are clean (separated at the source, and not collected from mixed waste)? _____%

3R.2 - Quality of recycled organic materials

- How much food waste is separated at source by households?

□ Very low □ Low □Average □High □ Very high

- How much food waste is separated at source by commercial?

□ Very low □ Low □Average □High □ Very high

- Is there some separation at source of wet recyclables from dry recyclables?

□ Very low □ Low □Average □High □ Very high

- When separated at source (such as separation bins in Bangkok public areas), what is the quality of separation?

□ Very low □ Low □Average □High □ Very high

3R.3 - Focus on top level of the waste hierarchy

- Do BMA have policies / promotion activities related to waste reduction?

□ Yes □ No

If yes, please describe: _____

- Do BMA have policies / promotion activities related to reuse of second hand products and materials?

□ Yes □ No

If yes, please describe: _____

- Do BMA or Government authorities have policies related to extension of useful life through improved design, or organized repair / refurbishment?

□ Yes □ No

If yes, please describe: _____

- Do BMA have policies / activities to divert waste from disposal or treatment to recycling?

□ Yes □ No

If yes, please describe: _____

- Is there any official target for recycling?

□ Yes □ No

What is the percentage target, for which year? _____% in _____ Year

Please describe:_____

- Is the informal recycling sector included in the measurement of the recycling targets?

□ Yes □ No

3R.4 - Integration of the community and/or informal recycling sector (IRS) with the formal solid waste management system

- Do you have policies to include IRS in the waste management plan?

□ Yes □ No

If yes, please describe: _____

- Does IRS have access to waste separated at source?

□ Yes □ No

- Does BMA buy organic waste for composting from IRS?

□ Yes □ No

- Is there any form of cooperation between BMA MSW workers and IRS?

□ Yes □ No

- If yes, please describe: _____

3R.5 - Environmental protection in recycling

- Is the collection of Waste of Electric and electronic equipment mainly done by BMA or IRS?

□ By BMA □ By IRS

- Can you describe BMA process for collection and recycling of Waste of Electric and electronic equipment _____

-

4U - User Inclusivity

4U.1 - Equity of Service Provision:

- Which percentage of Bangkok households receives door to door MSW service? _____%

- Do all residents of low income area have access to a bin less than 100m from their home?

□ Yes □ No

4U.2 - The right to be heard

- Is there any national or municipal law or regulation that requires BMA to consult and ask participation of citizen in the decision making process related to MSW?

□ Yes □ No

- If yes, please indicate which law or regulation: _____

4U.3 - Level of public involvement

- Do BMA involve representatives from the public such as women, youth, religious leaders, and unions at key stages of MSW decision making?

□ Yes □ No

If yes, how: _____

- Does solid management committees / taskforce / working groups are established and meeting regularly?

□ Yes □ No

If yes, please describe: _____

- Are there existing procedures to ensure public involvement?

□ Yes □ No

If yes, please provide copies: _____

4U.4 - Public feedback mechanism

- Does BMA have a customer service or system to collect feedback on MSW from the population?

□ Yes □ No

- If yes, please confirm the email / telephone number of service:_____

- It yes, please confirm how BMA communicate about this service:

_____

- If yes, please indicate if this service also collect ideas from the population for decision making

□ Yes □ No

4U.5 - Public Education and Awareness

- Does BMA organize information campaigns related to MSW?

□ On TV □ On Radio □ Community meetings □ School programs □ None

- Is there a specific budget for MSW communication and education?

_____THB / Year

- Are there a specific staff / department in charge?

□ Yes □ No

4U.6 - Effectiveness in achieving behavior change

- Do you consider previous campaigns were efficient in reducing illegal dumping in Bangkok area?

□ Yes □ No

- Do you consider previous campaigns were efficient in improving waste separation among the population?

□ Yes □ No

4P - Provider Inclusivity

- Do BMA contracts any private sector entity for MSW collection?

□ Yes □ No

If yes, which company and for which services?_____

- Do BMA contracts any private sector entity for MSW treatment (landfills, thermal treatment, and biological treatment)?

□ Yes □ No

If yes, which company and for which services?_____

- Do BMA contracts any private sector entity for MSW transport?

□ Yes □ No

If yes, which company and for which services?_____

- Do BMA contracts any private sector entity for MSW operation of transfer stations?

□ Yes □ No

If yes, which company and for which services?_____

4P.1 - Legal Framework

- Is there any national or local regulation related to public private partnership (PPP) that applies to MSW management?

□ Yes □ No

If yes, which company and for which regulation? _____

- Is there any national or local regulation related to private sector participation (PSP) that applies to MSW management?

□ Yes □ No

If yes which regulation? _____

- Is there any national or local regulation related to community based organizations (CBO) that applies to MSW management?

□ Yes □ No

If yes, which regulation and CBO? _____

- Are there clear regulations or guidelines for service contracts?

□ Yes □ No

If yes, which regulation? _____

- Are there restrictions in the law for the duration of such contracts?

□ Yes □ No

If yes, which regulation and which restriction? _____

4P.2 - Representation of the private sector

- Are MSW committees / taskforce / working groups are established and meeting regularly to ensure proper representation and participation of private sector?

If yes, please describe: _____

4P.3 - Role of the "informal" and community sector

- How would you rate the importance of informal sector in waste collection, recycling and reuse?

□ Not important □ low importance □ average □ quite important □ very important

4P.4 - The balance of public vs. private sector interests in delivering services

- Are the contracts with private sector fair and balanced?

□ Yes □ No

- Are there incentive and penalties depending on the performance of the providers?

□ Yes □ No

- If service provider goes out of business, is there a plan to continue service?

□ Yes □ No

4P.5 - Bid Process

- Are there a formal bid / tender public process to select private sector providers?

□ Yes □ No

- Do you consider the bid process is totally free from corruption / influence / unfair decisions?

□ Yes □ No

- Is the bid process open to all parties?

□ Yes □ No

Benchmark Indicator 5 – Financial Sustainability

5F.1 - Cost Accounting

- What is the total cost of solid waste management in Bangkok?

_____ THB in Year _____ (year)

- Are this accounts public, and audited by and independent authority?

□ Yes □ No

5F.2 - Coverage of the available budget

- Is the current budget of MSW in Bangkok sufficient to cover all MAS management costs?

□ Yes □ No

- If no, which percentage is covered by current budget? _____%

5F3 - Local cost recovery – from households

- What is the percentage of Bangkok household that actually pays for MSW collection services? _____%

5F.4 - Affordability of user charges

- Are there any procedures in place to support MSW charges for household that cannot afford to pay?

□ Yes □ No

If yes, please describe: _____

5F.5 - Pricing of disposal

- Is there a fee charged for each truck entering processing / disposal facilities?

□ Yes □ No

- If yes, does this charge cover all the costs of the processing / disposal site?

□ Yes □ No

- Does this charge also allow covering the investment and a provision for future investment?

□ Yes □ No

5F.6 - Access to capital for investment

- Do BMA have adequate funds to invest in new infrastructure / extend coverage of service?

□ Yes □ No

- What is the source of these funds?

□ Government Investment

□ Private sector investment

□ Grants or loans from international donors

□ Investment from BMA budget

Please describe: _____

6L - Benchmark indicators for sound institutions, proactive policies (ii)

6N.5 - National Regulatory control & enforcement

- Is there a well-organized department in charge environmental regulation enforcement?

□ Yes □ No

If yes please describe: _____

- How many staff works for this department? _____Persons
- Would you say that this department is fully efficient to issue permits and inspect waste disposal and treatment sites?

□ Very efficient □ Quite efficient □ Average □ Not so efficient □ Not efficient at all

6L.1 - Organizational structure / coherence

- Is there a single department in BMA in charge in charge of MSW management planning, implementation and funding?

□ Yes □ No

If yes which department_____

- Is the entire budget related to MSW managed by this department?

□ Yes □ No

6L.2 - Institutional capacity

- Is there a clear organization chart of the department?

□ Yes □ No

If yes please provide a copy.

- Does all the functions / positions currently staffed?

□ Yes □ No

- Is there regular training in class for the staff of this department?

□ Yes □ No

- Is there regular training in the field for the staff of this department?

□ Yes □ No

- Is there a clear career progression plan for staff of this department?

□ Yes □ No

6L.3 - City-wide solid waste management & plan

- Are there a BMA level strategy / plan for MSW management?

□ Yes □ No

If yes please describe_____

- Is this plan conforming to the national strategy / plan?

□ Yes □ No

- What is the year of this plan? _____ (year)
- Is it still valid?

□ Yes □ No

- Does BMA have sufficient funds and staff to implement this plan?

□ Yes □ No

Please describe_____

6L.4 - Availability of quality of solid waste management data

- Is there a Management Information System (MIS) in place?

□ Yes □ No

- Are the data regularly measured, collected and monitored?

□ Yes □ No

Please describe_____

- Does it include the following data, and what is the date of latest data set?

□ Waste generation / Date of last data set _____

□ Waste composition / Date of last data set _____

□ Quantity collected / Date of last data set _____

□ Quantity recycled / Date of last data set _____

□ Quantity treated / Date of last data set _____

□ Quantity disposed / Date of last data set _____

6L.5 - Management control and supervision of service delivery

- Is there clear supervision and control procedure for services provided by the private sector (such as trucks rented to private sector).

□ Yes □ No

Please describe_____

- Is there a separation between BMA staff performing MSW work (such a collection) and staff checking the work?

□ Yes □ No

- Does the checking staff have cars or motorbike?

□ Yes □ No

- Do they have the possibility to enforce their decisions if the find an issue?

□ Yes □ No

Please describe_____

- Are there clear processes for checking / controlling?

□ Yes □ No

- If yes please provide a copy:_____

6L.6 - Inter municipal (or regional) co-operation

- Are there good working relationships between BMA and government bodies in charge of MSW?

□ Yes □ No

Please describe_____

- Is there existing cooperation with government agencies for the following:

□ Funding MSW

□ Regulatory

□ Control and enforcement

□ Public Communication

Please describe: _____

Annex 2: Semi-structured questionnaire: second in-depth interview with BMA

1.1 Waste collection coverage.

- % of households in the city that receive a regular waste collection services (this is including formal and informal sector services, which is also including waste that are collected for recycle and treatment or disposal)
- Answer: last interview BMA answer 90% but it need to be confirmed whether this data is including waste collection service from informal sector or not?

1.2 - % of waste generated that is actually collected and delivered to official treatment or disposal facility, and recycling factory. (Not include waste that are collected but then dump in an illegal)

1C.5 - In terms of services (both public and private sectors), are there monitoring procedures and tools or regular supervision for checking that the services are well perform?

1C.6 - Do workers receive vaccinations and what kind of yearly health check do they get?

3 - Recycling Rate- what is the % of total MSW generated that is recycled?

3R.1 Source separation of "Dry Recyclable"

- What % of total materials collected for recycling is being separated at sources?

3R.2 - Focus on the separation of food waste at household or commercial level and quality of recycled organic products (such as; animal feed, or compost…)

- Score: 0=little/no separate/no quality control
  5= some separate to reduce contamination
  10=separate from other waste in treatment facility
  15=all input material separated at source
  20= same as 15 but meet formal quality standard

3R.4 - BMA confirmed that there is cooperation between IRS and BMA workers but which cooperation and how does it work?

4U.1 - Focus on equality of service that all citizens receive including density areas and informal settlement area. (This is to check whether they have door to door collection

service by informal sector in those areas or not? Are there containers provided which is 100m from each resident?)

4U.2 - BMA confirmed there's national municipal law/regulation that requires BMA to consult or ask participation of citizen in decision making process of MSW, but what is the name of that law/regulation? And how does it work?

4U.5 - BMA confirmed that the information related to MSW is provided through several methods such as TV, radio, community meeting, and school program. But what is the budget line for these activities?

- Is there a department or position in charge of creating and updating environmental awareness campaigns? How do these campaigns work particularly on school program or community meeting?

4U.6 - Change in habit and behavior of both public and business regarding their waste management practice. This is focusing particularly on behavior changed over last decade in terms of the use of garbage bins/collection container instead of dumping on the street, waste prevention and separation at source, etc.

4P.1 - BMA confirmed there's national/local regulation related to public private partnership that has been applied to MSW management with clear guideline of service contract, but what is the name/detail of this regulation?

5F.5 Degree to which all waste coming to final disposal is charged:

- For landfill or disposal site, how do private sector operators charge BMA? For example; charging by ton or by year?
- Does the charge rate cover some costs of operation? Or cover full operating & maintenance costs? Or cover both operating, maintenance costs and capital cost as well? Or cover everything including future closure and aftercare?

5F.6 - Do BMA has funds to extend the service to un-served areas (as per BMA report, waste collection coverage in Bangkok is only 90%, which means that 10% are un-served)? How?

6N.5 - BMA confirmed there's a well-organized department in charge environment regulation enforcement, but which department?

6L.1 - Is there a specific organization or department within the municipality which is responsible for ensuring that solid waste management services are planned, delivered and funded? (If no, who responsible on waste management? How it is organized?)

- Dose all of the solid waste management budget fall within the budget line of that organization or department?

6L.4 - Is there a management information system in place? Are data regularly measured, collected and monitored?

- What is the latest date/month/year of measurement or dataset? Such as for waste composition……..; quantity of waste that is collected…….; quantity of waste that is treated……

6L.5 - Do BMA have specific supervisory staff to check private sector operations including trucks checking, waste collection checking and landfill?

- How to measure the performance and enforce contracts of private operators?

Annex 3: Household survey questionnaire

Survey Questionnaire about Solid waste management and hazardous waste of Bangkok Population.

The survey is part of the thesis "Assessing Sustainability of Municipal Solid Waste Management in Bangkok, Thailand" by Ms. Bokham Chanhthamixay, graduate school student in in Environment, Development and Sustainability, Chulalongkorn University. Having Dr. Sujitra Vassanadumrongdee as advisor.

If you have any questions or concerns, Please contact 02 218 8217, 081 613 6530.

This survey <u>does not</u> ask for your name and address. So please answer all questions truthfully. The study results will be presented as an overview only.

<u>Part 1 – Personal information</u>

1. Gender □ 1) Woman □ 2) Man

2. Age ..... Years (A fraction of the year of more than 6 months is considered as 1 year)

3. Marital status: □ 1) Single □ 2) married (or widowed) □ 3) divorced / separated.

4. Education Level:

□ 1) Primary school (Year 1 to 4) □ 2) Primary School (Year 5 to 6).
□ 3) Secondary School (Year 1 to 3) □ 4) High School (Year 4 to 6).
□ 4) Vocational education (Vocational certificate) □ 5) Bachelor Degree.
□ 6) Master degree or over □ 7) Other (please specify) …….....

5. Your career

□ 1) Government Officer / Employee □ 2) Private Sector Employee
□ 3) Self-employed. □ 4) Seller
□ 5) Labor / part time □ 6) Farmer
□ 7) Pupils / students □ □ 8) Maid
□ 9) Retired / unemployed □ 10) Other.....

6. Number of persons in your household (including yourself): Adults..... Children (under 14 Years) .....

7. The average income of your household per month. (Including all members' income). *(Used for research only. Please answer truthfully).*

□ 1) Less than 10,000 baht □ 2) 10,001 - 20,000 baht
□ 3) 20,001 - 30,000 baht. □ 4) 30,001 - 40,000 baht
□ 5) 40,001 - 50,000 baht □ 6) 50,001 - 60,000 baht.
□ 7) 60,001 - 70,000 baht □ 8) 70,001 - 80,000 baht
□ 9) 80,001baht up.

8. Your current residence type.

□ 1) House □ 2) Townhouse / semi-detached house
□ 3) Building □ 4) Apartment / dorm / room
□ 5) condominiums □ 6) Other.....

9. Do you or your household own your present residence or not?

□ 1) Own □ 2) Rent □ 3) Other .....

10. How long have you been living in this residence (Specified in question 8)?

For ..... years (A fraction of the year of more than 6 months is considered as 1 year).

11. Does your household owns a car or a motorcycle?

□ 1) No □ 2) Yes.

12. Does your family buys plastic bottled water on a regular basis or not?

□ 1) Often □ 2) Not often (Due to the purchase of water from a vending machine, a water purifier, boil water to drink, etc.).

Part 2 - Behaviors and personal views related to solid waste management and hazardous waste.

1. During the past year, did you separate recyclable waste such as plastic bottle, paper, etc. at your residence often or not?

□ 1) Separate □ 2) Not Separate (if Not, please go to question 5).

2. If you answered "Separate". What do you do with the recyclable waste you separated?

□ 1) Sell it to a shop buying recyclable waste which is about ..... meters from my residence.
□ 2) Sell to recyclable waste collectors (SALENG) at doorstep.
□ 3) Placed in front of the house for collection. Or maid collects to sell.
□ 4) Other (please specify) .....

3. The important reason or motivation that made you separate waste (select only one item).
□ 1) The proceeds from the sale of recyclable waste □ 2) To help preserve the environment.
□ 3) Assist people with low income □ 4) Other (please specify) .....

4. If you answered "Separate" in the first question, how often do you sell (or donate) recyclable waste?
□ 1) Once a week □ 2) Once every two weeks□ 3) Once a month.
□ 4) Once every two months □ 5) Two times per year □ 6) Other .....

5. For persons who answered "Not Separate" in question 1, what is the reason for not separating? (You can select more than one item)
□ 1) Do not know how to separate garbage □ 2) Do not have space
□ 3) Lazy / Not interested / No time □ 4) No SALENG / shops buying close to home.
□ 5) No vehicle to transport to sell □ 6) No separation bins at home.
□ 7) Too few recycle waste / earn very few from selling (Not worth the time lost).
□ 8) Even if I separate, waste collection staff would put it together to dump it
□ 9) Other (please specify) ....

6. At your workplace, are there any waste separation bins, and does the employees / organization supports waste separation or not?(Types of waste separation bins, biodegradable / organic waste, recyclable waste, general waste (other waste) and hazardous waste - Recycling bins may be classified by type of recyclable materials, such as paper, plastic, aluminum, glass).
□ 1) Yes □ 2) No

7. During the past one year. Did the District office of Bangkok Metropolitan Administration (BMA) have organized any activity for village / community / neighborhood to reduce and separate waste or not? (For example: Information meeting, Booth, Announcement, Manuals, Brochures. etc)
□ 1) Yes there is □ 2) Not any activity
□ 3) I do not know.

8. During the past one year. Did the District office of BMA provide waste separation bins (garbage, recycling, solid waste, hazardous waste) in your village / community / neighborhood or not?
□ 1) Yes □ 2) No.

9. In the future (in 1 month), will you separate your waste a regular basis at home or not?

□ 1) Yes □ 2) No.

10. If BMA supports material to separate waste (bins, garbage bags) with information on how to separate waste correctly and information related to places where you can sell your waste near your residence: Would you have the intention to separate waste on a regular basis at home or not?
□ 1) Yes, have intention □ 2) No, have no intention.

11. During the past one month. When you go to shopping at markets, convenience stores, supermarkets, retail, do you bring cloth bags or reusable bags to put their purchases or not?
□ 1) Never □ 2) Sometimes (not frequently) □ 3) On a regular basis.

12. Do you know any public campaign to help reducing the use of plastic bags in order to reduce waste quantity coming from plastic bags waste by radio, television, social media or directly from the shops of grocery stores or not?
□ 1) I do not know □ 2) I know, but I am not interested
□ 3) I know and started to stop accepting plastic bags.

13. If convenience stores (eg 7-11) and Supermarkets or retailer (eg. Tesco Lotus, Big C, Tops) stop giving plastic bags to you (by selling reusable bags) would you agree to bring your own bag or use a reusable instead?
□ 1) Agree □ 2) Do not agree □ reason .....

14. Do you collect UHT drink packs or boxes (milk cartons, juice boxes) for recycling or not?
□ 1) Never collected □ 2) Collected for ( ) Donate ( ) Sell to SALENG / waste buyer shop.

15. During the past one year. How did you manage the hazardous waste from the community such as old bulbs, batteries, spray cans, expired drugs, etc.
□ 1) Disposed with general waste (go to question 16.) □ 2) Kept at home.
□ 3) Put it in separate bags before sending to garbage collection
□ 4) Bring it to dispose at specific hazardous waste bins or collection points.
□ 5) Submitted to an officer responsible for waste in the area during an event or activity in the community / village.
□ 6) Other .....

16. For persons who answered "Disposed with general waste" in question 15, what is the reason why you do not separate hazardous waste? (You can select more than one item).
□ 1) I do not know where to dispose. (No bins/ infrastructure for dangerous waste in the neighborhood).
□ 2) Low quantity. I think it is not dangerous to dispose it.

□ 3) Even if I separate, waste collection staff would put it together to dump it.
□ 4) Other (please specify) ....

17. Did you know that BMA schedules a specific day to dispose hazardous waste, which is every 1st and 15th of the month?
□ 1) No, I do not know □ 2) Yes, I know.

18. During the past one year. What did you do with your or your family members' broken or unused mobile phone*? (* Refers to very old/old models of mobile phone that cannot be sold to a shop).
□ 1) Disposed together with general waste □ 2) Kept at home.
□ 3) Sold SALENG or shop □ 4) Donate to relatives / foundation / projects.
□ 5) Put it in separate bags before sending to garbage collection
□ 6) Bring it to dispose at specific hazardous waste bins or collection points.
□ 7) Other .....
□ 8) I did not have this type of mobile phone during the past one year.

19. During the past one year. Did BMA have any activity to provide information on hazardous waste collection (i.e. event at market) or large waste items in your village or community?
□ 1) Yes, they did □ 2) No, they did not □ 3) I do not know.

20. In the future (during next month). If you have hazardous waste (such as bulbs or batteries), will you separate hazardous waste from the general waste before disposing?
□ 1) Yes I will □ 2) No I will not.

21. If BMA setups a hazardous waste bin in the community or convenience store near your home, would you bring your hazardous waste (bulbs, batteries) to dispose at that point?
□ 1) Yes □ 2) No.

22. Currently do you or your family to pay waste collection fee to BMA (20 baht per month or 240 baht per year)?
□ 1) Yes (included in the monthly maintenance fee).
□ 2) No, due to ( ) no waste collection staff ( ) low quantity of waste ( ) other .....

23. Current cost of waste disposal in Bangkok Metropolis is up to 6,500 million baht per year, but BMA can only collect less than 500 million baht per year of waste collection fees. The current fee is very low, at only 20 baht per month per household. In the meantime, the total cost is in average 150 baht per household per month. If BMA improves the waste collection service and setup infrastructures for better separation and waste redaction, are you willing to pay more?

□ 1) I am willing to pay more as per rate below.
(Please circle the figure in the table that matches you satisfaction. At the same time please consider the income and other expenditure involving with this decision)

Baht per month

40	60	80	100	120	140	160	180	200
220	240	260	280	300	320	340	360	380
400	420	440	460	480	500	Other…… ……		

□ 2) I am not willing to pay more because (choose only one item).
( ) I think this is the responsibility of the government to provide this service to the population
( ) I pay for many taxes already.
( ) The expenditure of my household is already high
( ) Other ....

Part 3 - Attitudes and knowledge acquisition related to the environment and waste.
Please consider each question and circle only one number on the right hand which is most matching with your thought.

3.1 Attitudes about the environment and climate change.

Nbr.	Question	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	We are approaching a point where the natural resources cannot support the world's population anymore.	1	2	3	4	5
2	If human continue behaving in this way, we will soon face an ecological catastrophe.	1	2	3	4	5
3	Climate change or global warming is a serious problem and a very actual issue.	1	2	3	4	5
4	We should give priority to solving the problem of global warming. Even though the solutions that will impact negatively on economic growth and employment (eg. For example increasing taxes on products generating carbon emissions will result in higher prices for goods and services).	1	2	3	4	5
5	I'm willing to pay more for goods and services that helps help reduce global warming. (For example having to pay an additional150. Baht per	1	2	3	4	5

	month for electricity or fuel from clean energy).					
6	Even the environment is getting worse; I still think that economic issues are more important than environmental issues.	1	2	3	4	5

3.2 attitudes about solid waste and garbage:

Nbr	Question	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	Solving the issue of pollution related to MSW is the responsibility of the government and local authorities, not mine	1	2	3	4	5
2	I think the issue of country waste is getting more and more serious and will impact on the environment and human health.	1	2	3	4	5
3	If we all participate to reduce and separate waste, It will help to solve the country MSW issue.	1	2	3	4	5
4	Waste separation helps reduce global warming.	1	2	3	4	5
5	Disposing hazardous waste mixed with general waste can spread dangerous substances and create harm the environment.	1	2	3	4	5
6	Waste separation is easy and close.	1	2	3	4	5
7	Waste separation is a waste of time / useless.	1	2	3	4	5

8	Waste separation is difficult and complicated.	1	2	3	4	5
9	Segregating requires storage space. It makes it inconvenient to separate waste.	1	2	3	4	5
10	Even if I separate, the waste collection staff will dump it together.	1	2	3	4	5
11	I know how to separate waste very well. (I know which type of waste can or cannot be recycled).	1	2	3	4	5
12	Reducing or preventing waste (such as plastic bags or bringing reusable bags) is difficult. This is not my habit.	1	2	3	4	5
13	Waste separation is the duty / responsibility of everyone.	1	2	3	4	5
14	I feel that waste separation is an important responsibility for me	1	2	3	4	5
15	I feel guilty if I do not separate waste as the way it should be.	1	2	3	4	5
16	I feel that the people around me (family, friends) expect me to separate waste.	1	2	3	4	5
17	If I see my neighbor's separating waste, I will do so.	1	2	3	4	5

3.3 To acquire knowledge Information about solid waste management.

Nbr	Question	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	How much knowledge did you acquire on waste reduction and separation (Organic waste, general waste, recyclable waste, hazardous waste) from the school where you to studied.	1	2	3	4	5
2	How much knowledge did you acquire on waste reduction and separation, including the separation of hazardous waste, from the district office? (such as through announcements, brochures, banners, PR).	1	2	3	4	5
3	How much knowledge did you acquire on waste reduction and separation, including the separation of hazardous waste, from the television / radio / newspaper?	1	2	3	4	5
4	How much do you think that the public relations of BMA in the past (through various means) helped you to gain better knowledge on waste reduction and separation, including the separation of hazardous waste?	1	2	3	4	5

5	How much satisfied are you with the BMA solid waste collection service?	1	2	3	4	5

Part 4 – Knowledge and understanding about MSW and hazardous waste.
Please consider each question and circle only one number on the right hand which is most matching your thought.

Nbr	Do you know that	Don't Know	Know
1	The current waste generation in Bangkok is up to 9000 tons per day, which is equivalent to 9000 cars per day, and most of this waste is disposed in landfills at Chachoengsao and Nakhon Pathom.	1	2
2	If we do not separate waste, then the waste is disposed to landfills or incinerated. This will create greenhouse gases that causes global warming, as well as other pollutants.	1	2
3	Thailand ranked one of top five countries in the world that through the highest amount of plastic waste into the sea.	1	2
4	Electronic waste such as broken mobile phones contains several types of hazardous substances. It is considered being hazardous waste but can be recycled.	1	2
5	The Government (NBC) declared that waste issue is a national problem. They have planned a roadmap to solve the problem of solid waste and hazardous waste.	1	2
6	The government has prepared a draft law to manage discarded electronic products, appliances and electronics.(E-waste), so the manufacturer should recall the products and recycled them properly.	1	2

7. How many years do you think it takes for plastic bags and foam boxes that we currently use to biodegrade?
A) 50 years for plastic bags and 100 years for foam boxes.
B) 450 years for plastic bags and 1000 years for foam boxes, or not biodegraded.

Part 5 - Comments and suggestions to MSW and hazardous waste management of Bangkok Metropolis.

....
....
....
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....

**** Thank you very much for your cooperation. ****

Annex 4: Household survey elements used in Wasteaware analysis

Table 1: Separation behavior of Bangkok population as per field survey

	Frequency	**Percent**
Do not Separate waste	368	34.2
Separate waste	708	65.8
Total	1,076	100
Do not Separate UHT containers	719	66.7
Separate UHT Containers	357	33.2
Total	1,076	100

Table 2: Awareness of BMA MSW related activity as per field survey

	Frequency	**Percent**
During the past one year, did the District office of BMA have organized any activity for your village / community / neighbourhood to reduce and separate waste or not?		
Yes	203	19.9
No	515	47.9
I do not know	358	33.3
Total	1,076	100

Table 3: Crosstab analysis of Awareness of BMA MSW related activity * Separation Behavior

	Separation Behaviour		Total
	No	Yes	
Aware of BMA Activity	45	158	203
	22.2%	77.8%	100.0%
Unaware of BMA Activity	323	550	873
	37.0%	63.0%	100.0%
Total	368	708	1,076
	34.2%	65.8%	100.0%

Annex 5: Sample size calculation using Taro Yamane formula.

Estimate of sample size (n) required based on the Size of Polulation, for a comfidence level of 95%

Size of Population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
500	a	222	145	83
600	a	240	152	86
700	a	255	158	88
800	a	267	163	89
900	a	277	166	90
1,000	a	286	169	91
2,000	714	333	185	95
3,000	811	353	191	97
4,000	870	364	194	98
5,000	909	370	196	98
6,000	938	375	197	98
7,000	959	378	198	99
8,000	976	381	199	99
9,000	989	383	200	99
10,000	1,000	385	200	99
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100
a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.				

Source: (G.D. Israel)

Annex 6: SPSS output of Logistic Regression analysis

```
LOGISTIC REGRESSION VARIABLES Intentionseparate_yes
  /METHOD=ENTER Gender_Female Age Marital_Married_divorced
Edu_bachelormore Income House_house Period Comp_1.1 Comp_1.2 Comp_1.3
Comp_2 Comp_3 Comp_4.1 Comp_4.2 Comp_4.3 Comp_5 Comp_6 Comp_7
  /PRINT=GOODFIT CI(95)
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
```

Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	1,076	100.0
	Missing Cases	0	.0
	Total	1,076	100.0
Unselected Cases		0	.0
Total		1,076	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
0	0
1	1

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted		
			Intentionseparate_yes		Percentage Correct
			0	1	
Step 0	Intentionseparate_yes	0	0	218	.0
		1	0	858	100.0
	Overall Percentage				79.7

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	1.370	.076	326.319	1	.000	3.936

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Gender_Female	4.028	1	.045
		Age	12.642	1	.000
		Marital_Married_divorced	4.658	1	.031
		Edu_bachelormore	.078	1	.780
		Income	.041	1	.839
		House_house	11.548	1	.001
		Period	6.714	1	.010
		Comp_1.1	1.567	1	.211
		Comp_1.2	5.712	1	.017
		Comp_1.3	29.561	1	.000
		Comp_2	96.280	1	.000
		Comp_3	68.464	1	.000
		Comp_4.1	11.456	1	.001
		Comp_4.2	334.800	1	.000
		Comp_4.3	57.328	1	.000
		Comp_5	18.696	1	.000
		Comp_6	39.955	1	.000
		Comp_7	11.666	1	.001
	Overall Statistics		395.186	18	.000

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	428.018	18	.000
	Block	428.018	18	.000
	Model	428.018	18	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	656.566[a]	.328	.517

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.344	8	.500

Contingency Table for Hosmer and Lemeshow Test

		Intentionseparate_yes = 0		Intentionseparate_yes = 1		Total
		Observed	Expected	Observed	Expected	
Step 1	1	84	82.999	24	25.001	108
	2	56	59.814	52	48.186	108
	3	38	38.713	70	69.287	108
	4	23	16.675	85	91.325	108
	5	9	7.393	99	100.607	108
	6	3	4.853	105	103.147	108
	7	3	3.313	105	104.687	108
	8	0	2.241	108	105.759	108
	9	1	1.427	107	106.573	108
	10	1	.571	103	103.429	104

Classification Table[a]

			Predicted		
			Intentionseparate_yes		Percentage Correct
	Observed		0	1	
Step 1	Intentionseparate_yes	0	133	85	61.0
		1	61	797	92.9
	Overall Percentage				86.4

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.
Step 1[a]	Gender_Female	-.001	.002	.257	1	.612
	Age	.007	.010	.519	1	.471
	Marital_Married_divorced	.000	.002	.020	1	.886
	Edu_bachelormore	.003	.002	1.178	1	.278
	Income	-.043	.049	.764	1	.382
	House_house	.002	.002	1.123	1	.289
	Period	-.005	.009	.376	1	.540
	Comp_1.1	-.032	.191	.028	1	.867
	Comp_1.2	-.090	.179	.250	1	.617
	Comp_1.3	-.078	.235	.110	1	.740
	Comp_2	.737	.213	11.961	1	.001
	Comp_3	.611	.177	11.974	1	.001
	Comp_4.1	-.032	.288	.013	1	.911
	Comp_4.2	2.854	.234	149.295	1	.000
	Comp_4.3	.779	.232	11.256	1	.001
	Comp_5	.389	.109	12.800	1	.000
	Comp_6	.180	.138	1.709	1	.191
	Comp_7	.723	.263	7.571	1	.006
	Constant	-5.910	.975	36.715	1	.000

Variables in the Equation

		Exp(B)	95% C.I.for EXP(B)	
			Lower	Upper
Step 1[a]	Gender_Female	.999	.995	1.003
	Age	1.007	.988	1.026
	Marital_Married_divorced	1.000	.996	1.005
	Edu_bachelormore	1.003	.998	1.007
	Income	.958	.871	1.054
	House_house	1.002	.998	1.007
	Period	.995	.978	1.012
	Comp_1.1	.968	.666	1.408
	Comp_1.2	.914	.644	1.299
	Comp_1.3	.925	.584	1.466
	Comp_2	2.089	1.376	3.171
	Comp_3	1.842	1.303	2.603
	Comp_4.1	.968	.551	1.702
	Comp_4.2	17.354	10.980	27.430
	Comp_4.3	2.180	1.383	3.437
	Comp_5	1.476	1.192	1.826
	Comp_6	1.197	.914	1.569
	Comp_7	2.060	1.231	3.448
	Constant	.003		

a. Variable(s) entered on step 1: Gender_Female, Age, Marital_Married_divorced, Edu_bachelormore, Income, House_house, Period, Comp_1.1, Comp_1.2, Comp_1.3, Comp_2, Comp_3, Comp_4.1, Comp_4.2, Comp_4.3, Comp_5, Comp_6, Comp_7.

VITA

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