IMPROVING MUNICIPAL SOLID WASTE MANAGEMENT THROUGH RECYCLING IN URBAN SETTLEMENTS OF THAILAND

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การศึกษาปรับปรุงการจัดการขยะชุมชนให้เหมาะสมตามลักษณะเมืองของประเทศไทย โดยการรีไซเคิล

นายอมรชัย แจวเจริญวัฒนา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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Thesis Title	IMPROVING MUNICIPAL SOLID WASTE MANAGEMENT THROUGH RECYCLING IN URBAN SETTLEMENTS OF THAILAND
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Field of Study	Environmental Management
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อมรชัย แจวเจริญวัฒนา : การศึกษาปรับปรุงการจัดการขยะชุมชนให้เหมาะสมตามลักษณะเมืองของประเทศไทยโดยการรีไซเคิล (IMPROVING MUNICIPAL SOLID WASTE MANAGEMENT THROUGH RECYCLING IN URBAN SETTLEMENTS OF THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร.ชนาธิป ผาริโน, 135 หน้า.

งานวิจัยนี้มีเป้าหมายเพื่อพัฒนาแนวทางในการสนับสนุนการตัดสินใจแบบองค์รวมสำหรับการเพิ่มประสิทธิภาพของการจัดการขยะชุมชนของประเทศไทยโดยการส่งเสริมการคัดแยกขยะและการรีไซเคิลตามความเหมาะสม โดยมีการคัดเลือกเมืองเพื่อเป็นกรณีศึกษาได้แก่ เมืองขนาดเล็ก (PS—เทศบาลตำบลพังโคน) เมืองขนาดกลาง (US—เทศบาลเมืองหัวหิน) และเมืองขนาดใหญ่ (MS—กรุงเทพมหานคร) ในกระบวนการวิจัย ได้มีการศึกษาองค์ประกอบขยะ ณ หลุมฝังกลบ รวมถึงการเก็บแบบสอบถามที่นำมาใช้ในการวิเคราะห์จำนวน 1064 ชุด เพื่อนำไปใช้ศึกษาความเต็มใจที่จะจ่าย (Willingness to Pay—WTP) สำหรับการปรับปรุงระบบการจัดการขยะชุมชน และการศึกษาพฤติกรรมการจัดการขยะในครัวเรือน เพื่อนำไปวิเคราะห์กับปัจจัยด้านเศรษฐกิจและสังคม รวมถึงทัศนคติต่อการรีไซเคิล ผลจากการศึกษาพบว่า องค์ประกอบขยะของเมือง PS, US และ MS มีความคล้ายคลึงกันยกเว้นองค์ประกอบของพลาสติกและกระดาษ ในส่วนของความเต็มใจที่จะจ่ายเพื่อปรับปรุงระบบการจัดการขยะชุมชน พบว่า ค่าเฉลี่ย ต่อเดือน คือ 22.43 บาท สำหรับ PS 60.23 บาท สำหรับ US และ 50.70 บาท สำหรับ MS ซึ่งค่าความเต็มใจที่จะจ่ายดังกล่าว มีค่าสูงกว่าค่าธรรมเนียมการเก็บขนที่จัดเก็บอยู่ในปัจจุบัน ซึ่งค่าความเต็มใจที่จะจ่ายดังกล่าวสูงกว่าอัตราค่าธรรมเนียมเก็บขนขยะที่องค์กรปกครองส่วนท้องถิ่นจัดเก็บในปัจจุบัน แต่ก็ยังต่ำกว่าต้นทุนการจัดการขยะที่ท้องถิ่นต้องจ่าย ในส่วนของการศึกษาพฤติกรรมโดยเปรียบเทียบระหว่างกลุ่มที่ไม่มีการแยกขยะ (DNO) กับกลุ่มที่มีการแยกขยะเพื่อขายขยะกับคนรับซื้อของเก่า(IRB) ร้านรับซื้อของเก่า (RCB) หรือการบริจาคขยะรีไซเคิลเพื่อการกุศล (DOC) ผลจากการวิเคราะห์พบว่าระดับการศึกษา จำนวนสมาชิกในครอบครัว และ ทัศนคติต่อการรีไซเคิลขยะ มีอิทธิพลต่อการตัดสินใจในการรีไซเคิล ผลการวิเคราะห์ด้วยวิธีวิเคราะห์เชิงลำดับชั้น (The Analytic Hierarchy Process—AHP) โดยพิจารณาองค์ประกอบด้าน ความเต็มใจจ่าย ความสามารถในการลดค่าใช้จ่ายในการฝังกลบขยะ ความเต็มใจในการรีไซเคิล ผลการศึกษาสรุปได้ว่า IRB เป็นทางเลือกเหมาะสมที่สุดในการเพิ่มประสิทธิภาพการรีไซเคิลขยะชุมชนในทุกขนาดของชุมชนเมือง

สาขาวิชา การจัดการสิ่งแวดล้อม ลายมือชื่อนิสิต .....

ปีการศึกษา 2558 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

5387823220 : MAJOR ENVIRONMENTAL MANAGEMENT
KEYWORDS: WILLINGNESS TO PAY / MUNICIPAL SOLID WASTE MANAGEMENT / ANALYTIC HIERARCHY PROCESS / INFORMAL RECYCING / URBAN SETTLEMENT

AMORNCHAI CHALLCHAROENWATTANA: IMPROVING MUNICIPAL SOLID WASTE MANAGEMENT THROUGH RECYCLING IN URBAN SETTLEMENTS OF THAILAND. ADVISOR: ASSOC. PROF. .CHANATHIP PHARINO, Ph.D., 135 pp.

This study takes a holistic decision-making approach to identify an optimal process to promote MSW separation and diversion of recyclables into tailored MSW recycling system. The study was conducted in three scale settlements as case studies including Greater Phang Khon Area (PS), peri-urban settlements; Muang Hua Hin Municipality (US), a moderately urbanized settlement; and Bangkok (MS), a fully urbanized settlement. MSW characterizations at PS and MS were conducted to identify recycling potentials of MSW. Face-to-Face questionnaire surveys were collected (n=1064) on study sites to gauge willingness to pay (WTP) for improving MSW management, socio-economic and recycling attitude factors. The study found that MSW compositions between PS, US, and MS were similar except on the percentage of plastic and paper. WTP analysis indicated that means monthly WTP (0.73 USD, PS; 1.96 USD, US; and 1.65 USD, MS) were higher than the MSW fees currently charged by their municipalities (partially subsidized) but also lower than the full cost of MSW management. The study of recycling behavior of participants benchmarked the baseline condition of “Do-nothing” approach (DNO) to one the following recycling alternatives: itinerant recyclable buying (IRB); recycling center buying (RCB); donation to charity (DOC). The study found that socio-economic factors do not influence the decision to recycle except for education and the numbers of family member factors. Recycling attitudes instead exhibited a strong discriminating ability from one alternative to another. The Analytic Hierarchy Process (AHP) was employed to identify optimal MSW recycling choice and inputs from previous findings of WTP, MSW characteristic, willingness to recycle. The study concluded that the IRB is the best alternative and is recommended for the tailored recycling alternative to improve waste management in all types of urban settlement.

Field of Study: Environmental Management Student's Signature .....

Academic Year: 2015 Advisor's Signature .....

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I would like to declare that this study received financial support from the 90th ANNIVERSARY OF CHULALONGKORN UNIVERSITY FUND (Ratchadaphiseksomphot Endowment Fund) and the Center of Excellence on Hazardous Substance Management (HSM), CHULALONGKORN UNIVERSITY. I would also thank Ms. Kraisri Srithupthai from Rajamangala University of Technology Isan Sakonnakhon campus and Dr. Nipharat Sriprasert from Rajamangala University of Technology Rattanakosin Wangkraikangwon Campus, and Mr.Tatthap Veeratat, and Ms. Saravanee Singtong for their field supports.

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List of Abbreviations

C-MSW	Ability to Reduce Landfilling Cost Per Ton Of MSW
AHP	Analytic Hierarchy Process
BMA	Bangkok Metropolis Administrative
MS	BMA As a Metropolis Settlement
CMS	Chang Ming Sub-District Administration Organization
CBM	Community-Based Management
RI	Consistency Index
CR	Consistency Ratio
CV	Contingent Valuation
DOC	Donations to Charity
DNO	Do-Nothing Approach
EIA	Environmental Impact Assessment
A-WTP	Extra Willingness to Pay For A Recycling System
US	Hua Hin, Prachuap Khiri Khan Province As an Urban Settlement
IWW	Informal Waste Workers
IRB	Itinerant Recyclable Buying
LAO	Local Administrative Organizations
MRF	Material Recovery Facility
MCDA	Multiple-Criteria Decision Analysis
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MSWA	Municipal Solid Waste Management Authority

PAYT	Pay As You Throw
PCD	Pollution Control Department
PHA	Public Health Act B.E. 2535 (1992)
RCB	Recyclable Centre Buying
3Rs	Reduce, Reuse, And Recycle
PS	The Greater Phang Khon Areas in Sakol Nakorn Province As a Peri-Urban Settlement
PKM	Thumbon Phang Khon Municipality
USEPA	United States Environmental Protection Agency
WTA	Willingness to Accept
WTP	Willingness to Pay
WTR	Willingness to Recycle

CHAPTER I
INTRODUCTION

The relationship between urbanization and municipal solid waste (MSW) generation are moved in the same direction (AIT & UNEP, 2010; Hoornweg & Bhada-Tata, 2012). After the industrial revolution, improper management of MSW has been recognized as a potential public health issue as vectors can carry diseases, i.e. typhoid, dysentery, or deteriorated the aesthetic quality of urban settlement (Barbalace, 2014). Hence, MSW removal service has been free or heavily cost-subsidize (S. Callan & Thomas, 2012). While making senses on public health aspect, it disincentivise willingness to reduce MSW generation and many waste management authorities have been struggled to manage MSW under their supervision and may potentially consume 80-90 percent of city budget (Hoornweg & Bhada-Tata, 2012). Therefore, many cities start to charge for MSW removal service and also institute recycling service as alternatives.

Learning from waste management at the global scale, managing MSW tended to be increased in variety and, therefore, increase in management complexity as well (Hoornweg & Bhada-Tata, 2012) and Thailand has been categorized as a middle-income countries. The majority of Thailand's MSW Characteristics was classified as food waste (40-60 percent of MSW found at the landfill) while plastics, papers, glasses, and metals were the majority in the group of non-food wastes Thailand's Pollution Control Department [PCD] (2004). However, the rate of material recovery from MSW, excluding composting or biogas generation, in Thailand is still low (PCD, 2015). Thailand's recycling rate in 2014 was only 18.5 percent (PCD, 2015) while UK's recycling rate was 44.2 percent (Department for Environment Food & Rural Affairs,

2014) or United States' MSW recycling rate was 34.3 percent as reported in USEPA (2013). Hypothetically, maximizing material diversions from landfills via recycling is a preferred method to land dumping or landfilling (Environment Team, 2015). There are opportunities to achieve higher recycling rate and the concept of 3R had long been introduced, but the implementation of 3R has not reached its full potential (Hoornweg & Bhada-Tata, 2012). Furthermore, responses to the incentive for promoting recycle vary from one socio-economic, environmental, and attitude setting to another (Afroz, Hanaki, Tuddin, & Ayup, 2010; Jenkins, Martinez, Palmer, & Podolsky, 2003).Hence, crafting effective recycling strategies require a tailored program with consideration of social, economic and management constraints in different settlements. Efficient MSW recycling program has to consider recycling-inducing factors as well as engineering and cost-effectiveness elements into the development process to achieve a sustainable MSW plan. It also helps to alleviate the burden of running MSW service system, especially in developing countries where the cost of MSW collection may cost up to 90% of their annual budget (Hoornweg & Bhada-Tata, 2012).

The eventual goal of this study, illustrated in **Figure 1,** is to produce recommendations for an appropriate recycling collection and incentivizing a system from the perspective of recyclable generators (recyclers and non-recyclers). The second goal is to provide a decision support system that incorporates factors that may influence a population to engage and enhance their recycling practices. Creating a holistic evaluation guideline, including the reduction of landfilling cost, willingness to recycle, and increased willingness to pay for a recycling service for MSW. The results from case studies in Thailand may also be applicable to other developing countries with similar socio-economic characteristics, particularly in Southeast Asia, where 47% of the

population still resides in peri-urban settlements and urbanization has been occurring rapidly (United Nations, 2014), especially in Cambodia, Laos, Myanmar (CLM countries) where culture, religion, and language are similar to that of Thailand.

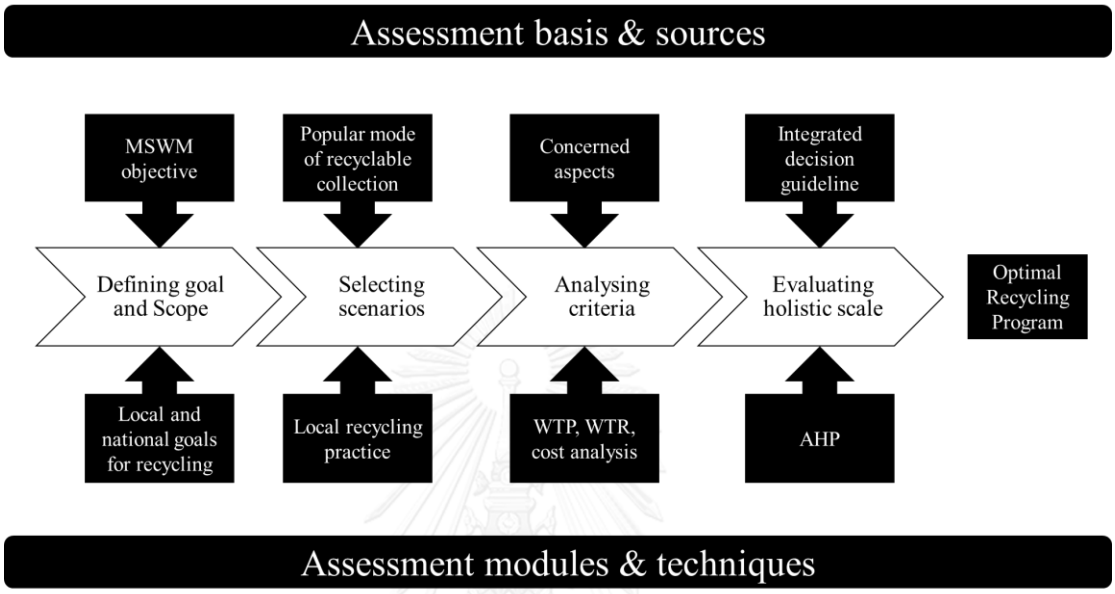


Figure 1. Outline of the study

Source. Adapted from H. Li, Nitivattananon, & Li, (2015)

1.1. Objectives

- To investigate MSW compositions and situation for each type of major settlement including Peri-urban, Urban, and Metropolis in Thailand
- To identify levels of willingness to pay for MSW recycling in different social structures
- To suggest tailored MSW management plans and policy suitable for different Thai settlement structures

1.2. Research Questions

- How do MSW characteristics and MSW quantity per capita in urban settlements differ from those of rural settlements and what are the causes of these differences?
- What are the obstructions that prevent maximization of MSW recycling in rural and urban settlements?
- What are the willingness to pay levels for MSW management in rural and urban settlements and what are the causes of these variances?
- How the factors on social and economics be integrated to create MSW management strategies that systematically promote MSW recycling in rural and urban settlements in Thailand?

1.3. Expected Outcomes

- Profiles of MSW quantity and characteristics from different socio-economic and geographical settlements that can provide details of current MSW situation in each area.
- Influencing factors, i.e. socio-economic or behavioral aspects that help to promote or to depress participation on MSW recycling and minimization as well as the WTP for MSW management.
- Suggested plan for sustainable MSW managements for different types of settlement to maximize MSW recycling pertaining to each settlement's potential.

1.4. Hypothesis

MSW generated from urban settlements identified by high population density, and high economic activities will yield higher MSW per capita and more characteristically diverse in term of waste compositions than MSW generated from rural settlements does.

Urban settlements with a high level of incomes and population density will demonstrate higher willingness to pay for better MSW management and a higher tendency to recycle.

1.5. Scope and Limitation

The scope of this study has been defined as a study of MSW management in the residential sector of different types of settlement as classified by the definition of Thumbon Municipality (Peri-urban settlement), Muang Municipality (Urban settlement) area per the Municipality Act. B.E. 2546 (2003), and the special administrative area of Bangkok (Metropolis settlement) per the Bangkok Metropolis Administrative Organisation Act, BE 2550 (2007). The study investigated MSW characteristic at landfills, willingness to pay for improvement of waste management through recycling system, and, the potential of reducing landfilling cost and potential efficiency improvement strategies. The framework and scope are depicted in **Figure 2.**

This study has been conducted strictly from the perspective of waste generators and waste management system. Nevertheless, the author understood that there are other aspects that are changing of MSW management, and recycling may also concern other parties i.e. environmental impacts from improper recycling after at-source recyclable separation occurs and they arrive at recycling center or other environmental justice

issues, i.e. compensation for landfill scavengers whose livelihood may be affected if at-source recycling has been implemented successfully.

Due to limitation arisen from budgets and manpower, the study only investigates one town per settlement type. The author realized that types of formal and informal recycling collection in Thailand were more diverse from the three types of informal recycling in this study. However, the author justified that the three types of informal recycling system are prominent in Thailand.

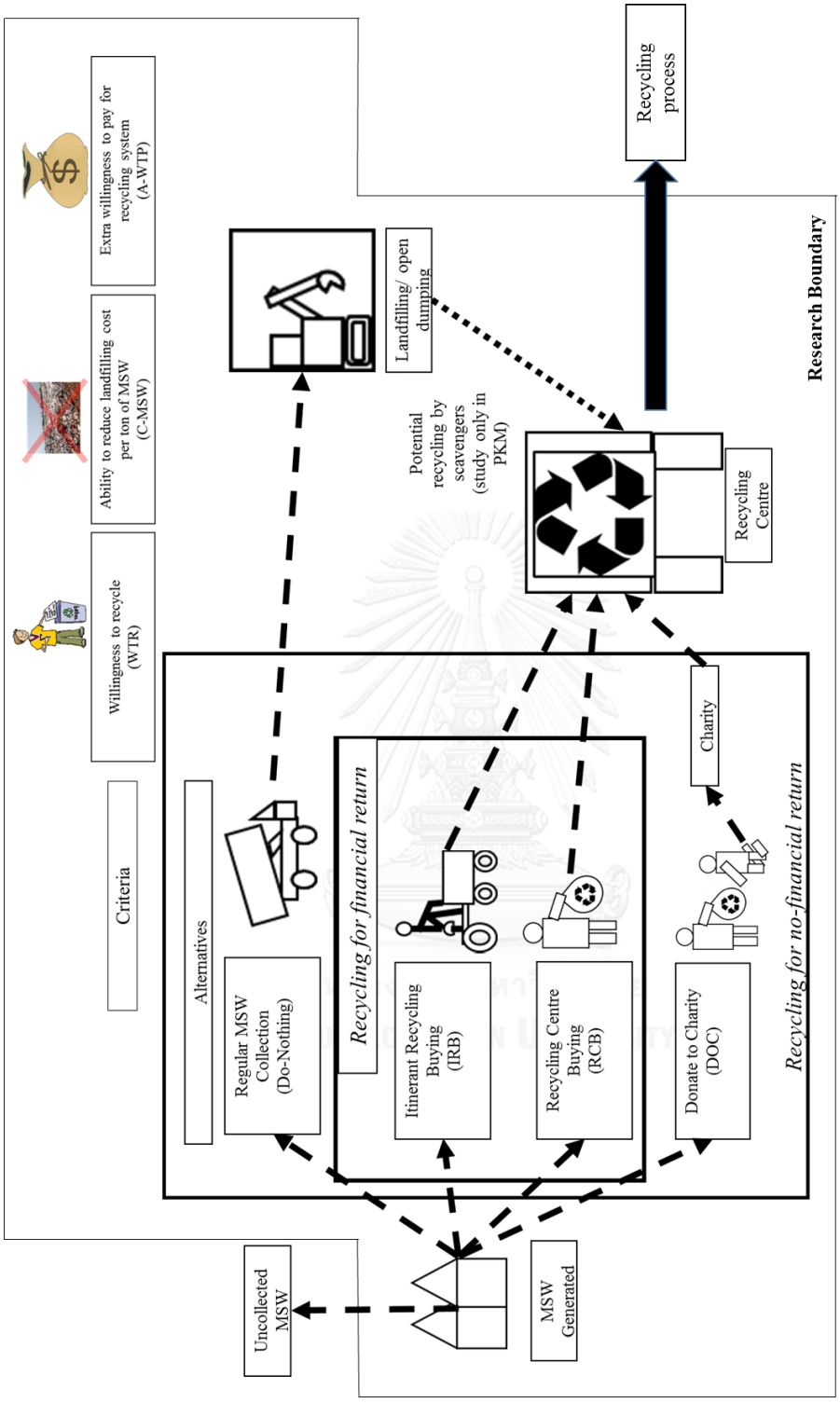


Figure 2. Research boundary

1.6. Description of Study Sites

This study classified selected three settlements in Thailand that are classified in different urbanized stage per the Municipality Act. B.E. 2546 (2003), and per the Bangkok Metropolis Administrative Organisation Act, BE 2550 (2007). Those Acts mandate the duty of keeping cleanliness and MSW management service. The three settlements also comprise different population characteristics, i.e. population size, economic activities and local government structures, as shown in **Table 1.** For clarification, The most fundamental type of municipality is called Thumbon municipality, defined by numbers of registered population higher than 5,000 and approved by Ministry of Interior, is estimated to produce MSW at a rate of **1.02** kg/capita**.** The more urbanized type of municipality is called Muang municipality, defined by the number of registered population higher than 10,000 and approved by Ministry of Interior, is estimated to produce MSW at a rate of **1.**15 kg/capita.The most urbanized type of municipality is called Nakorn municipality, defined by the number of registered population higher than 50,000 and approved by Ministry of Interior, is estimated to produce MSW at a rate of **1.**89 kg/capita (PCD, 2013). The duty to maintain sanitation and waste management has been stated explicitly in all three type of municipalities in the Municipality Act, and Public Health Act.

The three settlements selected for the study include (1) the Greater Phang Khon areas in Sakol Nakorn Province as a Peri-Urban Settlement (PS); (2) Hua Hin (Prachuap Khiri Khan Province) as an Urban Settlement (US); and (3) Bangkok as a Metropolis Settlement (MS), shown in **Figure 3.**

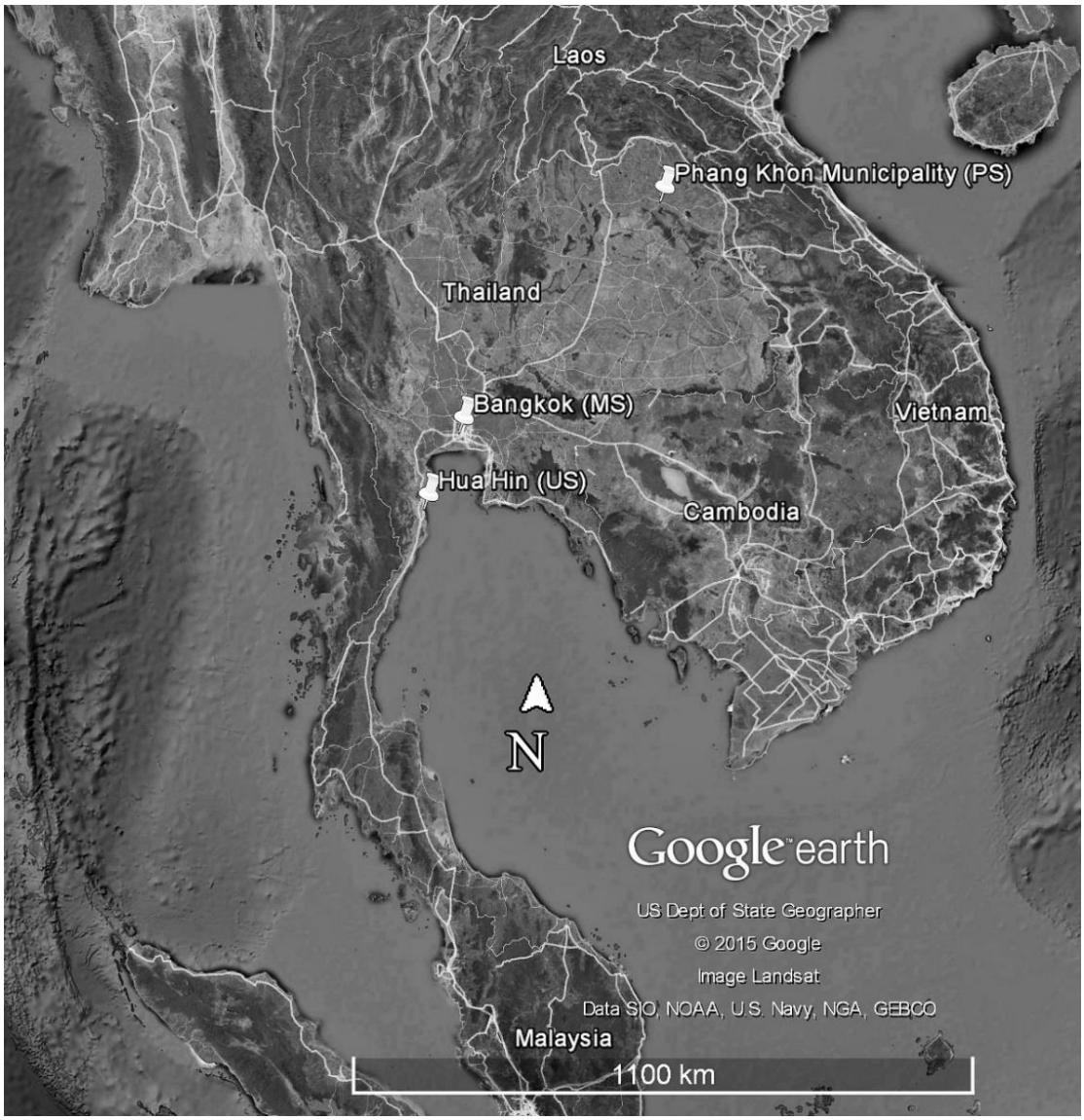


Figure 3. Map of study sites (Courtesy of Google™)

Table 1. Comparison of socio-economic factors at study sites

Parameters	Study sites		
	Peri-Urban Settlement (PS): Greater Phang Khon Areas	**Urban Settlement (US): Hua Hin Municipality**	**Metropolis Settlement (MS): BMA**
Registered Population	7,950	55,300	5,701,394
Administrative Area [km]	42.08	86.36	1,568.74
SignificantEconomic Activities	Agriculture, Mixed Uses	Tourism	Business, Capital City, Governance
Population Density [ppl /Km2]	164.21	640.34	3,634.38
Established MSWM	Yes	Yes	Yes
2008 Gross Provincial Product (GPP) per capita [USD]	1,297	3,963	10,928
Current MSWM fee (Based on household that generated less than 20 liters per day) (USD/month)	0.16	0.98	0.65

1.6.1. Additional information regarding settlements in the Peri-urban site

For PS, the study has conducted an additional investigation on the community-based recycling program “waste bank” to identify impacts from such a system. In this section, Thumbon Phang Khon municipality (PKM), depicted in **Figure 4,** is a small municipality located in Sakon Nakorn province in the northeastern region of Thailand. The municipality is well recognized for its MSW reutilization activities.

PKM runs a voluntary MSW collection service that charges members 1.95 USD per household per year (60 THB) to receive waste collection service daily. PKM operates a semi-sanitary landfill with an oxidative pond for leachate treatment. At the time of the study, there is no material recovery facility at the landfill but the municipality allows scavenging activities between 8:00 and 14:00 daily. The landfill is also contracted to accept MSW from other municipalities at the rate of 16.27 USD/ton (500 THB), and 32.54 USD/ton (1,000 THB) if the MSW comes from a private entity.

PKM also facilitates two voluntary MSW reduction programs to reduce landfilling of MSW including:

Waste bank program: PKM staffs collect recyclable wastes from 11 villages according to prearranged schedule by visiting two to three villages every Thursday. The municipality acts as a trader by buying recyclables, *i.e.* plastics, paper, glass, aluminum items, and metals, from waste bank's members and sorts these recyclables to increase the resale value. Finally, the municipality sells sorted materials to a recycling company. Transactions between PKM's waste bank and its members are settled in a credit system. Members and waste bank officers witness the weighting and sign in the transaction recording book. The members can withdraw their balances every Monday of the following week. The program, as an incentive, also provides around 160 USD (5,000 THB) funeral-assistance benefit to family members of whom pass away if two conditions are met: (1) the member maintains a minimum of 16.27 USD (500 THB) in his/her waste bank account at the time of death and (2) the member sells their recyclables to the waste bank within the last month before his or her death. As of October 2013, there are 522 members actively participating in the program.

Organic waste reutilization program: PKM provides technical support to its residents for installing waste composting bins and household-scale biogas generating systems at a subsidized cost, and routinely visits the participants. Residuals from biogas generation and compost are used in rice fields and for other agricultural practices in the municipality.

Figure 4. Map of Thumbon Phang Khon Municipality (PKM)

(Courtesy of Google).

Chang Ming Sub-district Administration Organization (CMS), located in the vicinity of PKM, is an administrative area that is not qualified to be chartered as a municipality, due to its failure to meet the requirements of minimum self-collected tax revenue. The MSW collection service is on a voluntary basis in which the subscribers pay 1 USD per month (40 THB) for a pickup of each 120-L trash bin on a weekly basis. The residents can also opt to manage MSW themselves. Despite being classified as non-municipality, CMS was selected for comparison with MSW characteristics from PKM because CMS service subscribers are mostly living in an urbanized part of the administrative area. Based on interviews with waste management administrators of

municipalities that dispose their MSW at PKM's landfill, CMS is the only urban settlement within proximity to PKM that does not officially promote any MSW reduction program at the time of this study.

Table 2. Socio-Economic Background of PKM and CMS.

Aspects	Phang Khon municipality (PKM)	Chang Ming Sub-district Administration (CMS)
Major economic activities	Retails, government office, private sector	Agricultural
Area under management (km2)	3.29	51.2
Percent of household subscribing to waste collection service	100.00%	37.68%
populations receiving MSW service[1]	6,848	3,478
Annual generation rate per registered population	372.30 kg/capita	322.15 kg/capita
Frequency of MSW collection	More frequent than every 3 days	Weekly basis
Government-facilitated MSW recycling system	Yes- waste bank, composting, and household biogas	No

[1] The numbers were provided by local government offices of PKM and CMS. They were derived from # of household that pay for MSW collection service in in 2013 and average dwellers per household.

CHAPTER II
LITERATURE REVIEW

2.1. Overview of Municipal Solid Waste

For effective mitigation of MSW crisis, the social behavior, generation rate, and MSW characteristics were reviewed before an effective management plan can be produced. Globally, the composition of MSW can be classified according to each country's level of incomes. Hoornweg and Bhada-Tata (2012) provided a snapshot of global MSW situation and reported that annual global MSW generation amount was at 1.3 billion tons and global MSW generation rate at 1.2 kg/capita/day. High-Income Countries produced MSW at the highest rate of 2.13 kg/capita/day while lower income countries produced MSW at lower rates. When lower and lower-middle income strata were combined, the average of combined urban waste generation was 0.84 kg/capita/day. Generation rates in upper-middle-income and high-income countries were increased at 1.37 and 2.53 times consecutively. These findings provide supporting evidence that once countries gain higher economic activities, the rate of MSW generation is likely to escalate in the same direction.

Considering MSW composition from countries with different income levels, the percentage of organic wastes in MSW and income levels are often inversely correlated while other MSW constituents tend to correlate directly with income levels. It reveals that low to upper-middle-income strata often process the highest percentage of organic waste [64%, 59%, 54% consecutively] while the high-income stratum has a paper [31%] as the highest proportion in MSW composition with organic wastes ranked as second [28%]. Percentages of plastic, glass, metal wastes do not wildly differ among

income strata. In all income strata, Organic, paper, plastic wastes tend to hold the ranks of the highest constituents in MSW.

In term of MSW disposal, landfilling remains the most popular choice when the waste management authority is in developing countries (Agamuthu, 2013). From **Table 3**, the cost of open dumping and landfilling tend to be at the lower range compared to other waste disposal methods, i.e. waste-to-energy or anaerobic digestion.

Table 3. Estimated costs for MSW disposal (in USD)

Source. Adopted from Hoornweg & Bhada-Tata (2012)

	Low-income countries	**Lower middle-income countries**	**Upper middle-income countries**	**High-income countries**
Collection	20-50	30-75	40-90	85-250
Sanitary Landfill	10-30	15-40	25-65	40-100
Open Dumping	2-8	3-10	N/A	N/A
Composting	5-30	10-40	20-75	35-90
Waste-to-Energy incineration	N/A	40-100	60-150	70-200
Anaerobic Digestion	N/A	20-80	50-100	65-150

Table 4.Composition of MSW in developing countries and selected cities.

Locations	Generation Rate (kg/ capita·day)	Organic (%)	Paper (%)	Plastic (%)	Glass (%)	Metal (%)	Other (%)	Source
Average Low Income Countries	0.6	64	5	8	3	3	17	(Hoornweg & Bhada-Tata, 2012)
Average Lower middle income Countries	0.79	59	9	12	3	2	15	(Hoornweg & Bhada-Tata, 2012)
Average Upper middle income Countries	1.2	54	14	11	5	3	13	(Hoornweg & Bhada-Tata, 2012)
Average High Income Countries	2.1	28	31	11	7	6	17	(Hoornweg & Bhada-Tata, 2012)
Bangkok, Thailand	1.57	50	11.3	22.5	2.7	1.7	12	(BMA, 2013)
Delhi, India	0.5	38.6	5.6	6	1	0.2	49	(Talyan, Dahiya, & Sreekrishnan, 2008)
Beijing, China	0.85	63.4	11.1	12.7	1.8	.3	11	(Zhen-shan, Lei, Xiao-Yan, & Yu-mei, 2009)

2.2. MSW Management in Thailand

2.2.1. Overview

Thailand, like many other developing countries, is also facing problems of rising MSW generation. The trend continues to grow upward according to Thailand's PCD (2013). Daily MSW generation rates were found to be at 0.91 kg per capita in the smallest towns, classified by Thailand's Department of Local Administration where population size is lower than 5,000, to 1.89 kg per capita in fully urbanized towns, categorized by Thailand's Department of Local Administration where population size is higher than 50,000.

Table 5 suggests that Thailand's MSW compositions are also similar to other developing countries whereby organic wastes are the dominating waste type in all town sizes. Plastic and paper, however, gain a higher share of the waste stream in more urbanized towns.

2.2.2. Legal framework for MSW management and obstacles

Public finances for MSWM often fail to provide and enforce incentives for MSW separation and recycling. From **Table 5,** the majority of towns in Thailand still employ unsounded disposal methods as alternatives, *i.e.*, open dumping or open burning. This is because of the benefits of having relatively lower out-of-pocket cost as compared to other more advanced MSWM methods (Hoornweg & Bhada-Tata, 2012). Environmental impact assessment (EIA) for landfill construction without MRF system in Thailand is not required [Notification of the Ministry of Natural Resources and Environment dated 24 April B.E. 2555 (2012)]. Despite relatively more relaxed rules

for landfill chartering, many landfills, however, often face strong oppositions from stakeholders. For example, in 2012, seven out of 121 sanitary landfills in Thailand were put on suspension or unable to be commenced due to protests and legal proceedings (2013).

Table 5. Statistics of MSWM methods in Thailand

Source. (ThaiPublica, 2014)

MSWM Methods	Details	Numbers of Sites
Compliance to Thailand's MSWM standards	Sanitary/Engineered landfill	73
	Controlled Dump	367
	Incinerator with appropriate pollution control equipment	10
	Waste-to-Energy system	1
	Mechanical-Biological Treatment	3
	Integrated solid waste management	12
Non-compliance with Thailand's MSWM standards	Controlled Dump	24
	Open dump	1,955
	Incinerator with not-up-to-standard pollution control equipment	45
	total	2,490

Given the disparity of collected fees to the cost of MSWM, it is understandable that the low upfront and operation costs of landfilling and open dumping continue to make them a popular option. Complex and ambiguous regulations in Thailand are a burden on financing MSWM. The investment and operating costs for more modern

MSW management are often higher when they are compared to landfilling technique. The cost estimation for MSWM in Thailand is shown in **Table 6**.

Table 6. MSW cost estimation

Source. Adapted from Department of Local Administration (2015)

Technology	MSW collection fee (THB per ton)	Disposal Cost (THB per ton)	Total cost (THB per ton)
Sanitary landfill	850	314	1,164
Incinerator	850	1,092	1,942
Incinerator with gasification system	850	672	1,522
Refuse derive system (RDF)	850	171	1,021
Integrated MSW management	850	500	1,350

Under the Public Health Act B.E. 2535 (1992) (PHA), the responsibility to collect and dispose of MSW is delegated to Local Administrative Organizations (LAOs) such as municipal governments. However, the PHA only authorizes LAOs to bill the collection cost to MSW generators. Disposal costs are to be recovered by the guideline in the Enhancement and Conservation of the National Environmental Quality Act B.E. 2535 (1992) as utilized in few municipalities , i.e. Muang Nakorn Phanom Municipality or Muang San Suk Municipality (National Environmental Board, 2013). Consequentially, most LAOs, which are more familiar with the PHA, only enforce and collect MSW collection fees and use the fees to cover both collection and disposal costs.

Also, MSWM expenses per resident rise substantially due to increasing complexity in collection and disposal as the town size increases. As indicated in **Table 6,** collected MSWM fees cover only approximately 10-37% of the annual cost of MSWM in sampled small municipalities and less than 10% for sampled larger municipalities.

At the time of writing this dissertation [27th November 2015], the Royal Thai government has been in the processes of updating and promulgating new MSW management laws and regulations, e.g. (Draft) Ministral Regulation on the MSW Management B.E.… and (Draft) Ministral Regulation on the Fees for MSW Management B.E.… . Once both Ministral Regulations are ratified and announced in the Royal Thai Government Gazette, municipalities will have the power to mandate recycling and rising MSW servicing fee from the current ceiling, which households that generate MSW at 20 L or lower per day, can be risen from 40 THB, on monthly basis, to 65 THB for MSW collection service and 155 THB for MSW disposal service (Ministry of Public Health, 2015).

Table 7.Selected 2013 municipal budget reports in Thailand

Source. (Muang Municipality, 2014; Muang Nong Pre Municipality, 2014; Nakorn Chieng Rai Municipality, 2014; Nakorn Nakorn Rajsrima Municipality, 2014; Thumbon Krui Buri Municipality, 2015; Thumbon Lamthough Municipality, 2015)

Parameters	Settlements classified as Peri-urban (Thumbon municipality)		Urbanized municipality) Muang Municipality)		Most Urbanized Municipalities (Nakorn municipality)	
	Thumbon Lamthough Municipality, Nakorn Rajsrima	Thumbon Krui Buri Municipality, Prachub Khirikhan	Muang Nong Pre Municipality, Chonburi	Muang Municipality, Prachub Khirikhan	Nakorn Nakorn Rajsrima, Nakorn Rajsrima	Nakorn Chieng Rai, Chieng Rai
Registered Populations	5,950	9,830	61,198	17,901	136,153	69,612
% MSW's related expense from overall expenses	0.57%	3.48%	13.88%	10.41%	9.78%	14.54%
% fee covered in MSWM expense	36.36%	10.47%	11.48%	3.47%	0.05%	6.37%
Expense for MSWM per head (USD)	0.91	5.69	18.06	26.16	23.23	27.17

2.3. Impact of Traditional MSW Management

Over the last few decades, adverse impacts of landfill has become one of the major causes of environmental quality deterioration, particularly of worsening of groundwater quality by heavy metal or organic pollution seeped with leachates, poor air quality from emitted gases and noxious odors, and worsening climate change impact (Aguilar-Virgen, Taboada-González, & Ojeda-Benítez, 2014; Gentil, Christensen, & Aoustin, 2009; Menikpura, Sang-Arun, & Bengtsson, 2013). To make the matter worst, lacking of waste separation and recycling system cause contamination of household hazardous waste (Slack, Gronow, & Voulvoulis, 2005) and electronic waste (Jinhui, Huabo, & Pixing, 2011; Tang et al., 2010) in the waste stream. Analysis of leachate from landfill also reveals potential contaminants of the xenobiotic and heavy meal (Glassmeyer et al., 2009; Slack et al., 2005) or even leachate contamination from expired medicine (Metzger, 2004).

Not surprisingly, employing landfill has become a less preferred MSW management (MSWM) technique. Moreover, stakeholders who live around landfills often suffer from deteriorated aesthetic and living quality in their neighborhood (Zaman & Jam, 2014) and depressed property value (Hite, Chern, Hitzhusen, & Randall, 2001; Owusu, Nketiah-Amponsah, Codjoe, & Afutu-Kotey, 2014). The pressure of finding alternative means to handle MSW continues to challenge the capability of the MSWM system. Under the presence of urbanization, MSW generation rates have been found to accelerate along with increases in population size and wealth (UN-HABITAT, 2010). MSW composition has also changed according to various stages of urbanization. Generally, MSW composition in a less urbanized town tends to contain mostly food

wastes while a more urbanized town tends to contain more diverse waste with a rising proportion of paper and plastic wastes (Hoornweg & Bhada-Tata, 2012).

2.4. Formal MSW Recycling

MSW is an unsolved global problem as the population increase, the generation rate of MSW also increases while the availability of land for landfilling and management resources, including governmental budgets for MSW collection and disposal, i.e. waste-to-energy, anaerobic digestion, are limited. Hence, promoting MSW separation and recycling has become one of the approaches to reduce MSW landfilling. Many countries, e.g. Japan, South Korea, and the USA, approach the rising MSW generation through mandating waste separation and charging a relatively higher fee for landfilling MSW as a deterrence of landfilling mixed or unsorted wastes. The strategies involve at-source waste separation of recyclables from the regular wastes to minimize relatively high MSW disposal fees.

Environmentalists, economists, politicians are concerned with this problem and the 3R approach: Reduce, Reuse, and Recycle, has been introduced to mitigate the crisis. Nauclér and Enkvist (2009) reported that MSW recycling is a cost-effective measure for solving both MSW crisis and can also help to greenhouse gas emission concurrently. Nevertheless, the accomplishment of the 3R program is still not widely successful because of social structure/culture, such as the lack of appropriate education on the management of MSW and the lack of incentives from utilizing 3R approach. In general, global recycling and source reduction programs around the world can be summarized in **Table 8**.

Table 8. Recycling and source reduction practice of MSW classified by country's levels of incomes

Source. Adopted from Hoornweg & Bhada-Tata (2012)

Activity	Low-Income Country	Middle-Income Country	High-Income Country
Source Reduction	• No organized programs • Low per capita waste generation rates	• Some discussion of source reduction • Rarely incorporated into an organized program	• Organized education programs emphasize the three 'R's' — reduce, reuse, and recycle. • More producer responsibility & focus on product design.
Recycling	• Most recycling activities conducted by the informal sector and waste picking • high Recycling rates in local markets and international markets • Unregulated	• Informal sector still involved • Some high technology sorting and processing facilities. • Relatively high recycling rates • Recycling works mostly on, imported	• Regulated operations of recyclable material collection services • High technology sorting and processing facilities • Overall recycling rates greater than low and middle income.

Table 9. Recycling statutes and policy toward MSW reduction in various countries

Countries	Statutory Required	Target Recycling rates	Current rates	Source
Wales, UK	Yes	52	56	(BBC, 2015)
The European Union	Yes	50	39	(European Environment Agency, 2013)
Virginia, USA	Yes	25	41.2	(Virginia Department of Environmental Quality, 2014)
Thailand	No	30	18.4	(PCD, 2015)
Vancouver, Canada	Yes	70	60	(Nagel, 2014)
Singapore	Yes	70	60	(National Environment Agency, 2015)

From **Table 9,** the recycling rate of Thailand is low comparing with most of the high-income nations. Most countries with good recycling records often have set targeted recycling rate. Focusing on setting recycling goal, Thailand has not had established a mandatory targeted rate for recycling. Instead, Thailand has just merely mentioned a target for improvements in recycling activities in the 11th National Economic and Social Development Plan (NESDB, 2011).

2.5. Informal MSW Recycling

Relying on scavenging activities to recover recyclables may be inadequate because high potential recyclables may be contaminated by wet wastes, which degrades their quality and can eventually be deemed not suitable for recycling (Gunsilius, Chaturvedi, & Scheinberg, 2011) or household hazardous waste, i.e. motor oil. Recovery by ragpickers was found to be approximately 4-12% of the generated MSW (Challcharoenwattana & Pharino, 2015; Ojeda-Benitez, Armijo-de-Vega, & Ramírez-

Barreto, 2002; D. Wilson, Whiteman, & Tormin, 2001). Additionally, a material recovery facility (MRF) may not function better than traditional ragpicking if at-source separation is not conducted (Zero Waste Houston Coalition, 2014).

Recycling activities in developing countries tend to be practiced on a community basis or by a for-profit practice. The typical model of for-profit recycling is that informal waste workers (IWW), both in term of ragpickers at landfills and itinerant recyclable buyers (IRB), divert a portion of recyclable MSW from being sent to landfills. In many settlements, IWWs performed multiple roles in servicing MSW collection processes, such as hauling wastes from households, then scavenging wastes, and eventually discarding rejected wastes to dumpsites, resulting in high diversion rates of recyclables compared with that of urban settlements that do not allow informal recycling (Gunsilius et al., 2011).

For non-scavenging informal waste workers, itinerant recyclable buyers function as a service provider for curbside recycling where households sell or donate recyclables to IRBs. IRBs then gather those recyclables and resell them to recyclable buying centers, which is the equivalent of a drop-off recycling center in a formal recycling system. Nevertheless, the strong advantage of IRB and Recyclable Centre Buying (RCB) are that they are self-funded, and the cost of running them is not a burden to the government or taxpayers, which is in contrast to the official curbside or drop-off recycling that may incur great costs to the public (Kinnaman & Fullerton, 2000).

2.6. Community-Based MSWM

Community-based management (CBM) is a bottom-up approach to solve problems where members of the community function as core operators. Efficiency

comparisons between CBM and traditional models often found that CBM can resolve issues effectively with less burden on other taxpayers (Cunningham, Bremner, & Boyle, 1995; Liddle, Mager, & Nel, 2014; McKenzie-Mohr, 2000). Employing CBM as a tool for resource management has been found in the fields of water resource management (Dewan, Mukherji, & Buisson, 2015; Margerum & Robinson, 2015), forest management (Cagalanan, 2015; Sharma, Deml, Dangal, Rana, & Madigan, 2015), community services (Farmer et al., 2001; Wallerstein & Duran, 2006), *etc.*

For solid waste management, CBM activities are employed for both regular MSW services and specific waste services. For regular MSW services, CBM members collect refuses from households, and sort and manage wastes (Afroz, Hanaki, & Hasegawa-Kurisu, 2009; David C. Wilson, Velis, & Cheeseman, 2006). Specific waste services focus on certain types of waste, e.g. only accept recyclables for further recycling activities or only organic wastes for composting/biogas generation. In addition to promoting better resource reutilization, associated benefits of CBM in MSW are also reported such as rising incomes for CBM members due to better economy of scale and the reduction of health risks from random scavenging (Medina, 2008). An example can be found in the city of Surabaya, Indonesia where it successfully manages organic wastes using a community composting system (Afroz et al., 2010; Kurniawan, Puppim de Oliveira, Premakumara, & Nagaishi, 2013). Other examples include the recycling program by waste picking service of Zabbaleen group in Cairo, Egypt or CBM projects in Lusaka (Scheinberg, Spies, Simpson, & Mol, 2011; David C. Wilson et al., 2006).

In Thailand, CBM for MSWM is often chartered as “waste bank programs”. Program operators act as an intermediary in order to sell sorted recyclables at greater

net revenues. Activities are often taken part in as a collaboration between waste generators and other entities that agree to host recyclables at their site (often at schools or community centers). The success of waste bank activities in Thailand has been varied depending on the social structure and political situation (Mongkolnchaiarunya, 2005; Suttibak & Nitivattananon, 2008).

Examples of CBM in Thailand can be demonstrated in Mongkolnchaiarunya (2005) who reported the "recyclable wastes for eggs" recycling project introduced in Yala municipality. The project had initially able to drawn a large volume of recyclable wastes, but the rate was significantly decreased during the 13-month reporting period. Nevertheless, the decrease was viewed as usual as dwellers may bring waste from their storage out before the volume reached a normal MSW generation rate. The author also observed an increasing percentage collected MSW collection fees from 37.7% in 1999 to 58.6% in 2001. BMA (2013) reported that its community-based MSW management program helped to reduced MSW generation of 12 participated communities by 40 percent compared to collect MSW in 2010. Its special showcase, the Tawee-Saph Tawee-Boon Recycling Project **(โครงการทวีทรัพย์-ทวีบุญ)** from BMA, which is one of waste bank programs, used a drop-off system to collect recyclable materials and credit participant's account after waste dealers pay for the lot. During its 3-year program, the system has 2,197 members and able to divert 130 tons of recyclable materials from landfills. Other styles of community-based MSWM are provided in **Table 10.**

Table 10. The performance of community-based MSWM.

Activity	Incentive	Reutilization Metric
Regular MSW collection and disposal service		
Enugu, Nigeria (Nzeadibe, 2009)	Cash revenue higher than minimum wage	Potential earning of 3.91–5.47USD per day
Guiyang, the People Republic of China (Xu, Zhou, Lan, Jin, & Cao, 2015)	Monetary incentive for MSW separation	87.3% of MSW is separated
Nungankkan, India (Colon & Fawcett, 2006)	De facto rights to provide service	6.5% of generated MSW is sold
Jubilee Hills, India (Colon & Fawcett, 2006)	De facto rights to provide service	25% of generated MSW, ½ as compost, and ½ as recyclables
Waste Bank Operations		
Rayong municipality, Thailand (Rayong City Municipality, 2013)	Community recognition and cash return	17.33 kg/member
Yala municipality, Thailand (Mongkolnchaiarunya, 2005)	Bartering between unused recyclables to egg	15.71 kg/member
Averaged 10 community-based programs in Thailand(Suttibak & Nitivattananon, 2008)	Community recognition and cash return	18.6 kg/member
Average 100 school-based programs in Thailand(Suttibak & Nitivattananon, 2008)	Community recognition and cash return	32.13 kg/member

2.7. Economics of Municipal Solid Waste

In Environmental Economics perspective, unregulated MSW disposal is classified as “Public Goods” because it processes non-rivalry and non-excludability characteristics. During those times, city dweller can dump or burn their waste in an open space area. The practice eventually causes an outbreak of diseases and displeasure of town dwellers. Governmental bodies started to issue MSW management regulations

prohibiting city dwellers to dispose of their wastes except on designated dumpsites or landfills. With such mandate and attempt to promote sanitation on MSW management with financing those MSW out from initial consideration, the Municipal Solid Waste Management Authority (MSWA) is now struggling to commence new landfill projects and must even suspend existing landfill operations due to public demonstrations. Schemes to change MSW management (MSWM) to alternative disposal technologies, such as incineration, are often too costly and create significant budgetary burdens. The city of Harrisburg provides an excellent example of a town that has to declare bankruptcy as it cannot pay the debt arisen from its incinerator project (Varghese, Bathon, & Sandler, 2011).

To balance budgets, governmental bodies starts to charge collection and disposal for MSW with different fee schemes: flat rate and unit pricing. However, flat rate scheme for MSW management renders no incentive for MSW reduction, as it does not impose marginal cost of disposal to polluters whereas the unit pricing, both fixed pricing or progressive pricing of disposal units, provides incentives for MSW reduction and recycling as observed in South Korea (Lee & Paik, 2011), and USA (Jenkins et al., 2003).

To expand the operating life of landfills and minimize environmental burdens on stakeholders, MSW diversion before landfilling has been recommended by the principle of the "3Rs"—Reduce, Reuse, and Recycle. However, many MSWAs struggle to incorporate a recycling system into their MSW management systems, citing a deficit of investment, lack of participation, and insufficient technical support as their primary reasons (Ezebilo, 2013). Alternatively, pricing the disposal of MSW using a "Pay as You Throw" (PAYT) scheme is often employed to incentivize a reduction of

disposed MSW and to promote separations of recyclables in many towns with good track records (Gellynck & Verhelst, 2007; Hong, 1999; Reschovsky & Stone, 1994). In Thailand, various municipalities' experiments with PAYT and reported a reduction of collected MSW. A result from PAYT in Thumbon Nangla municipality was reported by Manomaivibool (2015) that implementing PAYT with promoting recycling helped to reduce disposal rate of MSW with a supporting evidence that waste quantity remained low despite weaning of recycling program.

Despite clear benefits of PAYT for reducing the overall burden of public finance, many cities still opt to maintain the status quo by absorbing the cost of MSW services using the justification that households may turn to illegal dumping and create adverse health and sanitation situations. Another potential cause of slow adoption of system improvements is the fear of political backlash from increasing MSWM fees despite the city managers' awareness of the long-term benefits. A good example in Thailand of BMA's ordinance regarding MSW and night soil collection issued under Public Health Act (issue #2) B.E. 2548 (2005) discounted the MSW management fee from 40 THB to 20 THB, the result of political campaigning.

Contrary to popular belief, outcomes from many contingent valuation surveys have indicated that respondents often understand and express increased willingness to pay if MSW services are improved (Blaine, Lichtkoppler, Jones, & Zondag, 2005; Palatnik, Ayalon, & Shechter, 2005).

Nevertheless, MSWM fees must be set at an appropriate level. When the fees are too high, residents are more likely to engage in illegal dumping or refuse to subscribe to the MSWM system (US EPA, 2004). If the fee is too low, recycling rates may decrease because MSW generators may opt to pay the fees to continue their

existing practice of not recycling, and they may view the fee as a “reparation fee for not recycling.” Uri Gneezy and Aldo Rustichini (2000) indicated that penalties that are too lenient can encourage behavior that they were intended to curb. Also, there are cases of waste generators outsmarting the volume-based MSW pricing system by compacting their refuses to reduce disposal cost (Mazzanti, Montini, & Zoboli, 2008). Also, some MSW generators illegally dispose of their refuses on neglected spaces or in neighbors’ trash containers (Nestor, 1998; Taylor, 2000).The same impact of charging too little of MSW management fee can act as a perverse incentive for MSW generators to not reducing their MSW generation but rather pay the fee and continue not sorting MSW.

Abrahamse, Steg, Vlek, and Rothengatter (2007) demonstrated that education with follow-up can provide an improvement of environmental consciences. The experiment was conducted on a group that received tailored energy-saving training with 5-month follow-up and a control group that only receive general energy-saving education with no follow-up. The group that received tailored energy-saving recommendations has reduced their energy uses by 5.1% with 0.7% from the control group. Bulte, Gerking, List, and de Zeeuw (2005) evaluated the reaction and willingness to pay of respondents on scenarios that similar environmental disaster occurs from natures, indirect human act, or direct human act. The study group demonstrated the highest willingness to pay for fixing environmental damages arisen from the human act. Hence, tailored waste management provides great promises for MSW reduction as socio-economic factors from each human settlement has people with different income levels to achieve high recycling performance.

2.8. Contingent Valuation and Underlying Econometric Analysis

To estimate current aptitude and financial potential of employing Polluter-Pays-Principle on MSW management, Willingness to pay [WTP] and Willingness to Accept [WTA] estimation techniques are employed. WTP is a value or benefits the consumer expects to receive from consumption of the commodity while WTA is a value or benefit the consumer expects to receive for giving up the procession of the commodity (Gentil, Clavreul, & Christensen, 2009). Coase Theorem (Coase, 1965) indicates that although there are externalities of total environmental service cost, society would bargain to obtain efficient solutions whether solvers are polluters or victims. Hence, either waste generators may decide to minimize waste in order to minimize MSW management fees or waste generators may decide to pay MSW fees so they do not have to conduct the task themselves can yield similar results.

Although both WTA and WTP are designed to, measure the same commodity, results from WTA often yield a higher value than results from WTP do. The reasons are speculated that WTA is viewed as compensation for a problem while WTP is viewed as out-of-pocket expenses to abate a problem (Horowitz & McConnell, 2002) .Of the two, WTP has become more popular because values as reported tend to be more conservative than those of WTA (He & Asami, 2014; Horowitz & McConnell, 2002). The CV technique gained acceptance when the National Oceanic and Atmospheric Administration (NOAA) used the technique to evaluate the public's willingness to pay to prevent environmental and ecological damages similar to the Exxon Valdez oil spill case (Carson et al., 2003). CV is also used in other non-market valuations to gauge the public's WTP for improvement or introduction of public services, i.e., river management (Loomis, Kent, Strange, Fausch, & Covich, 2000), air quality

improvement (Wang & Whittington, 2003), climate change mitigation (Choi, 2014), and improvement of MSWM (Aadland & Caplan, 1999; Dunn, 2012; Kinnaman, 2000). WTP studies related to solid waste management both in Thailand and other countries are shown in **Table 11.**

Relationships between WTP, incomes, socio-economic factors, and recycling behaviors can be demonstrated using the random utility theory. As adapted from Wang and Whittington (2003), in a situation where no MSWM service (V_0) exists, the utility can be explained as:

$$V_0 = V(Y, P, E_0, Z, \varepsilon_1) \qquad \textbf{Equation 1}$$

Where Y is incomes, P is a price vector, E_0 is an environmental status of lacking MSWM services, Z is the observed socio-economic, perception, knowledge toward the issue and ε_1 is a group of factors that are not reflected in Y, P, E_0, Z.

If an MSWM service is offered, an individual is willing to pay up to the amount of X monetary unit (WTP_x) for the service and the environmental status changes from E_0 to E_1. The utility for this situation (V_1) can be expressed as:

$$V_1 = V(Y-(WTP_x), P, E_1, Z, \varepsilon_1) \qquad \textbf{Equation 2}$$

Solving for WTP results in:

$$V_0 \rightarrow V_1 \text{ and } WTP = WTP\ (Y, P, E_0, E_1, Z, \varepsilon_1) = E[WTP] + \varepsilon_2 \qquad \textbf{Equation 3}$$

Table 11. WTP studies related to MSW management

Technique	Year Surveyed	Sample sizes	Mean monthly WTP [USD[PPP @2005]]	Study site	Source
Dichotomous choice CV-double bound	1,999	401	4.99	Ogden, Utah	(Aadland & Caplan, 1999)
Dichotomous choice CV-double bound	2,002	204	9.81	Bangkok Thailand	(Arayameth, 2003)
Open-ended stated preference	1,993	300	6.64	Udonthani, Thailand	(Nimpongsak, 1993)
Dichotomous choice CV-double bound	2,007	381	5.27	Kampala City, Uganda	(Banga, Lokina, & Mkenda, 2011)
Dichotomous choice CV-double bound	2,006	480	4.18	Dhaka City, Bangladesh	(Afroz, Hanaki, & Hasegawa-Kurisu, 2009)
Stated Preference	2004	300	0.68	Hua Hin, Thailand	(Srivisitphan, 2004)

Where E [ ] is an expectation transformation, and ε_2 is the random term of the individual's WTP for MSW service in which ε_2 values are unique for each individual.

WTP can be estimated by a contingent valuation method that has four different techniques as described in (Venkatachalam, 2004)

- Open-Ended Stated Preference: interviewers ask interviewees to state the amount that each individual would like to pay to obtain/refrain from certain commodity
- Payment Card or Bidding Game Question: interviewers show series of cards that have difference values to interviewees, who will choose the card that matches with his/her preference
- Single-ended dichotomous choice: interviewer shows the stated number and asks if the interviewer would indicate if he/she is willing to pay for this amount or not.
- Double-ended dichotomous choice: the procedure is similar to the single-ended dichotomous choice except once an interviewee selects the first choice, the second dichotomous choice is presented to the interviewee.

Among four techniques, payment card and double-ended dichotomous choice techniques have been the most populous techniques on eliciting WTP. Blaine et al. (2005) and Cameron and Huppert (1989) compared WTP elicited from the payment card and the dichotomous choice methods and found that both techniques yield indifferent results. In Thailand, Ahlheim et al. (2007) conducted a face-to-face WTP valuation for better water quality arisen from the reduction of upstream polluting activities on citizens of northern provinces using the dichotomous choice (DC) technique and payment card (PC) and the study reported that WTP from the DC method yielded the mean WTP of 196 THB per month while the PC method yielded the mean WTP of 69 THB per month respectively. However, the mean WTP derived from the

mail survey indicated that WTP derived via DC was 69 THB per month while PC was 68 THB per month.

This study employed the payment card (PC) method because PC tends to provide more conservative outcomes than other methods (Ahlheim et al., 2007; Rowe, Schulze, & Breffle, 1996; Ryan, Scott, & Donaldson, 2004). Also, results from PC typically do not generate high numbers of protests or the extreme value bids (Venkatachalam, 2004). The biases associated with PC, namely potential cantering and range biases, can be minimized if the method is designed correctly (Mitchell & Carson, 1989).

2.9. Behavioral Study of Recycling

Despite the availability of recycling services (both formally and informally), the success of a recycling program relies heavily on the participation of waste generators, and using only price incentives may not be sufficient to encourage recycling due to the inelasticity of the demand for MSW services (Germà Bel & Gradus, 2014; Suwa & Usui, 2015). Designing a program that considers behavioral, the socio-economic background, and attitude toward concerned issues has provided plentiful examples of turning a failed program into a successful program (Akerlof & Kennedy, 2013; the Cabinet Office Behavioural Insights Team, 2012). Therefore, additional reinforcements are required to promote recycling.

For any behavioural study related to recycling, a holistic consideration of both socio-economic, i.e., age, gender, and level of income, and the pro-environment attitude, i.e., positive attitude toward recycling, are required to ensure a robust

prediction power (Jenkins et al., 2003; Lee & Paik, 2011). From **Table 12,** although relationships between recycling practice and socio-economic and pro-environment attitudes exhibit similar tendency on recycling practices, several studies have reported contradictory results

2.10. Decision Support System for Implementing Recycling

Given the complexity and many factors required for efficient decision making, the need for providing decision guidelines that unify decision criteria into one indicator is often required for a clear decision support. Multiple-criteria decision analysis (MCDA) has been commissioned to assist policy makers. Amongst the many MCDA techniques, e.g., analytic hierarchical process (AHP), technique for order of preference by similarity to ideal solution (TOPSIS), elimination and choice expressing reality (ELECTRE), and preference ranking organization method for enrichment of evaluations (PROMETHEE), AHP remains one of the most used techniques (Soltani, Hewage, Reza, & Sadiq, 2015).

Applications of AHP have been reported in the selection of faculty (Mamat & Daniel, 2007) and the choice of power plant systems (Aragonés-Beltrán, Chaparro-González, Pastor-Ferrando, & Pla-Rubio, 2014). In waste management, AHP has been used in the process of identifying landfill space to select the most optimal waste treatment techniques (De Feo & De Gisi, 2010; Z. S. Li, Fu, & Qu, 2011; Molinos-Senante, Gomez, Garrido-Baserba, Caballero, & Sala-Garrido, 2014)

Table 12. Selected relationships between socio-economic, attitudes, and norms toward recycling

Factors	Relationship with recycling (only factors with statistical significant)		
	positive	**neutral**	**negative**
Increase of age	(Afroz, Hanaki, Tuddin, & Ayup, 2010; Lee & Paik, 2011; Zen, Noor, & Yusuf, 2014)	(Czajkowski, Kądziela, & Hanley, 2014) (Jenkins et al., 2003)	
gender (Male)			(Afroz et al., 2010)
levels of education	(Czajkowski et al., 2014; Zen et al., 2014) (Jenkins et al., 2003)		
levels of income	(Lee & Paik, 2011; Zen et al., 2014) (Jenkins et al., 2003)	(Czajkowski et al., 2014)	
Positive attitude toward recycling	(Czajkowski et al., 2014; Zen et al., 2014)		
Concern of environmental quality	(Afroz et al., 2010; Lee & Paik, 2011; Zen et al., 2014)		(Czajkowski et al., 2014)
Engage in pro-environment activity	(Czajkowski et al., 2014; Zen et al., 2014)		

CHAPTER III
METHODOLOGY

The research is divided into four phases: [1] Design and planning, [2] Data collections and questionnaire deployment, [3] Analysis of gathered data [4] Develop suggestions/plan for improvement in MWS management. The outline has been shown in **Figure 5**.

3.1. MSW Characterizations

This study conducted MSW characterization on MSW arrived at landfills from the Peri-urban site (28th and 29th October 2013) and the Urban site (23rd and 24th November 2013), using procedure described in Challcharoenwattana and Pharino (2015) where MSW arrived at the landfill on that day was mixed, and removed until the final volume of MSW was around 200 liters. Those wastes were then characterized on weight basis using a scale readable to 0.01 kg into the following: readily recyclables, plastic, paper, glass, aluminum, and metals; not economically sensible for recycling, organic wastes, plastic, paper, glass, garments, aluminum and miscellaneous wastes. The process was repeated three times on each day. Due to the limitation of financial resources, and a massive quantity of MSW from Bangkok, we opted to employ published data from Bangkok Metropolitan Administration (BMA, 2013).

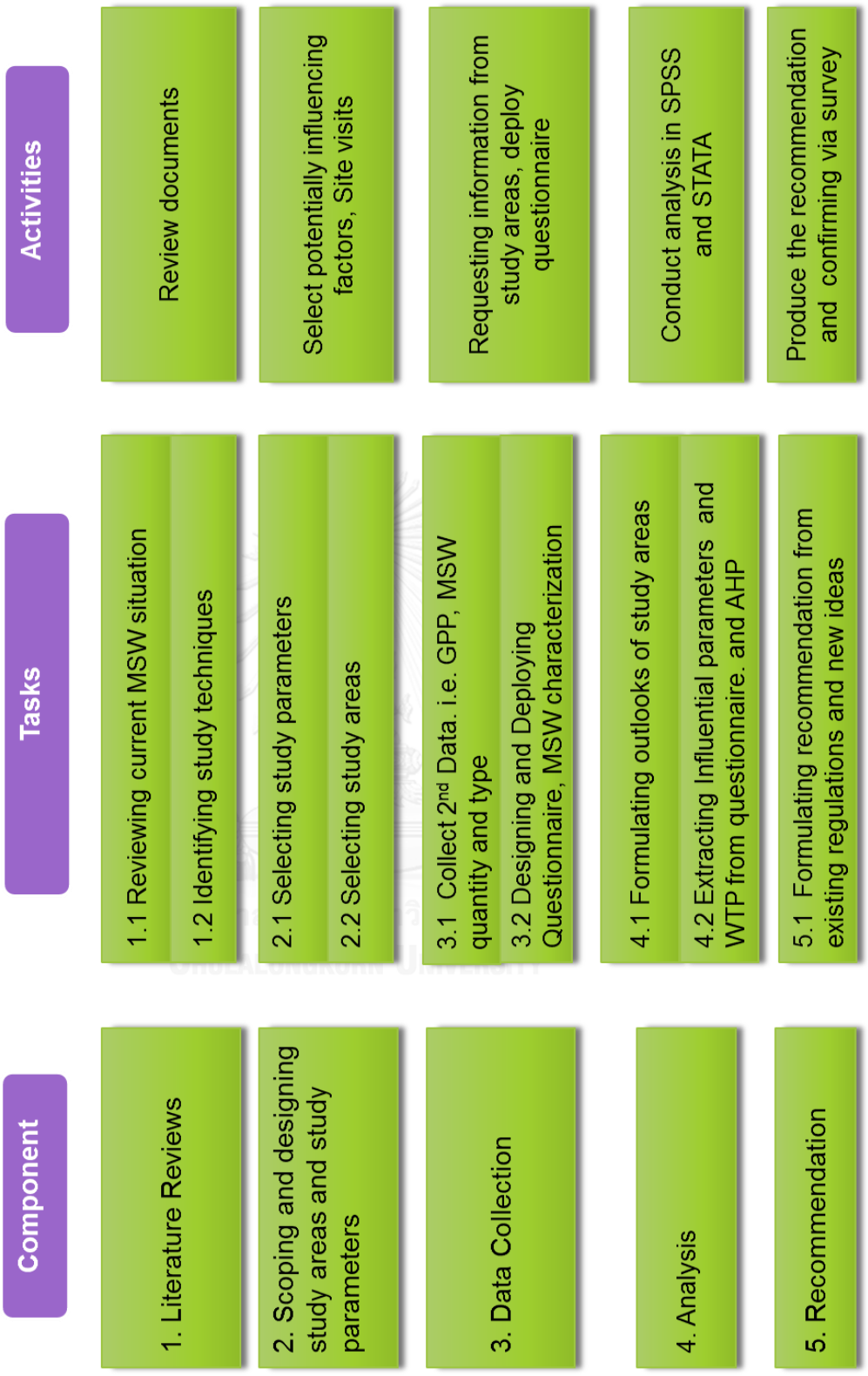


Figure 5. Outline of the Research

3.2. MSW Landfilling Costs

The cost of landfilling was set at 13.18 USD per ton of MSW (405 THB). This was based on the estimated cost provided by Thailand's Pollution Control Department, which is consistent with the cost estimated by the World Bank (Hoornweg & Bhada-Tata, 2012).

To estimate the saved landfilling cost per ton, we assumed that respondents who already practice recycling on a particular waste type would likely to separate or recycle more of that specific waste type if adequate support or incentives were provided. In this paper, we assumed that the recyclable buyers bear the cost of collection and processing, and the recyclables were separated at the source. Hence, the zero expense from IRB and RCB was justified, and the saving can be used to incentivize recyclable separation.

3.3. Questionnaire Survey

3.3.1. Questionnaire Design

The questionnaire used in this study was designed with the primary goal of determining the socio-economic status of survey interviewees, their attitude and management of MSW, and their WTP for MSW recycling (MSWR). The style and question pattern were developed based on questionnaires used in two previous studies (Afroz et al., 2009; Arayameth, 2003).

To reduce potential ambiguity, the pilot testing of the questionnaire was conducted via face-to-face interviews with students from Chulalongkorn University using the payment card table with a range of 0-1,000 THB and additional space was provided if the interviewee prefers to indicate a WTP greater than 1,000 THB (32.54 USD). After adjustments, an improved questionnaire was then retested with broader

audiences by posting it on the Thai bulletin board website, Pantip.com. Based on finding from the pre-test surveys, none of the stated maximum WTP from the pre-test was higher than 500 THB per month (16.27 USD). Hence, the range of payment card table was defined between 0-600 THB per month (19.52 USD). The final version questionnaire and the payment card table is shown in **Appendix 1.**

To determine WTP, we arranged the questions by asking the amount of MSWM fee that the interviewee was paying. Then, the interviewee was asked about his/her monthly income and expenses to indirectly remind him/her of his/her financial situation. Afterward, a statement was read to the interviewee that can be summarized as follows:

"Annually, 24 million tons of MSW are generated in Thailand, and we still lack the ability to treat this waste. If this trend is allowed to continue, MSW will become a crisis. Please also consider that the MSW disposal fee that you are paying covers only 9-15%[2] of the true MSWM cost, and the remainder is paid by taxes or money from the central government."

After the above statement had been read to the interviewee, we asked a hypothetical question related to a scenario in which the town is planning to upgrade MSWM with waste separation and a recycling system. The interviewee was told that if the plan is implemented, his/her monthly MSWM bill will be increased to cover the purchase of necessary sorting equipment, electricity costs and fuel expenses.

[2] Assumption made based on 20-40 THB of MSWM fee charged to a housing unit that generates MSW of 226.8 kg/month. The estimated true cost of MSWM was based on 1 THB for 1 kg of landfilled MSW. The exchange rate used was 1 USD = 30.73 THB

Nevertheless, the bill will ultimately be cheaper because the town does not have to purchase more land or construct new landfills. If the plan is not implemented, the interviewee will pay the current MSWM fee, but the town may have to charge him/her a more expensive fee in the future for new landfill construction, and he/she may experience inconvenience from disrupted MSW service if new landfills cannot be constructed before the current landfills reach capacity.

The interviewee was then asked to indicate his/her maximum WTP by looking at a payment card table where the range of values displayed in the table start at 10 THB (0.33 USD) and increase incrementally by 10 THB (0.33 USD) to the maximum of 600 THB (19.52 USD). Additional space is available if the interviewee prefers to indicate a WTP greater than 600 THB (19.52 USD). There was also a separated choice of zero WTP located above the payment table. The interviewee was then reminded again that the maximum WTP will come from his/her pocket. Therefore a sub-compartment of income and asked to circle his/her monthly maximum willingness to pay for the MSWM service with the MSW recycling system or he/she could check the zero WTP box if his/her WTP were zero. Space was also available for the interviewee to explain why he/she is unwilling to pay. The payment card table is shown in **Figure 6**.

3.3.2. Sample Size Calculation

Pre-test: The design of questionnaire was aimed to collect basic socio-economic information, attitude and practices of MSW recycling in Thailand, as well as willingness to pay for MSW management. The data were categorized and designated type of measurements in order to justify appropriate statistical analysis techniques. The first round of questionnaire was deployed during 6-14 December 2012 by advertising

on www.pantip.com, which is one of the top discussion websites in Thailand, in 3 different discussion rooms: Sathorn- for stock and investment related topics; Salaprachakom- laws and regulation related topics; Blue Planet- travelling and leisure activities related topics, that resonated different backgrounds of questionnaire takers.

Full-scale questionnaire to identify relationships among perceived socio-economic factors that expected to influent behaviors on MSW management. To ensure representativeness of sample selection, Taro Yamane's method, **Equation 4**, was employed, and the sample size is determined. Data gathered from the questionnaire survey were used for analyzing recycling preference in the studied recycling collection modes against selected factors on socio-economic and recycling practices, as listed in **Table 13.**

In managing MSW in the manner that is described above, there will be cost associate with it. We are asking your maximum WTP for this purpose.

( ) 0 THB (I don't want to pay)

Why do you think you should not pay?

[ ] It is the duty of the government to support MSW management

[ ] Usually self-manage

[ ] Too much of a burden for the household

[ ] Other please stated_____

( ) More than 0 THB

My maximum WTP is

10	110	210	310	410	510
20	120	220	320	420	520
30	130	230	330	430	530
40	140	240	340	440	540
50	150	250	350	450	550
60	160	260	360	460	560
70	170	270	370	470	570
80	180	280	380	480	580
90	190	290	390	490	590
100	200	300	400	500	600

( ) Higher than 600 THB (Please specify) _____

Figure 6. Payment card table

$$n = \frac{N}{1 + N(e)^2}$$ **Equation 4**

Where n= Sample Size, N= Household population size, e= percent of acceptable error

Data gathered from the questionnaire survey were used for analyzing recycling preference in the studied recycling collection modes against selected factors on socioeconomic and recycling practices, as listed in **Table 13.**

Table 13. Population size of study sites and number of samples required for representative samples at 95% confidential interval

Name of Area	Survey Date	Number of Households	Allowable error			
			1.00%	5.00%	7.00%	10.00%
MS	May 2014	2,459,679	9,960	400	204	100
US	December 2013	30,711	7,544	395	203	100
PS	October 2013	13,934	5,822	389	201	99
Total		2,504,324	9,960	400	204	100

Table 14. Description of studied variables

Code	Description
j	Recycling collection modes - 0 - if respondent does not recycle ("DNO") - 1 - if respondent recycles through itinerant recyclable buying ("IRB") - 2 - if respondent recycles through recycling center buying ("RCB") - 3 - if respondent recycles through donations to charity ("DOC")
gen	Gender of respondent - 0 - if respondent is female - 1 - if respondent is male
inc	Income in USD - 0 and positive number
fam	Numbers of family member - 0 and positive number
edu	Highest education level: College degree - 0 - if respondent does not have a college degree - 1 - if respondent has a college degree
age	Age of respondent (year) - positive integer
row	Respondent is currently living in his/her home - 0 - is a renter - 1 - is a homeowner
cri	Perception of MSW crisis - 0 - Least concerned - 1 – Concerned - 2 Very concerned

Table 14. Description of studied variables (continue)

Code	Description
sat	Satisfaction with current MSW service - 0 - Unsatisfied - 1 – Satisfied
hhw	Willingness to recycling dry cell battery - 0 – Unwilling - 1 –Willing
sre	Selling recyclables more frequent than every month - 0 – No - 1 –Yes
sep	Currently separate MSW - 0 – Not Engage in waste separation - 1 Engage in waste separation
pcp	MSW generation kg per capita - 0 and positive number
pls	Separation of plastic waste - 0 - Does not separate - 1 – Separate
pae	Separation of paper waste - 0 - Does not separate - 1 – Separate

3.3.3. Survey Deployment

In this study, stratified random sampling was employed in PS, US, and MS. The numbers of required questionnaire, stated in section 3.3.2, was used as the basis for designing of survey areas.

With a limited budget for the research, we requested help from local universities to provide 8-10 students who are in their senior year and have experienced in the questionnaire deployment and hire as research assistants (RA)**.** For each site, the survey durations were conducted during weekday and weekend to improve the representativeness of the samplings.

We set up half-day training for RAs who conducted the survey. The questionnaires and survey instructions were sent to a local survey coordinator who recruited students to study the questionnaire and the instruction. At the training day, RAs were quizzed and attended the mock-up interview whether they understood the survey materials clearly and clarified possible questions from interviewees, e.g. the impact of the study.

For PS and US, the centers of the surveying route were defined as the sitting location of municipality office and justification of the number of questionnaires needed in each area were estimated from the population density that was recommended by the staff of different municipality office. Interviewers were then assigned the quota of interviewees in assigned area. The interviewers were instructed to conduct a snowball sampling by ringing a house and ask for participation. After finished, the interviewers move on to other house. In the case of conducting the interview in an alley, the interviewers were instructed to assess the number of houses in that alley and conduct an interview to cover population in that alley.

For the questionnaire survey of MS, the author justified that MS is vast and obtaining representative are not practical on the determined sample size. Since the aim of this study is to identify financial supports for recycling in the residential sector, we decided to separate equally the survey quota of MS and deployed questionnaire surveys in two districts in MS that have contrasting characteristics: a district in downtown Bangkok (Khet Rajthevee), its residential sector comprises mostly high-rise, dormitory, and townhouse; a district in Bangkok's suburb (Khet Taweewattana); its residential sector comprises mostly gated community and single house. The stratified random sampling for those two districts was similar to PS and US except that the center of MS's settlement was defined at the district offices instead of the office of Bangkok Metropolitan Administration.

3.4. WTP Analysis

This study assumed that the true value of WTP from each respondent, defined as WTP_i, is latent. The expression WTP_i can be explained as:

$$WTP_i = x_i'\beta + u_i \qquad \textbf{Equation 5}$$

Where x_i' is the individual's characteristics, β is the coefficient of the characteristics and u is an error term that is normally distributed with mean at zero.

Because the WTP_{i_i} is latent and not directly observable, we assumed that it lies between the choices that respondents selected in the payment card as the lower interval (WTP_{ll}) and the value that is one step above the selected choice (WTP_{hh}), which can be explained as:

$$WTP_{ll} \leq WTP_i \leq WTP_{hh}$$ **Equation 6**

The WTP_i was estimated by an interval regression in STATA 13. The procedure follows the guidelines suggested in (Cawley, 2008), to avoid errors from the mid-point estimation of WTP. The maximum likelihood technique was used to calculating the probability of the individuals' likely contribution.

Due to limitation of Interval Regression that has to deal in range, we assumed that the real WTP for respondents whose response was zero WTP was between 0 and the lowest amount in the payment card (10 THB).

$$Pr(x_i'\beta + u_i \leq WTP_{10\,THB})$$ **Equation 7**

For responses within the range of the payment card, the likely contribution can be expressed as:

$$Pr(WTP_{ll} \leq x_i'\beta + u_i \leq WTP_{hh})$$ **Equation 8**

For responses above the range of the payment card, the likely contribution can be expressed as:

$$Pr(x_i'\beta + u_i \geq WTP_{hh})$$ **Equation 9**

3.5. Recycling Behavior Analysis

In this study, we employed multinomial logistic regression (MLR) analysis on the socio-economic, concerns of solid waste crisis, and recycling practice factors. Following the explanation provided in Greene (2003), we assumed that the probability function that respondent i will choose recycling collection mode j is given by

$$\boldsymbol{P(Y_i = j) = \frac{e^{\beta_j' X_i}}{\sum_{k=1}^{4} e^{\beta_k' X_i}}}$$ **Equation 10**

Where $j = 0,1,2,3,$(modes of recycling collections) and $i = 1,2,\ldots,n$ (Sample size). With normalization by assuming $\beta_0 = 0$, the probability function then becomes

$$P(Y_i = j) = \frac{e^{\beta_j' X_i}}{1 + \sum_{k=1}^{4} e^{\beta_k' X_i}} \quad \textbf{Equation 11}$$

$$P(Y_i = 0) = \frac{1}{\sum_{k=1}^{4} e^{\beta_k' X_i}} \quad \textbf{Equation 12}$$

Hence, the odds ratio (OR) for respondent *i* to choose the activity of recycling *j* is given by

$$\frac{P_{ij}}{P_{i0}} = e^{\beta_j X_i} \quad \textbf{Equation 13}$$

In this study, we set the option of "do nothing regarding recycling" as the reference category ($j = 0$). Interpretations of the result can be viewed as "how much choice *j* is preferred by respondent *i* over the alternative base category (*j* =0). The MLR was estimated using the maximum likelihood method.

3.6. Decision Support Analytic Hierarchy Process

3.6.1. Goal setting, study boundary, and analytical roadmap

In this section, the goal setting and criteria of MSW recycling was derived from the goal of promoting reduction and recycling of MSW as stated in the Roadmap for MSW and Hazardous Waste Management (PCD, 2014a) and the Eleventh National Economic and Social Development Plan (NESDB, 2011). The goal of the study boundary, as shown in **Figure 1**, and the outcomes of the assessment processes, as

described in **Figure 1**, were to yield a tailored recycling program that applies to settlements at different urbanization levels. The study defined the following four alternatives to recycling collection modes that primarily operate in Thailand: itinerant recyclable buying (IRB), recycling center buying (RCB), a donation to charity (DOC), and the do-nothing approach (DNO).

To produce a unified index individually assessed criteria from previous sections were then analyzed by the AHP scheme. The following are the descriptions of the criteria (shown in **Figure 7**):

- Ability to reduce landfilling cost per ton of MSW (C-MSW) — results from the calculated landfill cost under each alternative were benchmarked with the alternative with the highest ability to reduce landfill cost.
- Extra willingness to pay for a recycling system (A-WTP), — results from reported ratios of willingness to pay an existing landfill fee from all alternatives were benchmarked with the alternative with the highest value.
- Willingness to recycle (WTR) — WTR was created by multiplying the percentage of respondents who stated that they are separating plastic and paper to the odds values of *pls* and *pae*. Products from the multiplication of each recycling mode were then averaged to create a uniform index.

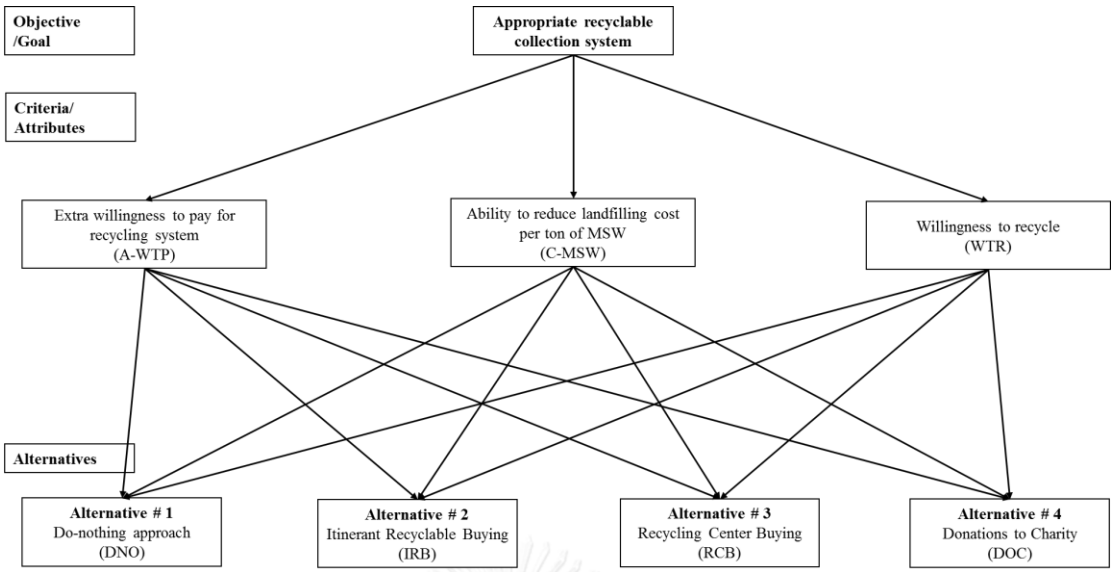


Figure 7. The analytic hierarchy process (AHP) formulation for alternative recycling options.

The weight vectors ($W_{C\text{-}MSW}$, $W_{A\text{-}WTP}$, W_{WTR}) were collected from interviews with waste management authorities and experts in the MSW management field in Thailand. The ranking guideline is provided in **Table 16.** Based on Saaty (2008), the weight vector was then verified through the consistency ratio (CR) to ensure that the judgments were consistent. If this failed, the pairwise comparison had to be redone. Calculation methods are described by **Equation 16** and **Equation 17.** CI depends on the maximum eigenvalue (λmax) and the number of factors in the judgment matrix (n). The consistency index (RI) is a pre-determined value produced from a purely random matrix (values reported in **Appendix 2**). The final verification is done by verifying whether the consistency ratio (CR) exceeds the acceptable value, determined at 0.1 (i.e. 90% consistent or 10% inconsistent) for this study.

The pairwise comparison scores were conducted by transforming inputs from stakeholders according to the scaling guideline (Saaty, 2008). The pairwise comparison scores for each criterion were then summed, and the outcomes were used for normalizing the pairwise comparison. The normalized scores of each criterion were then averaged to produce the weight vector.

For comparison of alternatives to the individual aspect of each criterion, the AHP score of each criterion was calculated using **Equation 14.** Calculation of AHP scores with values between 1 and 9 was calculated by basing the highest value of each criterion as the benchmark value for that criterion and assigned the value 9 in the AHP scale. The smaller values were then calculated to produce a proportional ratio, ranging between 1-9 accordingly.

AHP scores from each criterion were then entered into the pairwise comparison scoring using **Equation 15.**

$$\boldsymbol{AHP\ score} = \left(\frac{\boldsymbol{quantity\ of\ alternative} * \mathbf{8}}{\boldsymbol{quantity\ of\ the\ alternative\ with\ the\ higest\ value}}\right) + \mathbf{1} \qquad \textbf{Equation 14}$$

$$\boldsymbol{pairwise\ comparison\ score} = (\boldsymbol{higher\ AHP\ score} - \boldsymbol{lower\ AHP\ score}) + \mathbf{1} \qquad \textbf{Equation 15}$$

The pairwise comparison table was then produced using AHP scores from each criterion were then entered into the pairwise comparison scoring using **Equation 15**. The table compares on a horizontal line. Using an example from

Table 15, on line 1, when item A, the most superior choice and hold AHP score of 9, is compared to item B, which hold AHP score of 1, the pairwise comparison score is therefore 9.

Table 15. Example of a pairwise comparison matrix

		Item A	**Item B**	**Item C**
Line 1	**Item A**	1	9	1/2
Line 2	**Item B**	1/9	1	3
Line 3	**Item C**	2	1/3	1

The priority score of each alternative in each criterion was calculated from normalized pairwise comparison scores using the same process of producing the weight vectors. Verification through the CI procedure was also performed. The final decision scores were calculated by multiplying the weight vectors with the priority scores of each alternative.

Based on Saaty (2008), the weight vector was then verified through the consistency ratio (CR) to ensure that the judgments were consistent. If this failed, the pairwise comparison had to be redone. Calculation methods are described by **Equation 16** and **Equation 17**. CI depends on the maximum eigenvalue (λ_{max}) and the number of factors in the judgment matrix (n). The consistency index (RI) is a pre-determined value produced from a purely random matrix (values reported in **Appendix 2**). The final verification is done by verifying whether the consistency ratio (CR), calculated by **Figure 17** exceeds the acceptable value, determined at 0.1 (i.e. 90% consistent or 10% inconsistent) for this study.

$$CI = \frac{1}{n-1}(\lambda_{max} - n)$$ **Equation 16**

$$CR = \frac{CI}{RI}$$ **Equation 17**

Table 16. Scale for pair-wise comparisons

Source. Adapted from Saaty (2008)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment moderately favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6 and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

CHAPTER IV
RESULTS AND DISCUSSION

4.1. Relationship between Urban Settlements and MSW

Thailand generated 22.23 million tons of municipal solid waste in 2014 at the rate of 0.94 kg/person/day [65,124,716 persons—based on population statistics of Thailand in 2014 (Central Registry Office, 2015)] but only 3.80 million tons (percent) has been collected and disposed of sanitary landfills and 4.30 million tons of those MSW are utilized via composting and recycling (PCD, 2015) . Reviews of MSW composition in different municipalities in Thailand are summarized in **Figure 8**. It revealed that recyclable materials were usually composed of a minor portion of the total waste stream. Nevertheless, paper, glass, metals and plastic wastes usually dominated in large urban settlement's landfills such as Bangkok, Hat Yai, Chiang Mai. Industrial-town settlement such as Rayong, Samutprakarn usually have the highest percentage of recyclable material as plastic wastes. Tourist towns, such as Pattaya, Phuket, and Hua Hin, usually have high volumes of paper and plastic. Organic waste [food waste] is the major composition of domestic wastes from all settlements. When population density of each settlement is taken into consideration, **Figure 8** suggests that settlements with high population density [460 persons per km^2 or higher] tend to have a substantial percentage of food waste and fluctuation paper and plastic wastes as the highest percentage of non-organic wastes. Based on the finding, at population densities are in the range of 100 persons/km^2, food waste is still counted as the highest percentage of MSW. However, fluctuation of non-food waste categories can be observed as paper and plastic wastes are not significantly dominating shares of MSW.

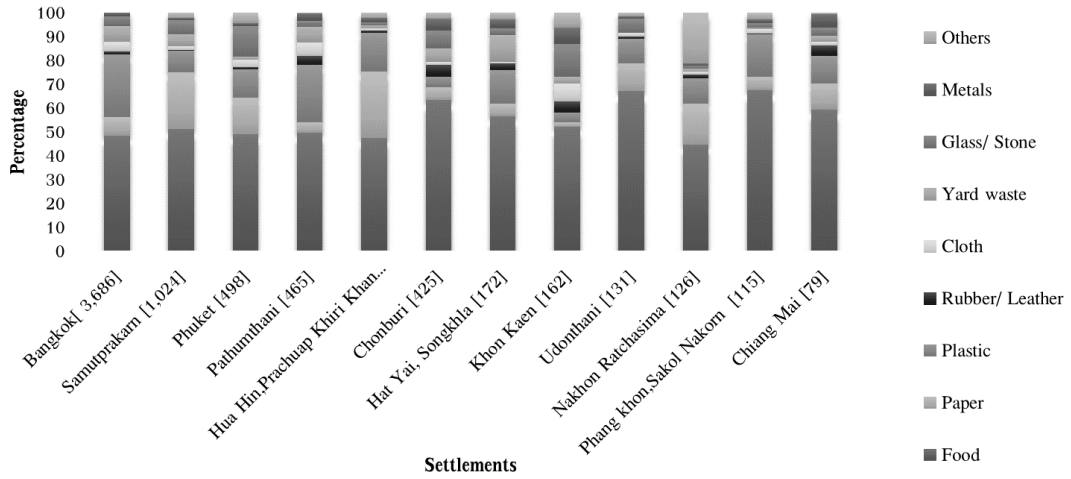


Figure 8. MSW composition from selected provinces of Thailand [population density]

Source. For all data except stated explicitly (Asian Institute of Technology, 2004), Bangkok (BMA, 2013), Thumbon Phang Khon Municipality (Puangsiri, 2010), Hua Hin, Prachuap Khiri Khan (Srivisitphan, 2004).

4.2. Case Study from Community-based Waste Management at Phang Khon Municipality

4.2.1. Mass accounting

Accurate estimation of at-source MSW generation is crucial for the evaluation of effectiveness in terms of MSW reduction activities. This study attempted to verify performances of MSWM from PKM and CMS. The unit of analysis was set as "an annual MSW generation of the town (W_{MSW})" which is equivalent to

$$\boldsymbol{W_{MSW} = (W_{MSW-td}) = \sum W_{Lf_i} + \sum W_{Re_i} + \varepsilon} \qquad \textbf{Equation 18}$$

where W_{Lf_i} = quantity of MSW arrived at the landfill; W_{Re_i} = quantity of reutilized MSW by organic waste reutilization and the waste bank; ε = quantity of MSW missing from MSWM; i = Waste types, *i.e.* organic waste, plastic, paper, *etc. a*

The true value of ε, by its nature, is, however, unknown. From **Equation 20**, an approximation of ε parameter can be estimated by comparing the accounted weight of MSW on a bottm-up approach (W_{MSW-bu}) against that of a top-down approach (W_{MSW-td}) which is calculated by multiplying Thailand's default MSW generation rate per capita to the number of populations receiving MSW service (listed in **Table 2**). The mass balance equation can be expressed as follows:

(W_{MSW-bu})= Default annual MSW generation rate * number register population **Equation 19**

And

$$W_{MSW} = (W_{MSW-bu}) = (W_{MSW-td}) \quad \textbf{Equation 20}$$

Based on mass accounting, the accounted weight of MSW ($W_{MSW-bu-PKM}$) is at 2534 tons per annum. This MSW arriving at the landfill ($\sum W_{\mathrm{Lf}_i} = 2{,}288$ tons per annum) and reutilized wastes in producing compost, bio-gas generation, and recycling by the waste bank ($\sum W_{Re_i}$ = 246 tons per annum). The result from the generated MSW($W_{MSW-td-PKM}$) calculation of the top-down approach indicated that MSW was generated at the rate of 2,549 tons per annum (please note that the weight of PKM is not the same with PS's MSW weight in the AHP section). The missing quantity of MSW from MSWM system (ε_{PKM}), derived from the difference between $W_{MSW-bu-PKM}$ and $W_{MSW-td-PKM}$, was estimated to be 15 tons or 0.59%, which is

slightly lower than $W_{MSW-td-PKM}$ and assumed to be negligible since loss of MSW may occur during operation or through the the loss of moisture. Hence, the value of the unit of analysis was set based on the top-down approach as the at-source generated MSW. For PKM, the unit of analysis ($W_{MSW_{pkm}}$) is 2,549 tons per year. For CMS, the unit of analysis for at-source generated MSW(W_{MSW_CMS}) was set based on the calculation of the top-down approach($W_{MSW-td-CMS}$) which is 1,155 tons per year.

From **Figure 9**, mass flow of MSW from PKM's households to disposal points, landfill, composting points, or the waste bank indicated that MSWM of PKM was very efficient because only 0.50% of MSW was not accounted for in the system based on comparison of $W_{MSW-bu-PKM}$ and $W_{MSW-td-PKM}$. PCD (2013) reported that 25.16% of generated MSW had disappeared before it was collected for further treatment. In contrast, 35.08% of generated MSW from CMS was not accounted for when MSW from CMS arrived at the landfill (mass flow of CMS based on the top town approach compared to the bottom up approach).The cause of missing wastes may come from an inefficient collection service or some recyclables is removed prior to the arrival at the landfill.

Table 17 suggested that organic waste was the highest waste type, followed by plastic and paper wastes. The percentages and trends of MSW composition, however, were found to change significantly when MSW compositions of PKM and CMS were compared to MSW compositions from 2004-2006. This was true of the composition of organic waste, paper waste, and plastic waste types. The percentage drop of food waste composition can be potentially explained by an increase in affordability for refrigerators

as observed by Hoornweg and Bhada-Tata (2012). Plastic waste—mainly dirty or contaminated plastic bags—was, however, found to have an increasing trend.

Table 17. Characteristics of MSW from towns within PKM vicinity

Composition	2004–2006		2013		
	Averaged in the region3	PKM4	CMS at sources (%W_{ag_i})	PKM at sources (%W_{ag_i})	PKM at landfill (W_{Lf_i})
Organic	64.36%	67.82%	45.90%	56.70%	56.30%
Paper	7.58%	5.66%	4.60%	3.60%	2.70%
Glass	3.30%	2.12%	6.30%	3.90%	1.60%
Plastics	17.26%	17.88%	33.40%	31.40%	34.60%
Garment	1.18%	2.04%	8.10%	2.50%	2.80%
Aluminum	0.97%	0.72%	0.40%	0.10%	0.10%
Metal	0.97%	0.72%	0.40%	0.20%	0.10%
Miscellaneous	2.69%	3.04%	1.00%	1.60%	1.80%

4.2.2. MSW characteristics and changes from reutilization activities

We found that MSW characteristics of PKM and CMS were consistent with Thailand's national average of waste composition for small towns in developing countries in South East Asia (AIT & UNEP, 2010; PCD, 2004; Thailand's Region 14 Environmental Office, 2012). Impacts of PKM's waste bank were observed in the reduction of recyclables at the landfill due to waste bank activities. From MSW characterization at the landfill, we found that recyclable components from PKM were consistently lower than those of CMS despite the fact that PKM is a more urbanized town and, therefore, should have higher recyclable content compared to that of CMS.

[3] (PCD, 2004)

[4] (Thailand's Regional Environmental Office 9, 2013)

Only recyclables that were not accepted by the waste bank, *i.e.* green glass bottles or food-contaminated plastic waste, were found in PKM's MSW. Overall, recyclables from PKM were found to be 4.34% of MSW arriving at the landfill in contrast to 15.35% of those from CMS.

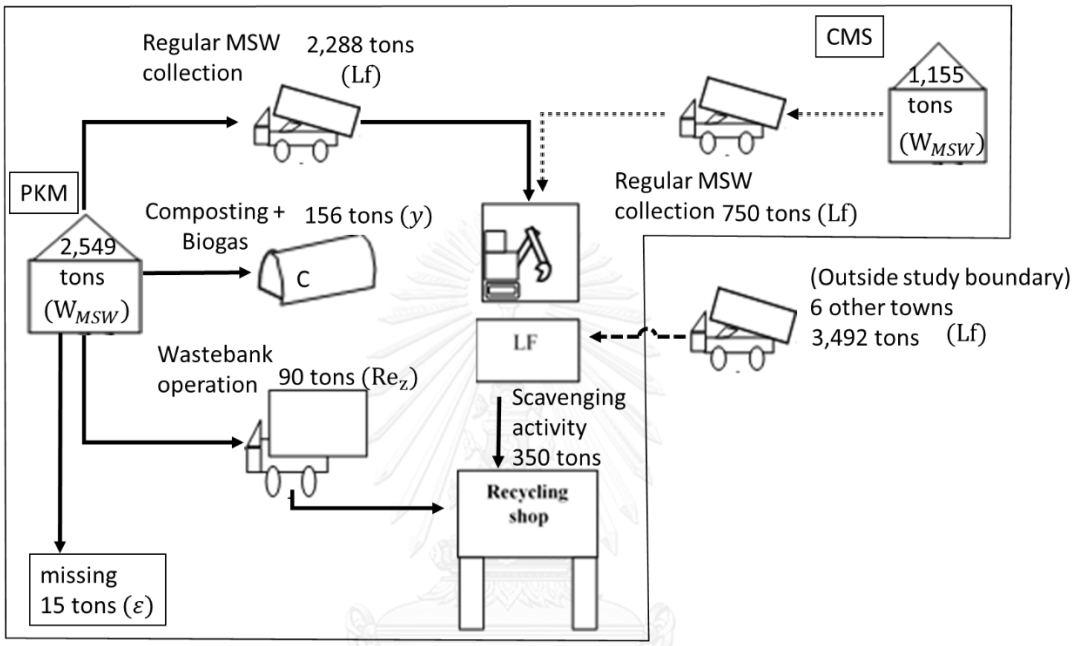


Figure 9. The annual flow of MSW arriving at PKM's landfill.

4.2.3. Efficiency of the organic waste reutilization and waste bank

The organic waste reutilization and waste bank programs in PKM helped reduce landfilling of MSW. Separation of organic wastes also helps prevent undue quality deterioration of recyclables. This has been done through a monetary incentive scheme, which entailed a wide range of price differences between unsorted and sorted waste, e.g. 16.66% higher price for newspapers in good condition and 18.75% higher price for clear glass as compared to mixed glass waste. Additional revenues, as well as potential budgetary saving from engaging in MSW reutilization, can also help increase co-operation within city administrative councils.

It should be noted that the efficiency of MSW reutilization in PKM was not equally distributed across all waste types. Easily recycled waste types such as paper, glass, aluminum, and metal were recovered at a higher rate compared to organic or plastic waste, which were often contaminated. The quantity of recyclables sold per member, as shown in **Table 18**, suggested that glass waste, paper, and plastic were among the most common materials in the recyclable stream.

Contrasting to a traditional belief that higher income level tends to correlate with lower level of participation in MSW recycling (Jenkins et al., 2003), the results from **Table 18** suggested that the waste bank members living in the more affluent area, *i.e.* Route D, sent more recyclables to the waste bank than the members in the less affluent areas, namely Route A to C.

Table 18. Average annual recycling rates of waste bank operations per recycler between November 2011 and October 2013.

Collection Routes for Waste Bank	# of Members	Plastic	Alu	Metal	Glass	Paper	Total (kg)
Route A	155	10.60%	0.48%	3.88%	55.05%	29.99%	159.18
Route B	127	11.79%	0.42%	5.45%	61.35%	20.99%	177.11
Route C	101	12.26%	0.59%	2.26%	54.52%	30.37%	144.47
Route D	139	6.99%	0.56%	2.76%	60.96%	28.74%	208.03
Average	522	10.16%	0.51%	3.61%	58.34%	27.38%	172.20

The success of PKM's waste bank program could also be attributed to the integration of a social dimension into creating incentives for reutilization by providing strong support from the authorities and through the involvement of waste bank members as evidenced by its high recycling performance. The recycling per member of

PKM's waste bank was found to be very efficient in terms of kg of recyclable per member (shown in **Table 18**) compared to average community-based management activities (18.6 kg of recyclables per member) (Rayong City Municipality, 2013). Puangsiri (2010) conducted independent research on members of the PKM's waste bank and reported that members decide to participate in the waste bank because of the convenience of the curbside pickup service, funeral-assistance benefits, and recycling education from the municipality. The positive development of PKM's CBM can be attributed to PKM's curbside pickup service and recycling awareness, which other waste banks fail to offer. Findings from Puangsiri (2010) were consistent with success factors found in other CBM activities in terms of strong public participation, peer support, convenience, and economic incentives as potential factors to sustain environmental-friendly service programs (Seik, 1997; Timlett & Williams, 2008).

4.3. MSW Characteristics from Study Sites

MSW characteristics of the three settlements were consistent with MSW composition from developing countries (The World Bank, 2014). From **Table 19**, organic waste is the highest proportion in the waste composition of all study sites. For non-organic waste, plastic and paper waste are the second and third highest constituent in the waste composition. We also found that the contents of readily recyclable, such as glass bottles, PET, and HDPE bottles, were presented in the Peri-urban, Urban, and Metropolis landfills with ranges between 9 and 10% of arrived MSW. Potentially recyclables but deemed non-economically feasible for recycling under Thailand's recycling market was found as food-contaminated plastic bags, food-warping papers, and dirty garments. Aside from promoting separation of food waste from composting,

plastic and paper waste remains the best residue for recycling due to their abundances in the waste stream with potential for quality improvement for higher buying price.

Table 19. MSW composition from study sites

Composition		Peri-urban (Greater Phang Khon area)	Urban (Hua Hin)	Metropolis (Bangkok) (BMA, 2013)
Organic waste		51.74%	53.00%	54.87%
recyclable	Paper	2.96%	0.50%	1.42%
	Glass	3.99%	4.34%	2.56%
	Plastics	2.02%	4.19%	3.40%
	Aluminium	0.64%	1.33%	0.86%
	Metal	0.22%	0.00%	0.86%
Non-recyclable	Paper	0.89%	10.67%	6.25%
	Glass	0.00%	0.00%	0.00%
	Plastics	32.10%	20.03%	21.43%
	Aluminium	0.00%	0.00%	0.00%
	Metal	0.00%	0.00%	0.00%
	Garment	5.44%	2.74%	1.40%
	Other waste	0.00%	3.20%	6.95%
Annual MSW generation (tons per year)		3,038	43,566	3,175,500

4.4. Descriptive Statistics from Questionnaire Survey

In total, 1,350 questionnaires were collected as planned. However, 286 questionnaires were disqualified due to the inconsistency of the answers or selections of zero WTP without any explanation. Diversity in terms of the socio-economic situations of respondents from different settlements was observed in most studied parameters.

As indicated in **Table 20**, socio-economic characteristics follow the traditional pattern of towns in various urbanized stages. The study found that respondents in urbanized towns tend to have higher incomes than respondents in less urbanized towns, and they are typically younger, more educated, and more likely to rent their homes instead of owning them.

For factors relating to attitude toward MSWM, the survey results revealed that respondents from the Metropolis settlements reported the highest satisfaction level among the three sites. Respondents from Peri-urban settlements reported higher satisfaction levels at the settlement's MSW service compared to the more urbanized settlements in this study, despite the fact that service performance and coverage in Urban settlements is better than in Peri-urban settlements. On the perception of a potential MSW crisis, most respondents indicated that they were less concerned about the MSW crisis. Nevertheless, a higher proportion of respondents who claimed to be "very concerned" about the MSW crisis in Metropolis and Peri-urban settlements than in Urban settlements. Average values of MSW generations per capita from Peri-urban, Urban, and Metropolis settlements were reported at 0.71, 1.01, and 1.26 kg per day, respectively. The averages of MSW generation increased in proportion to levels of urbanization and confirmed with the MSW generation rate of low to middle-income countries (Hoornweg & Bhada-Tata, 2012). Regarding MSWM practices, more than 60% of interviewees from all settlements reported that they separated, at least, one type of recyclables. However, the difference between reported percentages of interviewees selling recyclables every month and the percentage of separated wastes could be explained by interviewees' donation to the poor or even as a way of helping MSW collection crews.

We found that socio-economic attributes in this study followed a traditional pattern of increasing urbanization and increasing the percentage of respondents with a higher education and income but lower in age and percentage of home ownership. Therefore, the data set from the survey roughly mimics the traditional perception of MSW management and urbanization.

Table 20. Selected studied variables from three urban settlements

Variables description (abbreviated name provided in parenthesis)	Value (Dummy value provided in parenthesis)	Peri-Urban (PS) (n=387)	Urban (US) (n=318)	Metropolis (MS) (n=358)
Recycling collection modes (j)	DNO(0)	3.62%	9.12%	30.53%
	IRB(1)	88.63%	51.89%	57.70%
	RCB(2)	7.75%	25.16%	7.00%
	DOC(3)	n/a	13.84%	4.76%
Gender (gen)	Female (0)	61.47%	51.26%	63.69%
	Male (1)	38.53%	48.74%	36.31%
Monthly income in USD unit (inc)	0-600	88.37%	86.48%	42.46%
	601-1,200	8.79%	11.64%	40.50%
	1,201-1,800	1.29%	0.00%	8.10%
	1,801-2,400	0.26%	0.31%	5.03%
	2,401-3,000	0.26%	1.26%	1.40%
	3,001-3,600	0.26%	0.00%	0.28%
	>3,601	0.78%	0.31%	2.23%
Numbers of family member (fam)	=<2	16.06%	22.33%	8.10%
	2-4	51.81%	43.40%	57.82%
	>4	32.12%	34.28%	34.08%
Education level (edu)	Lower than college degree (0)	71.37%	60.43%	69.60%
	With college degree or higher (1)	28.63%	39.57%	30.40%
Age in year (age)	18-20	1.55%	13.84%	0.56%
	21-30	5.43%	36.79%	8.94%
	31-40	19.90%	24.21%	31.56%

Table 20. Selected studied variables from three urban settlements (Continue)

Variables description (abbreviated name provided in parenthesis)	Value (Dummy value provided in parenthesis)	Peri-Urban (PS) (n=387)	Urban (US) (n=318)	Metropolis (MS) (n=358)
Age in year (age)	41-50	34.63%	16.04%	28.21%
	51-60	21.45%	7.86%	22.07%
	>61	17.05%	1.26%	8.66%
Respondent is currently living in his/her home (row)	No (0)	0.00%	26.73%	29.61%
	Yes (1)	100.00%	73.27%	70.39%
Concerns toward MSW crisis (cri)	Least concerned (0)	51.16%	67.61%	63.13%
	Concerned (1)	34.37%	25.16%	22.07%
	Very concerned (2)	14.47%	7.23%	14.80%
Satisfaction with current MSW service (sat)	No (0)	8.79%	14.15%	1.40%
	Yes (1)	91.21%	85.85%	98.60%
Willingness to recycling dry cell battery (hhw)	No (0)	40.67%	38.36%	46.09%
	Yes (1)	59.33%	61.64%	53.91%
Selling recyclables more frequent than every month (sre)	No (0)	30.75%	65.09%	40.78%
	Yes (1)	69.25%	34.91%	59.22%
Separate MSW (sep)	No (0)	28.94%	33.96%	32.68%
	Yes (1)	71.06%	66.04%	67.32%
MSW generation kg per capita (pcp)	=<2 kg per day (0)	87.57%	79.87%	88.55%
	>2 kg per day (1)	12.43%	20.13%	11.44%
Separation of plastic waste (pls)	No (0)	26.61%	60.06%	37.99%
	Yes (1)	73.39%	39.94%	62.01%
Separation of paper (ple)	No (0)	38.50%	74.53%	55.87%
	Yes (1)	61.50%	25.47%	44.13%

4.5. WTP Analysis

4.5.1. Case of zero WTP preference

Approximately, 10-13% of respondents reported that they were not willing to pay for MSWM service. **Figure 10** shows stated reason of zero WTP.The expectation of free service from the government was the primary reason cited across all income ranges, and other CV studies also reported this entitlement mindset as the primary cause for zero WTP (Fjeldstad, 2004; Folz & Giles, 2002). This finding suggested that the subtraction of income in the **Equation 2** may not always be held true.(Fjeldstad, 2004; Folz & Giles, 2002). However, personal finance may remain a constraint on the group who may lack financial means, where respondents stated that they cannot afford the MSWM fee and, therefore, report zero WTP. It should be noted that the respondents who gave this reason for their zero WTP in all three sites generally earn less than 650.83 USD /month (20,000 THB), which is 2.2 times above Thailand's minimum wage (292.87 USD/30 work days) (9,000 THB)**.** Based on surveys from Thailand's National Statistical Office in 2013 (NSO, 2013), Thai's family structures and employment can post significant burden on working members of the household as the nationally-averaged monthly household expense was at 620 USD per household (19,052 THB), and the labour force participation rate has been around 72% of total population ages higher than 15-year-old (THE WORLD BANK, 2015).

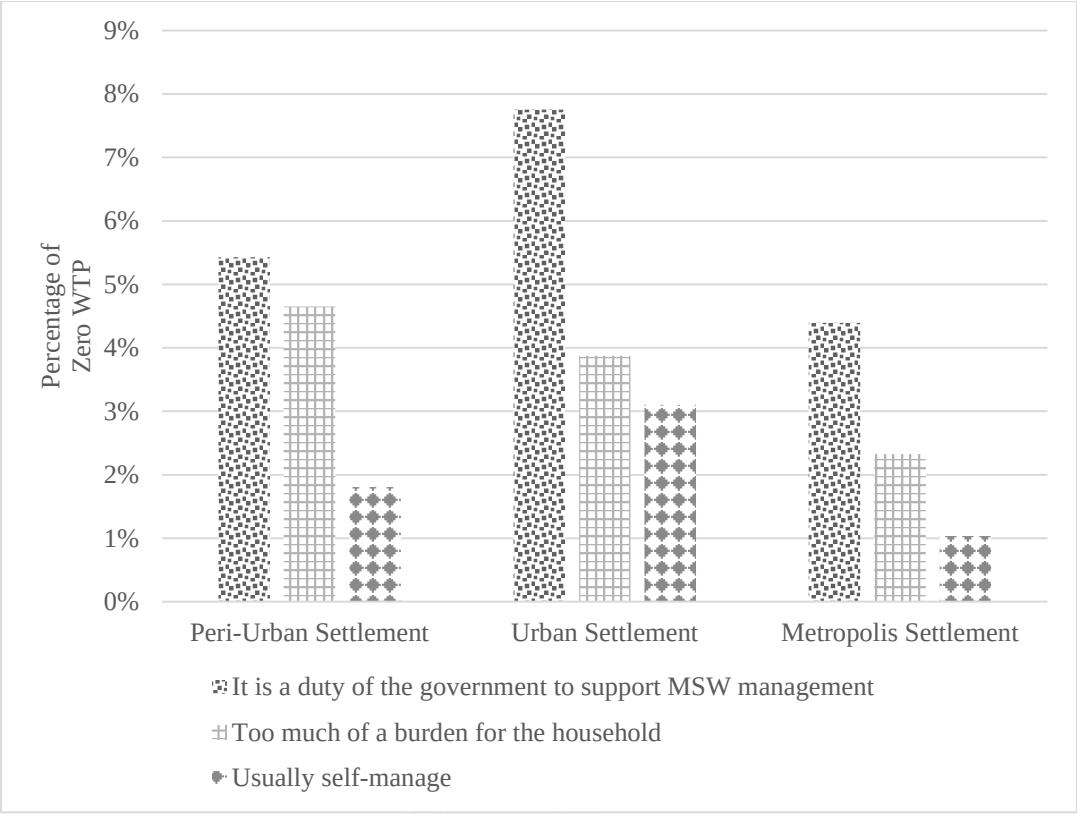


Figure 10. Reasons for zero WTP

4.5.2. Coefficients related to socio-economic factors

As indicated by **Table 21,** coefficients from the regression analysis suggested that the gender factor, *gen*, may change with urbanization. In Peri-urban settlements*, the male group tended to be less supportive for the upgrade of MSWR than the female respondents. Other studies have detected a similar pattern (Addai & Danso-Abbeam, 2014; Afroz et al., 2009). Despite being statistically insignificant, different trends were observed in Urban and Metropolis settlements where males tended to be more involved with household and shore work in more urbanized settlements (National statistical Office, 2009).

Among the socio-economic factors, the level of incomes, *inc*, displayed a divergent pattern of urbanization. In Peri-urban settlements (p-value<0.01), an inverse

relationship was observed between WTP and level of income. The inverse trend of *inc* was attenuated in Urban settlements and positively correlated in Metropolis settlements (p-value<0.01), which can be attributed to the lower percentage of MSW separation and selling of recyclables in more urbanized settlements (Afroz et al., 2009; Seth, Jerry Cobbina, Asare, & Ballu Duwiejuah, 2014).

The results suggested that education level is a strong predictor of changes in WTP. In all study sites, participants with at least a college degree indicated positive responses for WTP, particularly in the more urbanized towns (Metropolis (p-value<0.01) and Urban (p-value<0.01) settlements), consistent with the findings of previous studies (Blaine et al., 2005; Subhan, Bashawir Abdul Ghani, & Hasanur Raihan Joarder, 2014).

Increasing age, *age*, was negatively correlated with WTP. The older group may have tended to recycle and manage waste themselves whereas the younger group may be more interested in letting waste management services perform the separation. At all sites, increased age negatively influenced WTP. Based on the literature reviews conducted for this study, age increases were found to have both supporting (Afroz et al., 2009; Subhan et al., 2014) and damping influence on WTP (Afroz & Masud, 2011; Altaf & Deshazo, 1996). Household size seemed to influence the increase of WTP in all three sites. The increase in household size may have reduced the ability to self-manage MSW. Similar findings were found in previous studies (Afroz et al., 2009; Afroz & Masud, 2011). Relationships between MSW generation rate, *pcp*, did not provide a clear trend as the *pcp* coefficients were found to negatively correlated with WTP in Peri-urban (p-value<0.01) and Metropolis settlements, but they were positively correlated with WTP in Urban settlements (p-value<0.1).

4.5.3. Coefficients related to MSW and recycling attitude factors

On MSWM factors, we found that the perception of MSW crisis, *cri*, is positively correlated with WTP in Peri-urban (p-value<0.01) settlements. However, the variable was negatively correlated in Urban (p-value<0.05) and Metropolis settlements. We extrapolated that respondents in Urban and Metropolis settlements might expect that settlements classified as "urbanized" would eventually be able to mitigate the crisis whereas respondents in a less urbanized town may have seen or even experienced the MSW problem on a more personal level. In terms of satisfaction with the current MSWM, *sat*, the estimated coefficient suggested that satisfaction correlates with the increase in WTP. This result was consistent with our expectations because satisfied respondents will be more likely to trust that an improvement project would provide better benefits.

MSW separation, *sep*, tended to be a strong predictor of WTP because the coefficients from all 3 sites are positively correlated with WTP. This finding indicated that respondent groups who separate waste tended to support the MSW separation system. Previous studies also found similar results (Afroz et al., 2009; Blaine et al., 2005). The group that is actively selling recyclables, *sre*, exhibited negative coefficients for all three sites. This finding suggests that if the waste management authority provides volume-based pricing for MSW service, the group that separates recyclables for sale may be more willing to participate in MSW reduction activities to reduce their expenses, which has potential policy implications. The contradiction between the negative trend of *sre* and the positive trend of *sep* toward WTP suggested that the group selling waste might be different from the group that only sorts recyclables for the sake of the environment, and incentives should be provided differently to each group.

On the attitudes toward managing household hazardous waste (*hhw*), respondents in Urban (p-value<0.01) and Metropolis (p-value<0.01) settlements displayed less WTP compared to the Peri-urban. This finding suggested that the group that is willing to separate HHW tended to perceive that they should not be responsible for the cost of HHW disposal. However, respondents in Peri-urban settlements (p-value<0.01) demonstrated a positive correlation with WTP for *hhw*. A possible explanation was that respondents from Peri-urban settlements (p-value<0.01), who lived closer to the MSWM system may understand the importance and potential dangers of HHW and, therefore, be willing to support HHW recycling.

Table 21. Mean WTPs and relationship with studied factors

Stu site		*inc*	*fam*	*edu*	*age*	*cri*	*sat*	*hhw*	*sre*	*sep*	*pcp*	Constant	wtp ($)
PS	*b*	-1.00E-01 **	-1.90E-04 ***	3.30E-02	9.60E-03	-4.40E-03 **	1.30E-01 ***	1.50E-01 *	1.80E-01 ***	-2.00E-01 ***	7.70E-02	-3.60E-01 ***	0.73
	S	4.90E-02	5.40E-05	1.80E-02	7.80E-02	1.90E-03	3.30E-02	8.60E-02	5.00E-02	5.30E-02	6.00E-02	8.00E-02	
US	*b*	-2.90E-02	-1.80E-04	5.00E-02	8.90E-01 ***	-1.80E-02 ***	-1.70E-01 **	2.40E-01	-5.00E-01 ***	-3.50E-02	4.00E-01 ***	2.30E-01	1.96
	S	1.30E-01	1.70E-04	3.20E-02	1.40E-01	6.00E-03	8.50E-02	1.90E-01	1.40E-01	1.40E-01	1.40E-01	1.60E-01	
MS	*b*	1.50E-01	3.10E-04 ***	2.70E-02	6.80E-01 ***	-2.30E-03	-3.80E-02	5.40E-01	-6.90E-01 ***	-2.30E-02	6.30E-01 **	-6.30E-02	1.65
	S	1.70E-01	1.00E-04	6.40E-02	1.90E-01	8.10E-03	1.90E-01	7.00E-01	1.70E-01	2.30E-01	2.50E-01	2.50E-01	

Statistical significant level *** p<0.01, ** p<0.05, * p<0.1

4.6. Analysis of Behavioral Study

Comparison of the odds ratios (OR) between the group of non-recyclers against the groups of recyclers in any recycling collection mode, as shown in **Table 22** suggested that the group that engaged in any mode of recycling exhibited different ORs from the non-recycler group. However, the magnitude of the ORs also vary from one mode of recycling collection to another and when the same mode of recycling collection was compared in different settlements.

Although the statistically significant results of the ORs were mostly found in the mixed model, potentially due to the larger sample sizes, the relationships between modes of recycling collection (IRB,RCB, and DOC) socio-economic factors, i.e., gender, education levels, age, home ownership, and income, tended to exhibit a similar trend at most study sites. Overall, ORs from these socio-economic factors were relatively less influential toward the choice of recycling collection mode. Regarding the influence of gender, only the result of the metropolis settlement can be confirmed that males exhibited a strong tendency not to participate in a recycling activity. Regarding the influence of education level, we observed statistically significant results that showed that respondents with an education level lower than a bachelor's degree tended to engage in recycling. Levels of income do not affect the decision to engage in recycling as reported in Czajkowski, Kądziela, and Hanley (2014).

In contrast to socio-economic factors, factors on recycling practices, i.e., separating plastic, glass, and paper wastes or concern for environmental problems (i.e., concerned about the solid waste crisis), exhibited strong ORs. As shown in **Table 22**, the strongest ORs were found in the willingness to recycle plastic and paper across the study site.

Table 22. Odd ratios from MLR (DOC in Peri-urban case was not reported due to no samples in DOC)

Settlements			*gen*	*inc*	*edu*	*age*	*row*	*cri*	*pls*	*pae*	Const
Combined model n= 1060	IRB	*OR*	0.99	1 ***	0.48 ***	0.99	2.19 ***	3.04 ***	20 ***	4.11 ***	0.9
		se	(0.22)	0.00	(0.13)	(0.01)	(0.59)	(0.73)	(7.17)	(1.64)	(0.45)
	RCB	*OR*	0.92	1 ***	0.46 **	0.96 ***	0.83	5.17 ***	16.44 ***	9.96 ***	1.34
		se	(0.26)	0.00	(0.15)	(0.01)	(0.26)	(1.50)	(6.78)	(4.41)	(0.80)
McFadden's R^2 0.21	DOC	*OR*	0.9	1	0.39 **	0.95 ***	1.07	2.68 ***	6.1 ***	4.96 ***	1.5
		se	(0.29)	0.00	(0.15)	(0.01)	(0.39)	(0.90)	(2.84)	(2.49)	(1.03)
Peri-urban n=384	IRB	*OR*	1.51	1	0.26	0.99	Omitted	12.48 **	6.59 **	3.48	2.04
		se	(1.08)	0.00	(0.27)	(0.02)		(13.51)	(5.90)	(3.15)	(3.34)
McFadden's R^2 0.13		*OR*	1.5	1	0.25	0.98		9.63 **	6.01 *	18.22 ***	0.41
		se	(1.21)	0.00	(0.29)	(0.03)		(11.10)	(6.53)	(20.38)	(0.77)

OR= Odd Ratio; se = standard error; statistical significant level *** p<0.01, ** p<0.05, * p<0.1; reference category

Table 22. Odd ratios from MLR (DOC in Peri-urban case was not reported due to no samples in DOC) (Continue)

Settlements			*gen*	*inc*	*edu*	*age*	*row*	*cri*	*pls*	*pae*	Const
Urban n=318 McFadden's R^2 0.07	IRB	*OR*	0.78	1	1.61	1.01	1.92	1.34	2.48	1.59	1.34
		se	(0.34)	0.00	(0.78)	(0.02)	(0.89)	(0.60)	(1.43)	(1.11)	(1.17)
	RCB	*OR*	0.62	1	1.33	1	1.32	2.19	3 *	3.65 *	0.88
		se	(0.29)	0.00	(0.70)	(0.02)	(0.66)	(1.07)	(1.82)	(2.62)	(0.83)
	DOC	*OR*	0.85	1	0.82	1	1.58	0.8	1.14	0.93	1.2
		se	(0.43)	0.00	(0.46)	(0.02)	(0.87)	(0.42)	(0.78)	(0.78)	(1.21)
Metropolis n=358 McFadden's R^2 0.55	IRB	*OR*	0.2 *	1	0.64	1.03	1.35	0.79	1098 ***	46.55 ***	0.02 **
		se	(0.17)	0.00	(0.53)	(0.03)	(1.02)	(0.63)	(1088.00)	(39.56)	(0.03)
	RCB	*OR*	0.22	1	0.48	1.03	0.3	0.75	658.5 ***	139.8 ***	0.01 **
		se	(0.21)	0.00	(0.47)	(0.04)	(0.26)	(0.72)	(780.90)	(136.70)	(0.02)
	DOC	*OR*	0.06 **	1	0.95	1.05	0.89	0.48	228.5 ***	92.6 ***	0 **
		se	(0.07)	0.00	(0.92)	(0.04)	(0.78)	(0.50)	(256.50)	(89.32)	(0.01)

OR= Odd Ratio; se = standard error; statistical significant level *** p<0.01, ** p<0.05, * p<0.1; reference category

Preferences on recycling a specific waste type were not uniformly dominated by one mode of recycling collection. We found that ORs for recycling plastic and paper wastes were highest for IRB. The high OR value is because these recyclables are often used as food or drink containers and therefore, cannot be kept for a long duration. In contrast, paper wastes were popular with RCB because this waste does not generate an odor nuisance. The concern of the MSW crisis is also significantly larger in RCB except in the peri-urban settlement.

Because site-specific ORs of *pls* and *pae* in all three sites, as shown in **Table 22** did not concurrently exhibit a statistically significant value, ORs from the combined model were multiplied by the percentage of recycling to calculate the WTR. The WTR of all study sites suggested that the choice of IRB remains the most popular choice that is likely to induce more waste separation and recycling activities, whereas RCB remains the second choice to promote recycling at all three sites. RCB also had significant scores in the urban settlement. These findings suggest the significance of having multifaceted choices in towns that are developing and offering RCB and IRB in conjunction may help maximize recycling.

4.7. Decision-Making Scenarios

4.7.1. Potential landfilling cost saving

Using the MSW composition of plastic and paper and the annually generated weight in the study sites, as shown in **Table 19**, and the percentage of respondents who stated that they are willing to recycling plastic and paper, as listed in**Table 23**, the

normalized potential cost reduction, in the form of remaining landfilling cost per generated MSW, can be demonstrated, as shown in **Figure 11**.

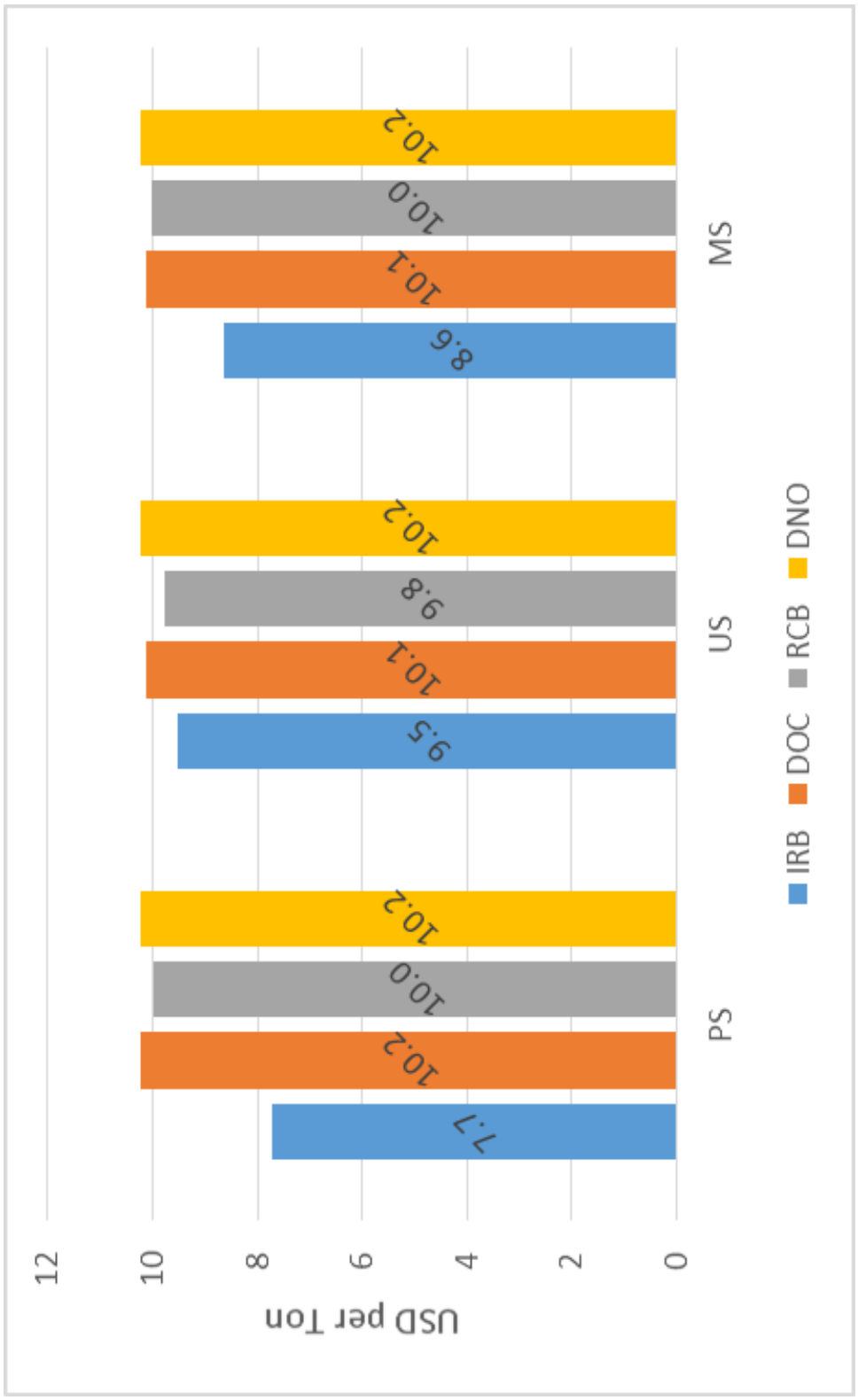


Figure 11. Potential landfilling cost per ton under different recycling practices

Table 23. Percentage of respondents who separate selected recyclables

Distribution of recycling choice		Paper	Plastic
Peri-urban	IRB	53.75%	65.37%
	DOC	0.00%	0.00%
	RCB	6.46%	6.46%
	DNO	39.79%	28.17%
	total	100.00%	100.00%
Urban	IRB	12.58%	22.64%
	DOC	1.57%	2.83%
	RCB	10.38%	12.89%
	DNO	75.47%	61.64%
	total	100.00%	100.00%
Metropolis	IRB	34.36%	51.96%
	DOC	3.35%	3.07%
	RCB	5.31%	6.15%
	DNO	56.98%	38.83%
	total	100.00%	100.00%

Based on comparisons of landfill cost under different management scenarios, the choice of landfilling all wastes (DNO) costs 10.22 USD per ton of MSW (Department of Local Administration, 2015). However, engaging in MSW reduction through IRB is likely to provide the most significant decrease in landfill cost (7.54%-26.94% reduction compared with the DNO scenario). The choice of RCB provided a relatively low reduction of the overall landfill cost due to a lower level of collected recyclables. The donation option can contribute marginally to the recycling effort (0.44-0.53% reduction compared with the DNO scenario). From this aspect, therefore, IRB is likely the most suitable option in this scenario because it could reduce the expenses the most. Using **Equation 14** and **Equation 15**, the pairwise comparison score for C-MSW is assigned and reported in **Table 24**.

Table 24. Pairwise comparison for C-MSW

Description	PS			US				MS			
	CR Value = 0.03			CR Value = 0.09				CR Value = 0.04			
	DNO	IRB	RCB	DNO	IRB	RCB	DOC	DNO	IRB	RCB	DOC
DNO	1	1/9	1/2	1	1/9	1/6	1/2	1	1/9	1/2	1/2
IRB	9	1	8	9	1	4	4	9	1	8	9
RCB	2	1/8	1	6	1/4	1	5	2	1/8	1	2
DOC		n/a		2	1/4	1/5	1	2	1/9	1/2	1

4.7.2. Willingness to recycle (WTR)

Using the ORs for *pls* and *pae* and multiplied by the percentage of respondents who is willing to participate in one of the alternatives**.** Using **Equation 14** and **Equation 15**, the pairwise comparison score for WTR is assigned and reported in **Table 24**. The WTR of all study sites suggested that the choice of IRB remains the most popular choice that is likely to induce more waste separation and recycling activities, whereas RCB remains the second choice to promote recycling at all three sites. RCB also had significant scores in the urban settlement. These findings suggest the significance of having multifaceted choices in towns that are developing and offering RCB and IRB in conjunction may help maximize recycling.

Table 24. Pairwise comparison for WTR

Description	PS			US				MS			
	CR Value = 0.05			CR Value = 0.07				CR Value = 0.07			
	DNO	IRB	RCB	DNO	IRB	RCB	DOC	DNO	IRB	RCB	DOC
DNO	1	1/9	2	1	1/7	1/4	3	1	1/9	2	1
IRB	9	1	9	7	1	4	9	9	1	8	9
RCB	1/2	1/9	1	4	1/4	1	6	1/2	1/8	1	2
DOC		n/a		1/3	1/9	1/6	1	1	1/9	1/2	1

4.7.3. WTP to currently-paid MSWM fees

From the questionnaire survey, we derived the ratio of willingness to pay to establish an MSW separation system to the MSW management fee that the respondent is currently paying and referred to it as "WTP to currently paid MSW fee" (A-WTP), as shown in **Table 25**. Comparing the ratio of each study site, we found that the group who does not participate in any recycling collection (DNO) expressed the smallest A-WTP across the study sites. The A-WTP was also found at the level that is lower than the fee that they are currently paying. In contrast, recyclers who engage with IRB expressed the highest level of the A-WTP ratio among the three recycling collection modes. A possible explanation is that if we considered IRB as one type of curbside recycling services, a curbside service for recycling could help boost the participation in recycling activities and therefore, boost the responses with a higher WTP (Palatnik et al., 2005; Seik, 1997 ; Timlett & Williams, 2008). In contrast, low WTP tended to be associated with the anti-improvement expectation, i.e. respondents in the group of do-nothing approach. Consequentially, rising the out of pocket cost without offering

alternatives. i.e. recycling may create adverse outcomes, i.e. illegal dumping or refuse to participate in the waste management service (US EPA, 2004). The pairwise comparison score for A-WTP is assigned and reported in **Table 26.**

Table 25. Average of WTP to currently-paid MSW management fee ratio

Recycling choices		Mixed model	Peri-urban	Urban	Metropolis
IRB	average	1.24	1.2	1.56	1.04
	S.D.	1.36	1.06	1.83	1.33
DOC	average	1.16	N/A	1.31	0.78
	S.D.	0.87		0.83	0.88
RCB	average	1.14	0.89	1.33	0.85
	S.D.	1.16	0.53	1.35	0.92
DNO	average	0.94	0.87	1.25	0.86
	S.D.	1.3	0.66	1.84	1.19

Table 26. Pairwise comparison for A-WTP

Description	PS			US				MS			
	CR Value = 0.05			CR Value = 0.01				CR Value = 0.01			
	DNO	IRB	RCB	DNO	IRB	RCB	DOC	DNO	IRB	RCB	DOC
DNO	1	1/3	1/2	11	1/3	1/2	1/2	1	1/2	1	2
IRB	3	1	3	3	1	2	2	2	1	2	3
RCB	2	1/3	1	2	1/2	1	1	1	1/2	1	2
DOC		n/a		2	1/2	1	1	1/2	1/3	1/2	1

4.7.4. Integrated decision outcome under AHP

In this study, we decided to attribute equal weight to all three criteria because a finding from an in-depth interview with waste management authorities were inconclusive, and there were no common outcomes. Hence, the criteria weights **[A]** ($W_{C\text{-}MSW}$, $W_{A\text{-}WTP}$, W_{WTR}) were assigned at 0.333 because there are three criteria presented in this study. The issue of a rank reversal when more criteria are added should not occur if more criteria are added to the current set of decision criteria because most of them are produced from quantitative measurements.

Normalized scores of each alternative were found at a similar level when the result of one settlement is compared with another, as shown in **Table 27**-**Table 29**. The priority scores for each criterion is reported in **Table 29**. The final priority scores, as shown in **Table 30**, suggest that the choice of IRB dominated in all settlement sites because the pairwise score in all criteria were the highest amongst all recycling collection alternatives. Nevertheless, the final priority score of the urban site indicated that DNO is the second highest score as recycling activities in the urban site. The study also found that DOC consistently obtained a low priority score in all study sites because respondents tended not to demonstrate a strong preference.

Table 27. Normalized value for C-MSW

Description	PS			US				MS			
	DNO	**IRB**	**RCB**	**DNO**	**IRB**	**RCB**	**DOC**	**DNO**	**IRB**	**RCB**	**DOC**
DNO	0.08	0.09	0.05	0.06	0.07	0.03	0.05	0.07	0.08	0.05	0.04
IRB	0.75	0.81	0.84	0.50	0.62	0.75	0.38	0.64	0.74	0.80	0.72
RCB	0.17	0.10	0.11	0.33	0.16	0.19	0.48	0.14	0.09	0.10	0.16
DOC		n/a		0.11	0.16	0.04	0.10	0.14	0.08	0.05	0.08

Table 28. Normalized value for A-WTP

Description	PS			US				MS			
	DNO	**IRB**	**RCB**	**DNO**	**IRB**	**RCB**	**DOC**	**DNO**	**IRB**	**RCB**	**DOC**
DNO	0.17	0.20	0.11	0.13	0.14	0.11	0.11	0.22	0.21	0.22	0.25
IRB	0.50	0.60	0.67	0.38	0.43	0.44	0.44	0.44	0.43	0.44	0.38
RCB	0.33	0.20	0.22	0.25	0.21	0.22	0.22	0.22	0.21	0.22	0.25
DOC		n/a		0.25	0.21	0.22	0.22	0.11	0.14	0.11	0.13

Table 29. Normalized value for WTR

Description	PS			US				MS			
	DNO	**IRB**	**RCB**	**DNO**	**IRB**	**RCB**	**DOC**	**DNO**	**IRB**	**RCB**	**DOC**
DNO	0.10	0.09	0.17	0.08	0.09	0.05	0.16	0.09	0.08	0.17	0.08
IRB	0.86	0.82	0.75	0.57	0.66	0.74	0.47	0.78	0.74	0.70	0.69
RCB	0.05	0.09	0.08	0.32	0.17	0.18	0.32	0.04	0.09	0.09	0.15
DOC		n/a		0.03	0.07	0.03	0.05	0.09	0.08	0.04	0.08

Table 30. Final rating matrix

Alternatives	Priority [B]								
	Peri-urban [B1]			Urban[B2]			Metropolis [B3]		
	C-MSW	A-WTP	WTR	C-MSW	A-WTP	WTR	C-MSW	A-WTP	WTR
DNO	0.08	0.16	0.12	0.05	0.12	0.1	0.23	0.06	0.11
IRB	0.8	0.59	0.81	0.56	0.42	0.61	0.42	0.73	0.73
RCB	0.12	0.25	0.07	0.29	0.23	0.25	0.23	0.12	0.09
DOC	N/A	N/A	N/A	0.1	0.23	0.05	0.12	0.09	0.07

Table 31. Results from decision

Criteria	final AHP score		
	Peri-urban $[B_1]^T[A]$	Urban $[B_2]^T[A]$	Metropolis $[B_3]^T[A]$
DNO	0.12	0.1	0.13
IRB	0.75	0.56	0.65
RCB	0.13	0.25	0.13
DOC	n/a	0.1	0.09

CHAPTER V
POLICY RECOMMENDATION

For Thailand, and countries where the formal/mandated recycling system does not exist, the attempt to promote recycling can be reinforced using lessons learned from this study:

- Rising MSW service fee is appropriate for improvement of MSWM system

Although PAYT as unit-based pricing remains the most appropriate pathway for MSW reduction, the option of rising MSWM fee to cover the cost is acceptable as the ratio of mean WTPs, shown in Table 21**,** and the current MSWM fee of each study site, listed in **Table 1**, are higher than 1 in all settlements. It indicates that average respondents for all study sites are willing to pay for the implementation of an MSW recycling system. Moreover, respondents from the Peri-urban site suggests that mean WTPs were almost 448.80% higher than their current MSWM fee. More urbanized settlements may have lower mean WTPs for the existing MSWM fee, but the percentages were still in surplus (Urban settlement =200.83% and Metropolis settlements =253.61% over their current MSWM fees). However, the mean WTP figures from all 3 study sites were still lower than the true cost of MSWM via landfilling, as listed in **Table 6**.

- Using price incentive to promote recycling

Evidences of the regression analysis on WTP and high popularity of recycling models with financial returns when compared to recycling without financial return provided support for changing from a flat-rate MSWM fee to a PAYT system because the negative correlations of "selling to recycling service at least once a month" indicated

that respondents might respond well to a change in price. We concluded that the inconsistency of coefficients studied factors in Peri-urban, Urban, and Metropolis settlements indicated that policies, incentives and pricing of MSWM should be tailored to suit the local context and not be a "one-size-fits-all" scheme as it is currently implemented in Thailand and other countries.On the other hand, if incentives to promote recycling is to be given instead of using PAYT, willingness to accept (WTA) by deriving from studies in this research. Using mean ratio [10.41] of WTA to WTP on public good categories of public property by Horowitz and McConnell (2002) and mean WTPs from **Table 21**, the potential WTA of respondents would be 232 THB [Peri-urban site] – 625 THB [Urban site]. The choice of incentivising through WTA render impractical as the WTA would exceed estimated cost for MSW management, shown in **Table 6**.

- Setting programs for recycler and non-recycler to maximize recycling

The results from regression analysis of WTP and MLR on behavioral analysis can be used to create specific recycling plan. If the choice of rising MSW fee is selected to cover the cost of running MSW service, factors, i.e. separation of waste, with positive coefficient in WTP study indicate that existing of that promoting those factors may help to gain more support for the rise, or the decision maker should approach the group who separate waste first if popular support is required to pass the rising of the fee.

- Internalizing informal waste workers

Base on the findings from this study, it is clear that itinerant recyclable buyers (IRB) are the possibly good choice in term of raising volume of recyclables compared

to other recycling collection activities in this study. The previous finding of Challcharoenwattana and Pharino (2015) provided support that curbside recycling service can help diverting more recyclables in term of unit weight of recyclables per member when compared to other drop-off collection programs in Thailand. The importance of running curbside collection service also found in Aadland and Caplan (1999) and Zen and Siwar (2015). Overall, incorporation of IRB into MSW service would be beneficial to the effort of MSW recycling as IRB often runs as for-profit and would tend to perform better on cost-effectiveness perspective as reported in (D. C. Wilson, Araba, Chinwah, & Cheeseman, 2009)

- Empowering community-based recycling

The special case of public-private partnership can be found in CBM activities, i.e. "waste bank," based on MSW characterization report (**Table 18** and **Table 19**), the importance of waste bank functions of a CBM program may be higher due to higher recyclable contents in the waste stream. Although widely used MSWM methods i.e. landfill or open dumping, may have relatively lower initial investment costs, in the long run, these methods can incur expensive operating costs as well as produce significant adverse impacts on the environment, particularly climate change. Therefore, the association of climate co-benefits, evidenced by negative greenhouse gas emission if recycling is engaged as reported in USEPA's Waste Reduction Model (USPEA, 2015), and the ability to save public funds through MSW reutilization should be preached widely, in order to raise public awareness, and elaborate benefits of reducing MSW, and create incentives for comprehensive waste management for citizens nationwide.

- Develop a Plan for promoting Tailored MSW servicing program

A roadmap to promote recycling should be started from conducting a public survey at the township before implementing the recycling program as dwellers in the settlements may already engage in informal recycling activities. The settlement's government, however, may need to provide incentives to those participating in the informal recycling system by allocating funds that are otherwise would have been used for landfilling those recyclables as an economic incentive. Establishing Public-Private Partnership program, especially the community-based style, may provide additional incentives, both in term of the economies of scale (S. J. Callan & Thomas, 2001; Zen & Siwar, 2015) and in term of moral support and peer pressure (Sekerka & Stimel, 2014; Sexton & Sexton, 2014). For Thailand, however, a local activist and elected town administration are often coming from the same side and synergism between both parts are likely to help to promote recycling activities, both in the formal and informal recycling sectors.

CHAPTER VI
CONCLUSIONS

6.1. Conclusions

This study provides significant findings of aspect in MSW management. Community-based recycling has been proved to provide the co-benefit of promoting resource recovery and can also reduce the financial burden of administration. The financial returns are also one of major influencing factors on boosting recycling rate. Findings from the study suggested that key success factors may stem from the synergism between curbside recycling services, community-wide collaboration, understanding of benefits from recycling, and fair pricing of recyclables purchased at the waste bank, which help to sustain participation in CBM activities.

The analysis of WTP for implementation of recycling service in different urban settlements in Thailand revealed that the mean monthly WTPs rose along the urbanization, although no linearly, in the least urbanized areas (~ 0.73 USD), the urbanized areas (~1.96 USD), and the most urbanized areas (~1.65 USD). Most respondents from all study sites revealed their preference for implementing recycling service in their settlements. Evidence from the regression analysis provided support for changing from a flat-rate MSWM fee to a PAYT system because the negative correlations of “selling to recycling service at least once a month” indicated that respondents might respond well to a change in price.

MSW characteristic at landfills indicated that plastic and paper waste constituted the largest proportion of theoretically recyclables (approximately 30% of generated wastes). Hence, empowering informal recycling may help increasing

recycling activities and, therefore, contribute reducing the quantity of wastes destined to landfill.

Separate assessments of each criterion suggested that the itinerant recycling collection tended to outperform other modes of informal recycling collection. This is especially true on the relative reduction of landfilling cost and the ability to command higher willingness to pay for the improvement of the recycling system. On the tendency to recycle, the weighted odd ratios with the percentage of respondents stated their willingness to recycle (WTR) indicated that respondents in the peri-urban and metropolis sites still have their largest WTR in IRB but the willingness to recycle has dropped significantly in the urban site.

Base on the AHP analysis, the most optimal choice to promote recycling at all three sites is the IRB. The second most appropriate choice, however, is closely contested between RCB (peri-urban and Metropolis sites) and DNO (Urban site).

6.2. Possibilities of Future Research

For future research and extended version of this study, the further explorations of these fields are recommended.

- As the Royal Thai Government is in the process of ratifying a fee hike for MSW service fee (Draft Ministry of Public Health Order on Fees for MSW Management B.E…), future research on the change of responses and WTP of respondents on the fee may provide insight into the change of WTP to the change of fee levels and impacts of fee setting on recycling attitude.

- Investigate mechanism to promote behavioral change using Behavioral Economics under "nudge theory." Since this research has identified impact from trait and characteristics on the behavioral study, different level on incentivisation on those high impact factors, i.e. specific practice of waste separation with a change of incentive, i.e. varying on cash incentive or bonus on the sale price, may help to induce more recycling practice. The author believes that experiments to find out the most appropriate method to raise popularity, trust, and the relationship between IRB and serving communities should yield the most fruitful boost on recycling.
- Although remaining outside the scope of this study, the author believes that a similar study can be conducted to identify potential venues to promote separation of household hazardous solid waste, where the large gap between the generated/import quantity into Thailand and the quantity that is recycling are widely reported (PCD, 2014b).
- Since there are estimated at 6.4% of respondents (protest bid) stated that they are not willing to contribute to the payment of MSWM fee, potential experiment on convincing those protest bidders to change attitude, which may be applicable to another effort of convincing pollution in other environmental issues to improve their practice as well.
- Co-benefit or life-cycle assessment may also be conducted based on a finding of this study to demonstrate symbiosis of promoting recycling and reduce of a certain type of pollution.

APPENDIX 1
QUESTIONNAIRE

แบบสอบถามเรื่องพฤติกรรมและความยินดีที่จะจ่าย

ในการจัดการขยะและ รีไซเคิล

เป้าหมายที่ต้องการศึกษา: ผู้ที่อยู่อาศัยในเขตเมืองในประเทศไทย

เวลาที่ใช้ในการทำแบบสอบถาม(โดยประมาณ): 10-15 นาที

คำชี้แจงของแบบสอบถาม

แบบสอบถามนี้สร้างขึ้นเพื่อใช้ในการประเมินพฤติกรรมและความต้องการจ่ายในการพัฒนาระบบการจัดการขยะชุมชนเพื่อนำ ไปเป็นข้อแนะนำในการสร้างระบบการลดปริมาณขยะที่จะต้องถูกฝังกลบรวมถึงการนำวัสดุที่สามารถนำกลับมาทำประโยชน์ ใหม่ มาใช้ให้เต็มประสิทธิภาพต่อไป

ข้อมูลที่ได้จากการตอบแบบสอบถามนี้ถือว่าเป็นความลับซึ่งผู้วิจัยจะทำการประมวลผลตามแบบแผนของงานจึงขอให้ท่านช่วยอนุเคราะห์ตอบข้อมูล ให้ตรงกับความเป็นจริง เพื่อให้ผลการวิจัย สะท้อนความเป็นจริงมากที่สุด

ด้วยความนับถือ

อมรชัย แจวเจริญวัฒนา

นิสิตปริญญาเอก

ศูนย์ความเป็นเลิศด้านการจัดการสารและของเสียอันตราย (ศรอ.)

จุฬาลงกรณ์มหาวิทยาลัย

ส่วนที่ **1:** ข้อมูลของผู้ตอบแบบสอบถาม

อายุของท่าน _____ปี

เพศของท่าน

( ) ชาย **( )** หญิง

ที่อยู่ปัจจุบันของท่าน

แขวง**(**ตำบล**):** _____ เขต**(**อำเภอ**):** _____

จังหวัด**:** _____ รหัสไปรษณีย์**:** _____

อาชีพของท่าน

( ) ข้าราชการ **( )** แม่บ้าน **( )** นักเรียน/นักศึกษา **( )** ธุรกิจส่วนตัว

( ) พนักงานบริษัท **( )** เกษียณอายุ **( )** รับจ้าง **( )** ระหว่างหางาน

( ) เกษตรกร **( )** อื่นๆ_____

การศึกษาขั้นสูงสุดของท่าน

( ) ไม่ได้ศึกษา **( )** ประถม-มัธยมต้น **( )** มัธยมปลาย/ปวช

( ) อนุปริญญา/ปวส **( )** ปริญญาตรี **( )** ปริญญาโท **( )** ปริญญาเอก

สมาชิกครอบครัวท่านมีจำนวน

	ชาย	หญิง
เด็ก **(0-10ปี)**		
วัยรุ่น **(11-20ปี)**		
ผู้ใหญ่ตอนต้น **(21-40ปี)**		
ผู้ใหญ่ **(40-60ปี)**		
สูงอายุ **(60** ปี หรือมากกว่า**)**		

บ้านที่ท่านอยู่อาศัยในปัจจุบันนั้น

( ) ครอบครัวท่านเป็นเจ้าของ **( )** ครอบครัวท่านเช่าอาศัย

ประเภทของชุมชนที่ท่านอาศัยอยู่ขณะนี้

( ) หมู่บ้านจัดสรร **( )** คอนโด

( ) บ้านเดี่ยว/ตึกแถว/ทาวน์เฮาส์ **( )** หอพัก/อพารต์เมนต์/แฟลต

ชุมชนท่านมีผู้จัดการโครงการ/นิติบุคคล

( ) มี **( )** ไม่มี

ส่วนที่ **2:** ความเข้าใจเกี่ยวกับการจัดการสิ่งแวดล้อมและของเสียจากภาคครัวเรือน

โปรดให้คะแนนความสำคัญของปัญหาสิ่งแวดล้อมตามความสำคัญ จากตารางด้านล่าง

สำคัญน้อยที่สุด **(1)**	สำคัญน้อย **(2)**	สำคัญปานกลาง **(3)**	สำคัญมาก **(4)**

เลือกได้ **1** ความสำคัญ ต่อ **1** ปัญหา

ปัญหา	น้ำเสีย	อากาศเสีย	โลกร้อน	ขยะไม่ที่ทิ้ง
ความเห็นของท่าน				

หน่วยงานที่ดูแลจัดเก็บขยะจากบ้านของท่านคือ

( ) กรมควบคุมมลพิษ **( )** องค์การบริหารส่วนตำบล

( ) เทศบาลตำบล เทศบาลเมือง เทศบาลจังหวัด **( )** กรุงเทพมหานคร

( ) ไม่ทราบ

ท่านคิดว่า ขยะควรถูกจัดการอย่างไร **(ตอบได้มากกว่า 1 ข้อ)**

( ) กองทิ้ง **( )** เผากลางแจ้ง **( )** ฝังกลบตามหลักวิชาการ

( ) ขุดฝัง **( )** นำไปทำปุ๋ย **( )** อื่นๆ_____

ท่านคิดว่าปัจจุบันขยะครัวเรือนถูกจัดการอย่างไร

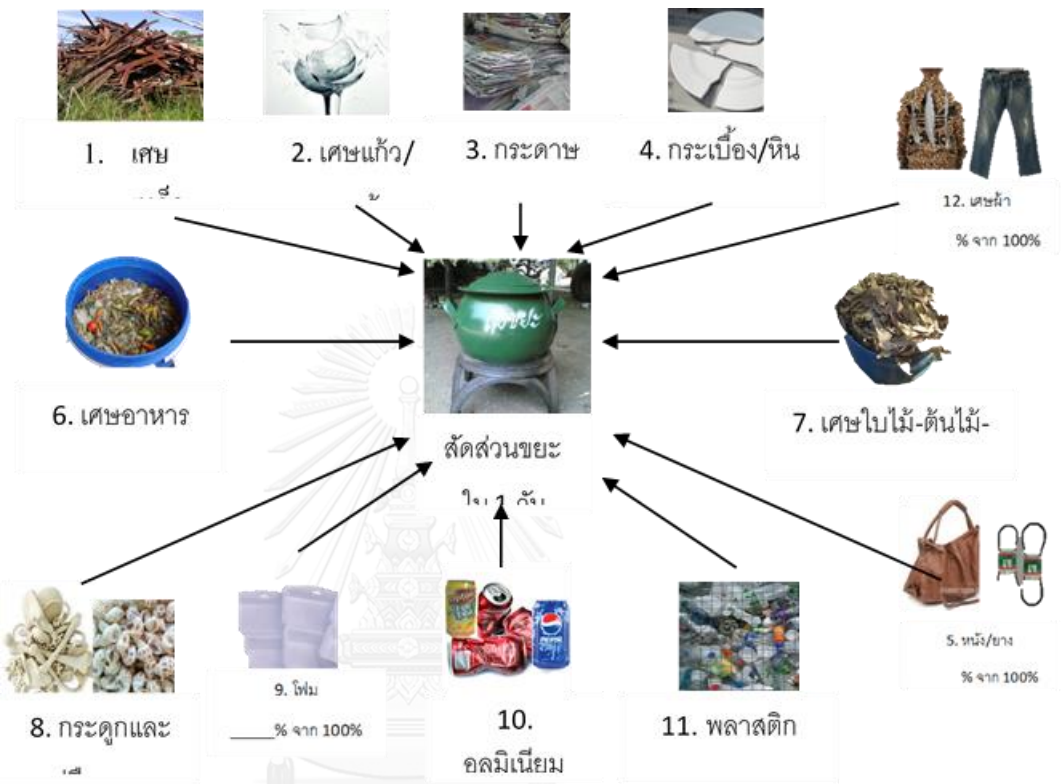
( ) ขยะชุมชนส่วนใหญ่**(95%)**ของประเทศไทย ถูกนำไปแยกและจัดการอย่างเหมาะสมเกือบทั้งหมด

( ) ขยะชุมชนเพียงบางส่วน**(50%)**ของประเทศไทย ถูกนำไปแยกและส่วนที่เหลือถูกนำไปทิ้ง

( ) ขยะชุมชนส่วนน้อย**(25%)**ของประเทศไทย ได้รับการแยก และส่วนที่เหลือถูกนำไปทิ้ง

( ) ไม่ทราบ

ส่วนที่ **3:** การจัดการสิ่งแวดล้อมและของเสียจากบ้านของ



ส่วนประกอบของขยะจากบ้านท่านโดยประมาณต่อวัน (เต็ม **100%)**

กรณีที่ไม่สามารถตอบได้ทั้งหมด ขอให้ประมาณข้อที่มั่นใจ

ความถี่ที่หน่วยงานที่รับผิดชอบ มาเก็บขนขยะจากบ้านของท่าน

( ) ทุกๆวัน **(**) **2-3** วัน ต่อครั้ง **(**) **4-7** วัน ต่อครั้ง **(**) ทุกอาทิตย์

( ) นานกว่าทุกอาทิตย์ **(**) ไม่เคยได้รับบริการ **(**) ไม่ทราบ

บ้านของท่านมีการแยกขยะประเภทใดบ้าง **(**เลือกได้มากกว่า **1** อย่าง**)**

(**)** ไม่ได้แยกขยะ**(** กรุณาตอบข้อ **19)**

(**)** พลาสติก **(** **)** แก้ว **(** **)** โลหะ

(**)** กระดาษ **(** **)** เศษอาหาร

(**)**อื่นๆ_____

เหตุที่บ้านท่านไม่ได้มีการคัดแยกขยะ

(**)** ยุ่งยาก ไม่สะดวก **(** **)** ความไม่สะอาด/กลิ่น **(** **)** ไม่เคยคิดถึง

(**)** คิดว่า เมื่อแยกไปแล้ว ขยะก็ถูกนำไปรวมกันอยู่ดี

(**)** อื่นๆ_____

ชุมชนของท่าน สามารถเข้าถึงร้านค้าหรือบริการรับซื้อของเก่าได้สะดวกหรือไม่

(**)** สะดวก **(** **)** ไม่สะดวก **(** **)** ไม่มีความเห็น

ความถี่ของการขายของเก่าของครอบครัวท่าน

(**)** ไม่เคยดำเนินการ

(**)** ถี่กว่าหนึ่งครั้งต่อสัปดาห์ **(** **)** ทุกสัปดาห์ **(** **)** ทุกเดือน

(**)** ทุกๆหกเดือน **(** **)** ปีละครั้ง **(** **)** มากกว่าปีละครั้ง

ท่านขายของเก่าโดยวิธี **(**เลือกได้มากกว่า **1** ช่อง**)**

(**)** มีคนเข้ามารับซื้อของเก่า **(**ได้รับเงิน**)** **(** **)** บริจาคให้แก่คนยากจน

(**)** ธนาคารขยะ

(**)** รวบรวมและขนไปขายที่ร้านรับซื้อ **(**ได้รับเงิน**)** **(** **)** อื่นๆ_____

ท่านเสียค่าธรรมเนียมการจัดการขยะ

_____ทุกสัปดาห์ _____ทุกเดือน

_____ทุกปี

จำนวนค่าธรรมเนียม

(**)** ไม่ได้จ่าย **(**กรุณาระบุเหตุผล**)** _____

(**) 20** บาท **(** **) 40** บาท **(** **) 40-120** บาท **(** **) 121-200** บาท

(**) 201-400** บาท **(** **) 401-500** บาท **(** **)** อื่นๆ **(**กรุณาระบุ _____**)**

ท่านพอใจกับการให้บริการเก็บขนขยะในปัจจุบันหรือไม่

(**)** พอใจ **(** **)** ไม่พอใจ เพราะ_____

ท่านจ่ายค่าธรรมเนียมในการจัดการขยะโดย

( ) ไม่ได้จ่ายเพราะ_____

[ ] จ่ายรวมกับค่าส่วนกลางไปแล้ว [ ] ไม่มีคนมาเก็บ

( ) จ่ายกับพนักงานเก็บขนขยะ ( ) จ่ายกับสำนักงานเขต/ อบต/ เทศบาล

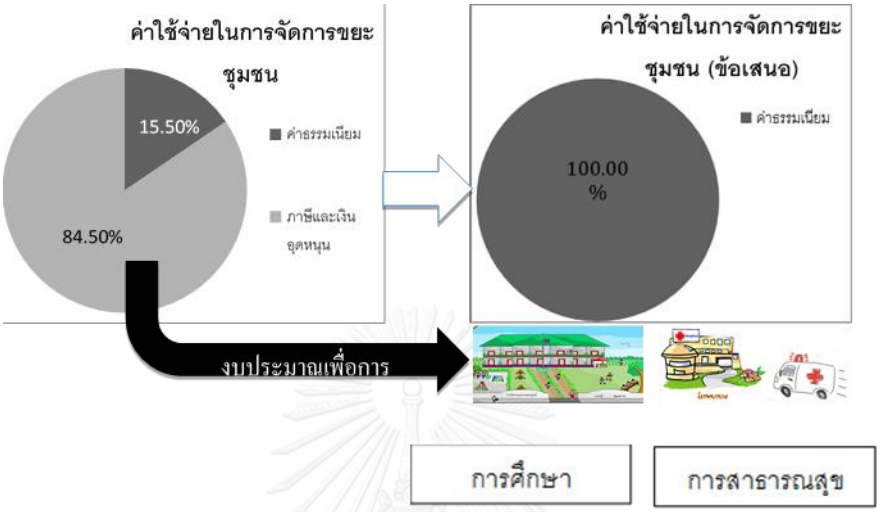
การสำรวจความยินดีที่จะจ่ายในการแยกและจัดการขยะอย่างมีประสิทธิภาพมากขึ้น

คำชี้แจง

ประเทศไทย มีปริมาณขยะจากชุมชนเกิดขึ้นประมาณ **24** ล้านตัน ทุกปี แต่พื้นที่สำหรับฝังกลบขยะนั้น กลับไม่ได้มีเพิ่มขึ้น ตามปริมาณขยะที่เพิ่มขึ้น และยังมีขยะที่ยังไม่ได้รับการกำจัดจำนวนมาก ซึ่งหากว่าเหตุการณ์แบบนี้ยังเกิดต่อไป ปัญหาขยะล้นเมืองก็ย่อมไม่สามารถหลีกเลี่ยงได้ และหลุมฝังกลบที่ดีต่อสุขภาพและสิ่งแวดล้อมนั้น มีค่าใช้จ่ายที่สูง

นอกจากนี้ค่าธรรมเนียมที่ท่านจ่ายในแต่ละเดือน คิดเป็น ร้อยละ **8.76-15.15** ของค่าใช้จ่ายในการกำจัดขยะทั้งระบบ ค่าใช้จ่ายส่วนที่เหลือนั้น มาจากเงินภาษีต่างๆที่ประชาชนได้จ่ายไป เงิน

ภาษีเหล่านี้ สามารถถูกนำไปใช้ประโยชน์อื่นๆเช่น การพัฒนาชุมชน การสนับสนุนการศึกษา หาก ว่า ค่าธรรมเนียมในการจัดการขยะ ได้เพิ่มขึ้นตามต้นทุนจริง



การเพิ่มประสิทธิภาพในการแยกประเภทขยะและการรีไซเคิลขยะที่นำกลับมาทำประโยชน์ได้ จึงเป็นวิธีที่จะช่วยลดค่าใช้จ่ายในการกำจัดขยะและการสูญเสียพื้นที่ไปในเพื่อการฝังกลบขยะ และสามารถช่วยลดภาระภาษีและค่าธรรมเนียมต่างๆที่ท่านและลูกหลานของท่านต้องจ่ายได้ในระยะยาว

แต่อย่างไรก็ดี การดำเนินการเช่นนี้ ย่อมมีค่าใช้จ่ายเพิ่มเติมโดยเงินลงทุนนี้ ย่อมต้องมาจากผู้ก่อให้เกิดขยะ ตามหลัก "คนทิ้งขยะเป็นคนจ่าย" ดังนั้น โปรดพิจารณาเหตุการณ์สมมุติดังต่อไปนี้เพื่อประเมินความต้องการจะจ่ายของท่าน

กรุณาเลือกคำตอบที่ท่านเห็นว่าเหมาะสมและตรงกับสถานการณ์ของท่านมากที่สุด

ช่วงรายรับต่อเดือน(บาท)ของท่านคือ	ช่วงรายจ่ายต่อเดือน(บาท)ของท่านคือ
( ) 0 – 5,000	( ) 0 – 5,000
( ) 5,001 – 10,000	( ) 5,001 – 10,000
( ) 10,001 - 15,000	( ) 10,001 - 15,000
( ) 15,001 - 20,000	( ) 15,001 - 20,000
( ) 20,001 - 25,000	( ) 20,001 - 25,000
( ) 25,001 - 30,000	( ) 25,001 - 30,000
( ) 30,001 - 40,000	( ) 30,001 - 40,000
( ) 40,001 - 50,000	( ) 40,001 - 50,000
( ) 50,001 - 70,000	( ) 50,001 - 70,000
( ) 70,001 - 90,000	( ) 70,001 - 90,000
( ) 90,001 - 100,000	( ) 90,001 - 100,000
( ) 100,001 - 150,000	( ) 100,001 - 150,000
( ) 150,001 - 200,000	( ) 150,001 - 200,000
( ) มากกว่า 200,000 โปรดระบุ_____	( ) มากกว่า 200,000 โปรดระบุ_____

เหตุการณ์สมมุติ

หน่วยงานท้องถิ่นขอท่าน มีโครงการปรับปรุงระบบการจัดเก็บและแยกขยะเพื่อเป็นการลดความต้องการพื้นที่ฝังกลบขยะเพิ่มเติม โดยรายได้จากการแยกขยะไปขายนั้น จะได้นำมาคิดเป็นรายได้ของเมืองของท่าน และค่าบริการการจัดเก็บขยะ จะไม่มีการเรียกรับเพิ่มเติมจากงบประมาณแผ่นดินเพิ่มเติม

หากท่านต้องจ่ายค่าธรรมเนียมในการเก็บขนและจัดการขยะจึงมีความจำเป็นที่จะต้องเพิ่มขึ้น แต่ค่าธรรมเนียมที่เพิ่มขึ้นนั้น จะช่วยลดภาระทางภาษีของท้องถิ่นของท่าน และจะสามารถนำไปพัฒนาท้องถิ่นของท่านในด้านอื่นๆ

ในการจัดการขยะที่ถูกสุขลักษณะจำเป็นจะต้องมีค่าใช้จ่ายในระบบการจัดการนี้ในพื้นที่ของท่าน ท่านมีความเต็มใจจ่ายค่าจัดการขยะสูงสุดเพื่อใช้ในการจัดการขยะที่มีการแยกขยะที่สามารถนำไปทำประโยชน์ได้ออกไป เป็นจำนวนเงินเท่าใด

( ) 0 บาท **(**ไม่เต็มใจจ่าย)

เหตุใดท่านจึงคิดว่าไม่ควรเสียค่าธรรมเนียมในการบริการจัดการขยะ

[ ] คิดว่าเป็นหน้าที่ของรัฐที่ต้องให้บริการประชาชน

[ ] ปรกติมีการจัดการขยะเองอยู่แล้ว

[ ] เป็นภาระทางการเงินที่เพิ่มขึ้นของครอบครัว

[ ] อื่นๆ_____

( ) มากกว่า **0** บาท

ความเต็มใจจ่ายค่าจัดการขยะสูงสุด เป็นจำนวนเงิน **(**บาท**)**

10	**110**	**210**	**310**	**410**	**510**
20	**120**	**220**	**320**	**420**	**520**
30	**130**	**230**	**330**	**430**	**530**
40	**140**	**240**	**340**	**440**	**540**
50	**150**	**250**	**350**	**450**	**550**
60	**160**	**260**	**360**	**460**	**560**
70	**170**	**270**	**370**	**470**	**570**
80	**180**	**280**	**380**	**480**	**580**
90	**190**	**290**	**390**	**490**	**590**
100	**200**	**300**	**400**	**500**	**600**

( ) สูงกว่า **600** บาท (โปรดระบุ) _____

การจัดเก็บค่าธรรมเนียมการจัดการขยะนั้น ท่านคิดว่าการจ่ายในช่องทางใดเหมาะสมที่สุด

( ) จ่ายผ่านพนักงานเก็บขนขยะจากบ้านท่าน

( ) จ่ายรวมกับค่าน้ำ-ค่าไฟ

( ) เก็บพร้อมกับภาษีที่ดิน-สิ่งปลูกสร้าง

( ) อื่นๆ **(**กรุณาระบุด้านล่าง**)**

ส่วนที่ **4:** การจัดการขยะอันตรายจากครัวเรือน

ท่านจัดการถ่านไฟฉายโดยวิธีใด

( ) ทิ้งรวมกับขยะธรรมดา ( ) แยกไว้ต่างหาก ( ) อื่นๆ_____

ท่านจัดการทีวีเก่าโดยวิธีใด

( ) ทิ้งรวมกับขยะธรรมดา ( ) แยกไว้ต่างหาก ( ) อื่นๆ_____

หากทางเทศบาลขอให้ท่านแยกถ่านไฟฉาย และ เครื่องใช้ไฟฟ้าจากขยะปรกติ ท่านจะยินดีที่จะทำหรือไม่

( ) ยินดี ( )ไม่ยินดี

หากท่านมีความเห็น แนวทาง หรือข้อเสนอทำให้ท่านหันมาให้ความร่วมมือในการรีไซเคิลขยะมากขึ้น

_____

_____

_____

APPENDIX 2

AHP TABLE

Random Index

n	RI
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.51

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APPENDIX

VITA

Mr. Amornchai Challcharoenwattana was born on February 21st, 1981 in Bangkok Province, Thailand. He received Bachelor of Science in General Science from Kasetsart University in 2003, and Master of Science in Environmental Management from the University Of San Francisco, United States Of America. For Doctoral degree, He received scholarships from Center of Excellence on Hazardous Substance Management (HSM) Chulalongkorn University and the 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund). On Employment aspects, He worked in the USA. as a Chemist and Environmental Health & Safety Officer for CPI International Co.,Ltd in Santa Rosa, California in 2008-2009 during his one-year Optional Practical Training (OPT). In Thailand, he has been employed by Chiva-Som International Health Resort Co.,Ltd in the capacity of Sustainable Development Officer since 2009.