Analysis and modeling of household solid waste separation behavior towards recycling promotion in Da Nang City, Vietnam

ベトナム・ダナン市におけるリサイクル推進に向けたごみ分別行動の分析及びモデリング

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ABSTRACT

Given the needs to both manage the increasing amount of solid waste and preserve natural resources, waste separation at source (WSS) has become a hot issue in Vietnam in recent years. Some municipalities in Vietnam have also established local regulations and action plans on solid waste management and introduced pilot projects including WSS. In 2017, under the management of Da Nang City authorities, a WSS program for the local community was introduced in 4 wards of Hai Chau District. In 2018, the WSS program was expanded to two additional wards of Thanh Khe District. In the WSS program, the recycling activity is managed by the ward-level authorities, and implemented by the community-level leadership under each ward, and there is no scheduled separate collection by official workers. As WSS expands, it is indispensable for Da Nang City to review the effect of the WSS program and clarify the weaknesses and strengths of existing systems in order to highlight the factors influencing success and failure.

This study focused on the household solid waste in Da Nang City, Vietnam. As the scientific basis for promoting citizens' recycling behavior and contributing to the successful expansion of the WSS program in Da Nang City, this study aims to achieve the following objectives: 1) To survey, describe the waste separation behavior (including the waste separation rate, and the disposal habits of leftover food and detail recyclable categories), and to develop the structure models for the waste separation behaviors to figure out the influencing factors of citizens' separation; 2) To assess the current status of implementing the waste separation at source (WSS) program by city authorities in some specific areas, and to clarify the effect of the current WSS program on waste separation behavior and its influencing factors, and to compare these influencing factors by time-series data to evaluate the changing over time; 3) To analyze the difference in waste separation behavior among the attribute categories including age, gender, household size, etc.; 4) To suggest the weaknesses and strengths of existing WSS program, the higher-priority waste categories, influence factors, and attribute categories for recycling promotion measures based on the abovementioned analytical results; 5) To estimate the potential impact of suggested promotion measures on waste separation rate and waste separation amount of detail recyclable categories via sensitivity analysis of the predictive models.

A questionnaire survey was conducted via face-to-face interviews with 150 households in six urban districts on November, 2016 and 602 households in 6 wards with WSS program on October, 2018. The questionnaire items covered the household attributes (age, gender, household size, etc.), the household's current waste separation activity, attitudes and

perception (e.g., behavioral intention, evaluation of trouble). The major findings were indicated as follows:

Regarding the leftover food separation behavior, the separation rate was 77.3% in 2016 and 76.1% in 2018. No significant difference was found by time. Most people participated in leftover food separation voluntarily without material benefits (nearly 70%). The positive factors included behavior intention, perception of information, and sympathy for the collector. The negative factor was the evaluation of trouble. Households located in high urbanization areas, male respondents and respondents in 1−2 persons families were less active in separating leftover food.

Regarding the recyclable separation behavior, in 2016, the separation rates of recyclables differed widely among the surveyed 13 recyclables, from the lowest 13.0% for Batteries to the highest 72.5% for plastic bottles. The recyclable categories were divided into three groups: “higher participation group” including plastic bottles (72.5%) and metal cans (63.8%), “moderate participation group” including cardboard (50%), newspaper (43.8%), book/photocopy paper (38.4%), and notebooks (37.7%), and “low participation group” including plastic products (33.3%), magazines (25.4%), metal products (23.9%), e-waste (18.8%), plastic bags (15.2%), carton paper (15.2%), and batteries (13.0%). In 2018, the recyclable categories including aluminum cans, plastic bottles, magazines, plastic products, cardboard, newspaper, steel cans, book or photocopy paper, notebooks, and metal products were categorized as “higher participation group” with the participation rate more than 80%. Besides, 4 recyclable categories including carton (63.9.0%), e-waste (57.8%), plastic shopping bags (40.8%), and batteries (22.4%) were still defined as “low participation group”.

Regarding the recyclable waste disposal habit, in 2016, more than half of the respondents separated recyclables for giving to others for free (53.6%) and about 30% of them separated recyclables for selling to the informal sector. In 2018, up to 70% of respondents engaged in waste separation without economic incentive and only about 12% of them sold recyclable waste to the informal sector.

The factors with a positive influence on waste separation behavior were the behavioral intention, perception of information, the incentive provided by recycling benefit, internal norm, and perception of responsibility and seriousness. The perception of information and behavioral intention were two important factors. A stronger behavioral intention and increased knowledge about waste separation would promote the waste separation rate. The negative factor was the evaluation of trouble. A higher evaluation of trouble could prevent respondents from participating in waste separation.

Regarding the current WSS program in 2018, the WSS program consisting of an explanatory meeting and the distribution of leaflets played an important role in improving the waste separation rate. Two-thirds of respondents had attended the explanatory meeting, while the remaining one-third didn't know about the program. Under the program, the residents were encouraged to separate recyclables for donating to their community or for independent direct sale to informal sectors. For donations, the women's union or youth union of the community collected recyclables from households and sold them to the junk shop for fundraising. Normally, recyclables were collected every week or every 2 weeks via door-to-door or drop-off collection.

Regarding the effect of the current WSS program, by the data in 2018, the separation rates for before the WSS program were higher for "higher participation group" were about 70.3%−72.3%, followed by carton (56.0%), e-waste (45.9%), plastic shopping bags (34.3%), and batteries (20.9%). The promotion effects of the WSS program, represented by the increase in participation in waste separation after the WSS program, were 12.5%−13.9% for recyclable items in "higher participation group", 7.9% for carton, 11.9% for e-waste, 6.5% for plastic shopping bags and 1.5% for batteries. In this WSS program, attendance of the explanatory meeting raised the separation rates by nearly 20% and also shifted the influencing factors of waste separation behavior in a positive direction. Receiving the leaflets in addition to attending the meeting enhanced the separation rate and also had positive effects on the influencing factors.

Regarding the potential effects of recycling promotion measures on waste separation behavior, recycling promotion measures were proposed as follows: (1) The provision of information (through frequent and convenient explanatory meetings, and leaflet on the knowledge of waste separation, the benefits of waste separation, etc.); (2) The provision of collection services (through designing the place for recyclable storage outside of the house, flexible times for disposing of recyclables, etc.); (3) The promotion of environmental awareness (through public relations, etc.).

By the sensitivity analysis of the predictive models, the provision of information has the largest impact on waste separation rate with an increase by 6.1%−9.5% for higher participation group and 26.4%−49.0% for low participation group. The total amount of recyclable can be separated was up to 22.15 g/cap/day, equivalent to 9.6% of total waste generation amount. The highest priority should be given to ensure that the knowledge related to waste separation is fully provided to everyone. By providing collection service, waste separation rate is expected to increase by 4.4%−5.8% for higher participation group and 1.6%−7.7% for low participation group. The total amount of recyclable can be separated was

about 17.86 g/cap/day, equivalent to 7.7% of total waste generation amount. By other promotion measures, waste separation rate is expected to increase by 1.5%−5.9%. The total amount of separated recyclable waste was 4%−4.5%. Therefore, to further promote waste separation behavior, additional promotion measures aimed to minimize the trouble, maximize the perception and internal norm should be considered.

In Vietnam, waste separation at source has been introduced in the national government regulation, and the Vietnam Government set the national target for a recovery rate of HSW. Vietnamese authorities of MSW promptly need to establish the explicit strategy and guidelines for waste separation at the local level. The findings of this study would be important to support a strategy formulation aimed to enhance waste separation activities at the household level and expand to the whole city.

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LIST OF ABBREVIATIONS AND ACRONYMS

3R: Reduce, Reuse, Recycle

ANOVA: Analysis of Variance

HSW: Household Solid Waste

MSWM: Municipal Solid Waste Management

SWM: Solid Waste Management

URENCO: Urban Environment Company

WGR: Waste Generation Rate

WSS: Waste separation at source

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CHAPTER 1: INTRODUCTION

1.1 Background

Vietnam has faced a rapid increase in solid waste generation in recent years. Together with the growth of the economy and population, the total amount of solid waste increased by 10% every year during the 2006–2010 period, and by 12% per year during the 2011–2015 period [8]. The municipal solid waste (MSW) generated from urban areas was approximately 32,000 tons/d in 2014 [8], which results in a great challenge for municipalities to handle.

Given the needs to both manage the increasing amount of solid waste and preserve natural resources, waste separation at source (WSS) has become a hot issue in Vietnam in recent years. Regarding national-level regulation, WSS was first specified by Decree No. 59/2007/NĐ-CP on Solid Waste Management dated April 9, 2007, then by Article 95 of the Law on Environmental Protection issued in 2014 [12, 13]. In the newest Decree on Management of Wastes and Discarded Materials issued in 2015, household solid waste (HSW) was required to be separated into three groups; "group of disintegrable organic wastes," "group of reusable and recyclable wastes," and "remaining group" [14]. A national target for waste separation was also set by Decision 491/QĐ-TTg on approving adjustments to national strategy for general management of solid waste to 2025 with vision towards 2050 [11]. Regarding HSW in urban areas, the specific targets up to 2025 were to improve rates of recycling, reuse, energy recovery, and organic fertilizer production, and consequently to reduce the rate of landfilling below 30%. It is indispensable for Vietnamese authorities of MSW to promote citizens' separation behavior effectively.

In order to promote recycling, the participation of citizens in waste separation should be improved by appropriate measures. This raised the question of which determinants that predict recycling behavior and how the behavior could be enhanced by 3R promotion measures. The cooperation of citizen in waste separation could be affected by various factors such as the awareness of environmental problems, the collection system, perceiving the environmental risks and responsibility, etc. It is necessary to develop a model of such environmental behavior aimed to extract factors affecting behavior. From that, the participation of citizen could be achieved by considering of such extracted factors.

In response to the national target, some municipalities in Vietnam have also established local regulations and action plans on solid waste management and introduced pilot projects including WSS.

There are advanced areas with active 3R promotion, including Ha Noi, Hai Phong, Hue, Cham Islands, Ho Chi Minh, Da Nang. In Cham Islands, as an example, residents separate their wastes into: biodegradable wastes for composting, recyclables for selling to junk buyers, and others wastes for dumping at the dump site. In terms of reducing activities, from 2009, Cham government had a program in limitation of using of plastic bags. The propaganda and education for residents are applied. Banners are hung, leaflets are given and the residents signed in the agreement contract. The participation of residents is showed through using paper bags and environmentally friendly bags instead of plastic bags.

The 3R-HN project is another example on implementing WSS. The Project developed source separation and collection system model for organic waste, inorganic waste and recyclable waste, composting model and environmental education model for three years from 2006 to 2008 in Ha Noi City. The Public Relations of the project was also designed on the theory of "AIDMA" aiming at integrated activities through PR tools, mass media to improve the awareness of the public and stakeholders from do not know – know little – know – understand – change behavior. Holding events, broadcasting TV commercials, making a 3R song, developing and distributing PR tools (T-shirt, cap, calendar, poster, flyer, eco-bag etc), etc. were carried out to raise awareness of Hanoi citizens on 3R.

Da Nang City issued a Decision on building an environmental city by 2020 [1] and set an aggressive target of recycling 70% of solid waste in the 2016-2020 period. Then, in 2017, under the management of Da Nang City authorities, a WSS program for the local community was introduced in 4 wards of Hai Chau District: Thuan Phuoc, Thach Thang, Hoa Thuan Tay, and Hoa Cuong Bac. In 2018, the WSS program was expanded to two additional wards of Thanh Khe District: Thac Gian and Tam Thuan. In the latest decision, the Da Nang People's Committee approved an implementation plan for WSS for the whole city up to 2025 [2]. In the WSS program, the recycling activity is managed by the ward-level authorities, and implemented by the community-level leadership under each ward (one ward comprises of several communities), and there is no scheduled separate collection by official workers. As WSS expands, it is indispensable for Da Nang City to review the effect of the WSS program and clarify the weaknesses and strengths of existing systems in order to highlight the factors influencing success and failure.

In this study, the authors intended to assess how the WSS program in Da Nang City affects the waste separation behavior and influencing factors in target areas. In order to obtain scientific findings that can contribute to the successful expansion of the WSS program.

1.2 General

1.2.1 Overview of Da Nang city

Da Nang (Vietnamese: Đà Nẵng), the fourth largest city in Vietnam in terms of urbanization and economy, is the commercial and educational center of the region. In addition, being located within 100 km of several UNESCO World Heritage Sites (the Imperial City of Hue, the Old Town of Hoi An, and the My Son sanctuary city), it also becomes a famous tourist destination. Da Nang is the fifth most populated city in Vietnam, with an area of 1,285.4 km² and a population of 1,046,876 as of 2015 [3].

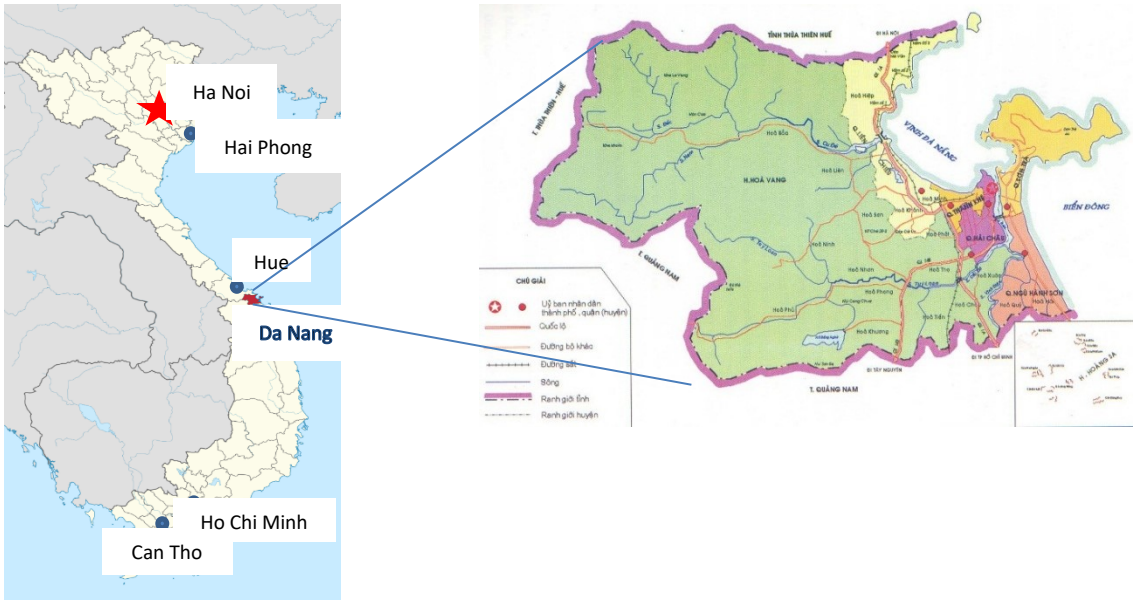

Figure 1-1 Location of Da Nang City

Regarding administrative divisions, Da Nang has 6 urban districts (Hai Chau, Thanh Khe, Cam Le, Lien Chieu, Son Tra, Ngu Hanh Son) and 2 rural districts (Hoa Vang and Hoang Sa). They are further subdivided into 45 wards (under 6 urban districts) and 11 communes (under Hoa Vang District). Da Nang has the highest urbanization ratio among provinces and municipalities in Vietnam with an average annual urban population growth at 3.5% as of 2015, and 87% of the population lived in urban areas [5].

The Urban Environment Company of Da Nang (Da Nang URENCO), the formal waste collection and treatment Company in Da Nang, reported that the collected amount of municipal solid waste (MSW) has been increased 16.7% in five years, from 223,521 tons (2010) to 260,923 tons (2014). In addition, 95% collected amount was from urban areas (248,995 tons). In rural area, the household solid waste (HSW) is dumped or open burned by residences [4].

1.2.2 Municipal solid waste management in Da Nang

1.2.2.1 Current situation of MSWM

(1) Waste generation and composition

Municipal solid waste is officially collected and transported to the landfill site by the Urban Environment Company (URENCO) of Da Nang. The average amount of collected waste reached 362,979 tons in 2018 (around 994 tons/day), an increase of 15% compared to the collected waste in 2017 [6].

In terms of waste generation and characterization, MSW in Da Nang city is generated from various sources including households, commercial sectors, offices, schools, institutions, hospitals, airports, parks, etc. The composition of MSW in 2010−2014 period was presented in report of URENCO (2019) as shown in Table 1-1. Organic waste accounted for the greatest part (around 70%), followed by Plastic (1.11−14.00%), and Nylon (0.00−12.13%).

Table 1-1 Composition of municipal solid waste in Da Nang (2010-2014) [6]

No.	Category	Percentage (%)
1	Biodegradable/ Organics	66.71−74.65
2	Paper	2.81−5.16
3	Cardboard	0.00−2.38
4	Textiles	1.55−3.50
5	Wood	0.00−2.79
6	Plastic	1.11−14.00
7	Nylon	0.00−12.13
8	Leather and rubber	0.32−2.12
9	Metal	0.19−1.01
10	Glass	0.14−1.89
11	Plate girder, ceramic	0.00−1.48
12	Soil, sand	0.00−6.75
13	Coal slag	0.00−0.60
14	Hazardous waste	0.00−0.27
15	Others	0.00−3.10

(2) Collection and transportation

In Da Nang City, the mixed waste system collection is implemented daily, and all the waste stream comes to landfill site. There are currently three main practices of waste collection (Fig. 1-2) [6, 9] as follow:

Practice 1: Dustbin collection and transport by truck

Several tens of households share a dustbin with a capacity of 240 L/280 L/660 L. Dustbins were put along the road lastingly or distributed by designed hour. Every day, the empty dustbins are placed from 14:30 to 15:00 by a small lift-equipped truck (mini-truck). Then, the residents are requested to bring their waste and put it into the dustbin by themselves. A forklift truck comes to transfer the waste by turning over the dustbin at the fixed time from 21:00 to 22:00, and directly carries it to the landfill site.

Practice 2: Door-to-door collection by tricycle/ motorbike/ electronic bike and transport by truck

A waste collection worker visits households from door to door to pick up the waste discharged at the side of the road by plastic bag, basket or foam box. The worker moves by tricycle/ motorbike/ electronic bike with a 660L dustbin, loads the waste into the dustbin, and carries it to a meeting point for transfer. In some areas, the worker rings a bell to inform the residents of waste collection and waits for a while, then the surrounding residents bring their waste for collection. At the meeting point, a forklift truck with loading and compaction equipment transfers the waste by turning over the dustbin, and transports it to the landfill site.

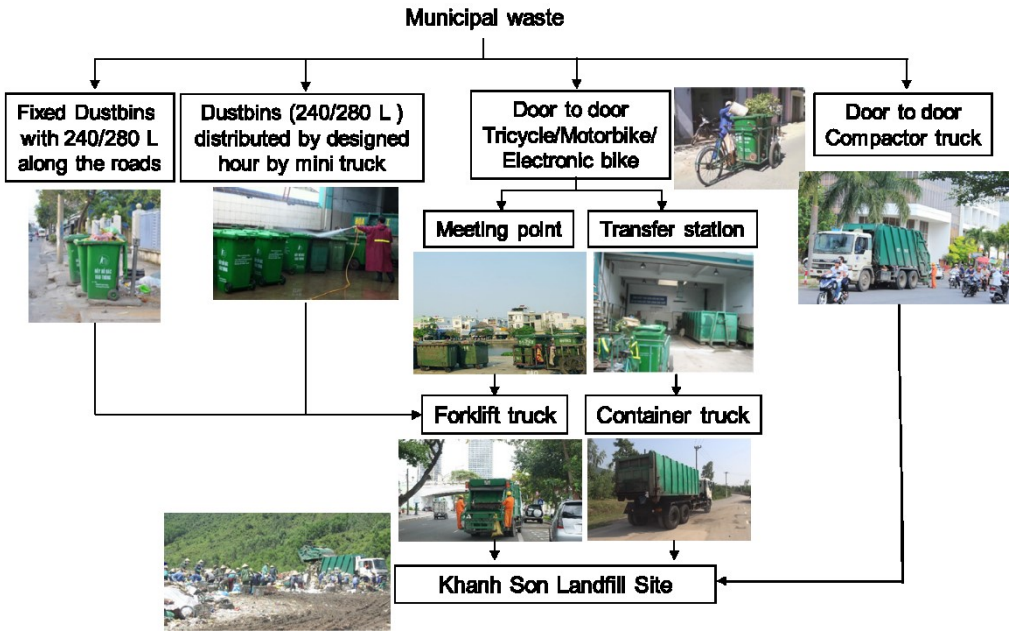

Figure 1-2 Municipal solid waste collection system

Practice 3: Door-to-door collection and transport by truck

A compactor truck with a loading and compaction equipment visits households from door to door to pick up the waste discharged at the side of the road by plastic bag, basket or foam box. The driver keeps driving at a walking pace, and the collection workers follow the

truck and load the waste directly into the truck. The truck plays music to inform the residents of waste collection, and some of the surrounding residents bring their waste for collection. After the waste collection, the truck directly carries the waste to the landfill site without transfer.

Regarding business sectors with large amounts of waste generated, they keep their own dustbins and do not have a daily dustbin distribution. There are some dustbins for public use put along the main streets.

(3) Treatment and disposal

All the waste stream is transported to landfill site (Khanh Son sanitary landfill).

- ✓ Regarding medical waste, there are 7 medical waste incinerators. Medical waste from all hospitals is collected, transported by separated system and treated by medical waste incinerator at the Khanh Son landfill.
- ✓ Regarding industrial waste, normal industrial waste is treated by sanitary landfill. Some hazardous industrial waste is incinerated with medical waste in the same incinerator.
- ✓ Regarding other waste (households, commercial sectors, offices, schools, institutions, etc.), it is collected and transported to Khanh Son landfill for burying.

1.2.2.2 The current status of recycling activity and WSS program

Recycling activity has been carried out by informal sectors such as junk buyers, waste pickers, and junk shops. Recyclables are primarily collected by junk buyers visiting households or by waste pickers collecting items from landfill sites/the street.

In 2016, Da Nang People's Committee cooperated with Yokohama City conducted "Solid waste management for promoting classification and recycling in Da Nang" project sponsored by JICA in the period 2017-2019. Then, in 2017, under the management of Da Nang City authorities, a waste separation at source (WSS) program for the local community was firstly introduced in 4 wards of Hai Chau District: Thuan Phuoc, Thach Thang, Hoa Thuan Tay, and Hoa Cuong Bac. In 2018, the WSS program was expanded to two additional wards of Thanh Khe District: Thac Gian and Tam Thuan.

In the latest decision, the Da Nang People's Committee approved an implementation plan for WSS for the whole city up to 2025 [2]. In the WSS program, the recycling activity is managed by the ward-level authorities, and implemented by the community-level leadership under each ward (one ward comprises of several communities).

At the ward-level, follow the decision for the whole city, the People's Committee of Wards contributed the specific implementation plans for each ward, set up the Steering Committee and the core propagator team to manage, propagated and guided the classification of garbage at the source to the residents.

The People's Committees of wards carried out various forms of propaganda such as:

- ✓ Hanging posters at the office, residential area and banners about classification of waste at the source.
- ✓ Decorating cars to propaganda about the content of waste separation at sources running on roads and in residential areas.
- ✓ Publishing contents about waste separation at source on the website of the ward.
- ✓ Organizing propaganda events.

In addition, People's Committees also cooperate with other official organizations in order to improve the popularity of the program. In 2017, People's Committee of Hai Chau District coordinated with Department of Education and Training organized successfully the festival for environment in 2017 which aims to educate all children about the role of environmental protection. At the same time, they will be equipped with basic knowledge and skills in the waste separation.

At the community-level, the community's leadership explained the WSS program to the residents through explanatory meetings and distributed a leaflet (Fig. 1−3 and 1−6). The target categories of recyclables were plastic, paper, and metal. In the explanatory meetings, the current status of solid waste management, the benefit of WSS, and the method how to separate recyclables were introduced. The leaflet was distributed to the meeting participants or delivered to all households in the target areas. It indicated the 3 steps for separation, including examples of recyclables with pictures, how to process recyclables like washing and bundling, and keeping in one bag as shown in Fig. 1−6. Besides that, guideline handbooks (Fig. 1−7) and recyclable bags (Fig. 1−8) were delivered to some residential areas. Recyclable waste containers (Fig. 1−9) were also provided for some residential areas of Thuan Phuoc and Thach Thang Ward of Hai Chau District (9-10 containers for each ward).

Under the program, the residents were encouraged to separate recyclables for donating to their community or for independent direct sale to informal sectors. For donations, the volunteers from women's union or youth union of the community collected recyclables from households and sold them to the junk shop for fundraising. Normally, recyclables were collected every week or every 2 weeks via door-to-door or drop-off collection (Fig. 1−4).

Drop-off points could be recyclable waste containers if applicable or the collectors' house - volunteers from women's union.

Figure 1-3 The explanatory meeting in Hai Chau District [10]

Figure 1-4 Recycling activities in Thach Thang Ward, Hai Chau District

Figure 1-5 Interview at household in Thach Thang Ward, Hai Chau District and Thuan Phuoc Ward, Hai Chau District

Figure 1-6 The leaflet for the WSS program [10]

Figure 1-7 Guideline handbook

Figure 1-8 Recyclable bag for households in Thuan Phuoc Ward, Hai Chau District

Figure 1-9 Recyclable waste container in the street in Thuan Phuoc Ward, Hai Chau District

1.2.2.3 Remaining issues

There are some remaining issues should be considered more as follows:

In general, solid waste has been increasing in the city due to the growing population. According to the report from JICA [7], the current landfill will be entirely filled by 2019 unless effective countermeasures are taken. In addition, industrial and hazardous waste are not strictly controlled, creating the potential for contamination.

Recyclable material is disposal of together with other waste on landfill. The mixed waste system collection is implemented daily, and all the waste streams come to landfill site while landfill capacity is limited. Also, a large quantity of recyclable waste was not recovery due to this combine collection system, and this might burden on the landfill capacity and demonstrate the inefficiency in material recovery [9].

Regarding environmental issues, a large amount of methane gas, leachate releases from open dumping site. Improper treatment practices cause a serious impact to local environment, especially the underground water.

Regarding social issues, unsanitary landfill causes an adverse impact on human health.

Regarding technical issues, there is lack of officially waste separated collection for WSS program. All recovery and recycling facilities are small, unorganized and are privately owned.

Regarding political issues, there is lack of scientific studies on evaluation the efficiency of source separation of waste.

1.3 Scope and objectives of the study

This study focused on the household solid waste in Da Nang City, Vietnam.

As the scientific basis for promoting citizens' recycling behavior and contributing to the successful expansion of the WSS program in Da Nang City, this study aims to achieve the following objectives:

1) To survey, describe the waste separation behavior (including the waste separation rate, and the disposal habits of leftover food and detail recyclable categories) and households' recognition and attitude of waste separation and environmental issues by questionnaire.
2) To develop the structure models for the separation behaviors of leftover food and detail recyclable categories to figure out the influencing factors of citizens' separation.
3) To assess the current status of implementing the waste separation at source (WSS) program by city authorities in some specific areas.
4) To clarify the effect of the current WSS program on waste separation behavior by comparing the separation rates among individuals before and after the program.
5) To clarify the effect of the current WSS program on the influencing factors of waste separation behavior, which were obtained from structure models, and to compare these influencing factors by time-series data to evaluate the changing over time.
6) To analyze the difference in waste separation behavior among the attribute categories including age, gender, household size, income level, working status, and urbanization level (represented by population density).
7) To figure out the weaknesses and strengths of existing WSS program, the higher-priority waste categories, influence factors, and attribute categories; to suggest the recycling promotion measures based on the abovementioned analytical results.
8) To predict the impact of suggested promotion measures on waste separation rate and waste separation amount of detail recyclable categories via sensitivity analysis of the predictive models.

1.4 Conceptual outline of the dissertation

In order to approach and obtain the proposed objectives, the contents of the individual Chapters are as follows:

Chapter 1 introduces the research background, overview of solid waste management in

Da Nang City, Vietnam, and the scope as well as objectives of the study. The outline of whole study was also presented in this chapter.

In Chapter 2, the literature review relating to this study was presented. The methods for behavior modelling, the influencing factors of the waste separation behavior were introduced by studies in Vietnam and other countries. In addition, the methods for measuring the effect of a waste separation program were also shown. Thereafter, the remained problems of past studies were pointed out aimed to clarify the novelty and originality of the proposed research. Finally, the research framework was proposed.

Chapter 3 described the household solid waste (HSW) separation behavior and its structure models in the whole city of Da Nang. The methodology including the research area, sampling method, outline of questionnaire survey, and data analysis for modeling was presented. The questionnaire survey was conducted in 2016. The separation behaviors of leftover food and 13 recyclable categories were shown. The factors influencing these waste separation behaviors was analyzed and discussed based on the developed models.

Chapter 4 was the main section of the dissertation. It described the structure models of the HSW separation behavior and the effects of WSS program on behavior and its influencing factors in 6 areas where WSS program was implemented by city authorities in Da Nang city. The survey was conducted in 2018. The methodology including the outline of questionnaire survey, the differences from past survey in 2016 and data analysis for modeling and measuring the effects of WSS program was presented. The results showed the separation behaviors of leftover food and 14 recyclable categories. The influencing factors of the behavior were explored by the modeling. The impact of WSS program on the changing of waste separation rate and the influencing factors was clarified. Besides, a comparison of the surveyed data by time series (in 2016 and 2018) was conducted. Thereafter, the weaknesses and strengths of existing WSS program were highlighted and the promotion measures were proposed aimed to improve the waste separation behavior.

In Chapter 5, the predictive effects of promotion measures, which were suggested in Chapter 4, on the waste separation rate and waste separation amount for 14 recyclable categories were presented. The predictive changes of waste separation rate by each promotion measures were estimated by the predictive models for 14 recyclable categories. The potential waste separation amount was also calculated for each recyclable category.

Finally, Chapter 6 summarized the main conclusions of the dissertation. The recommendations for future research were also described.

Chapter 1: Introduction
- Overview of solid waste management in Da Nang city
- Scope and objectives

Chapter 2: Literature review
- The methods for behavior modelling
- The influencing factors of the waste separation behavior
- The methods for measuring the effect of a waste separation program

→ *The remained problems of past studies were pointed out aimed to clarify the novelty and originality of the proposed research.*
→ *The research framework was proposed.*

Chapter 3: Current status and behavior modeling on household solid waste separation
- The survey was conducted in 2016 in the whole city of Da Nang
- The separation behaviors of leftover food and 13 recyclable categories by questionnaire survey
- The factors influencing these waste separation behaviors based on the developed models

→ *This survey was considered as a basis framework for later survey in 2018 (chapter 4).*

Chapter 4: Measuring the effect of a program of waste separation at source
- The survey was conducted in 2018 in 6 areas where WSS program was implemented by city authorities
- The separation behaviors of leftover food and 14 recyclable categories
- The influencing factors of the behavior by the modeling
- The impact of WSS program on the changing of waste separation rate and the influencing factors
- A comparison of the surveyed data by time series (in 2016 and 2018)

→ *The weaknesses and strengths of existing WSS program were highlighted and the promotion measures were proposed aimed to improve the waste separation behavior.*

Chapter 5: The prediction of the effect of promotion measures on waste separation behavior
- The predictive changes of waste separation rate by each promotion measures by the predictive models for 14 recyclable categories
- The potential waste separation amount for each recyclable category by each promotion measures

→ *The highest priority of promotion measures was pointed out to further promote waste separation behavior.*

Chapter 6: Conclusion
- Summary of the key points, remained problems of the current waste separation activities by interviews and observations, and the corresponding suggestions
- Recommendations for future research

Figure 1-10 Outline of dissertation

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CHAPTER 2: LITERATURE REVIEW

2.1 Literature review

Vietnam has faced a rapid increase in solid waste generation in recent years. Together with the growth of the economy and population, the total amount of solid waste increased by 10% every year during the 2006–2010 period, and by 12% per year during the 2011–2015 period [18]. The municipal solid waste (MSW) generated from urban areas was approximately 32,000 tons/d in 2014 [18], which results in a great challenge for municipalities to handle. Given the need to both manage the increasing amount of solid waste and preserve natural resources, waste separation at source (WSS) has become a hot issue in Vietnam in recent years. Regarding national-level regulation, WSS was first specified by Decree No. 59/2007/NĐ-CP on Solid Waste Management dated April 9, 2007, then by Article 95 of the Law on Environmental Protection issued in 2014 [24, 25]. In the newest Decree on Management of Wastes and Discarded Materials issued in 2015, household solid waste (HSW) was required to be separated into three groups; "group of disintegrable organic wastes," "group of reusable and recyclable wastes," and "remaining group" [26]. A national target for waste separation was also set by Decision 491/QĐ-TTg on approving adjustments to the national strategy for general management of solid waste to 2025 with vision towards 2050 [19]. Regarding HSW in urban areas, the specific targets up to 2025 were to improve rates of recycling, reuse, energy recovery, and organic fertilizer production, and consequently to reduce the rate of landfilling below 30%. It is indispensable for Vietnamese authorities of MSW to promote citizens' separation behavior effectively. This raised the question "What are the influence factors of separation behavior of citizens?" Barr (2007) and Oskamp (1995) have argued that the strategies or policies can only be implemented in an effective way to resolve the waste problems when the understanding of what factors influence individual behaviors is clarified clearly which in turn has to be grounded in scientific research.

2.1.1 Influencing factors of the behavior

Past studies on waste separation behavior in other countries

The environmental behavior is affected by various factors including the intention to perform or not perform the behavior, the perceptions of those individuals toward the behavior that they are undertaking, demographic factors, etc. The models of such behavior were reported in some past researches. In this context, researches related to waste separation behavior (recycling behavior) is reviewed.

The factors influencing waste separation behavior have been studied in some previous research. The structure model from Matsui et al. (2001 and 2007) provided a suitable framework for investigating the factors influencing waste separation behavior (Fig. 2−1). The model suggested three steps: waste separation behavior, behavioral intention, and goal intention. In the model of waste separation behavior, "behavioral intention", referring to the intention to perform a specific behavior, and "perception of information", referring to the understanding of how to separate waste and what to separate, were both positive predictors. In the model of behavioral intention, "evaluation of trouble" (i.e., the difficulty of waste separation or recycling, such as the space it takes up, the time and money required, etc.), "perception of neighbors' participation" (i.e., the recognition of neighbors' participation in waste separation), and "goal intention" (i.e., the intention to contribute to solve waste problems) were predictors of "behavioral intention". In the model of goal intention, "goal intention" was affected by 4 factors, "perception of seriousness & responsibility" – the individual's evaluation of their own responsibility for recycling and the need for recycling, "perception of coping efficacy" – perceiving that recycling is effective for reducing waste, "evaluation of social norm" – perceiving social pressure to perform or not perform the behavior, and "perception of neighbor's participation".

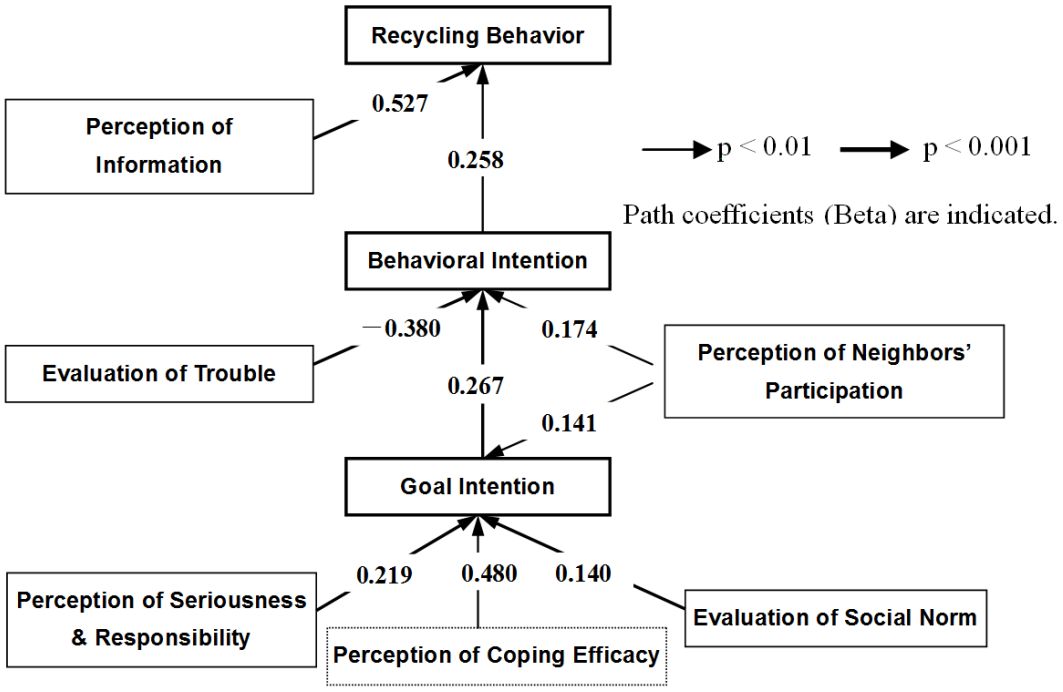

Figure 2-1 Structure model of recycling behavior on station collection of Cans & Bottles

This model can provide the basic framework and key concepts for understanding the current status of the separation behavior and determinants, and the framework is also applicable to clarify the effects of promotion measures on the changes of states of mind.

These above influencing factors of the behavior were also determined in other past studies. The following brief reviews on each factor are presented to examine the proposed determinants of separation behavior.

Behavioral intention and perception of information

As a model of environmental behavior, Ajzen (1991) presented the theory of planned behavior which aims to predict behavior directly from intentions (i.e. the intention to perform a specific behavior). The stronger the behavioral intention, the more likely the behavior should be performed. Several studies have demonstrated the theory's value in predicting behaviors. For example, Chu and Chiu (2003) developed an integrated household waste management model which indicated that recycling behavior was significantly influenced by behavioral intention. Another example is the model of environment-friendly behavior contributed by Hirose (1995), in which the decision-making process leading to the behavior was illustrated by two stages; behavioral intention and goal intention (i.e. the intention or desire to contribute to solving environmental problems by taking specific actions). A positive effect of behavioral intention has also been reported in other later studies (Boldero, 1995; Stoeva & Alriksson, 2017; Ulhasanah & Goto, 2018; Tran et al., 2019).

In the previous report (Matsui et al., 2007), the authors described a structural model for recycling behavior by referring to Hirose (1995). In this model, recycling behavior was affected by two factors; behavioral intention and perception of information – perceiving the information on the collection date and place, knowledge of recycling. This suggested that even though the intention was high, the behavior can not be performed unless sufficient information was provided. Other studies by Schahn & Holzer (1990), and Vining & Ebreo (1990) stated that a person's knowledge of how to recycle and the types of materials eligible for recycling is an important factor influencing recycling participation. The knowledge for action is a significant prerequisite for behaving in an appropriate manner and would be a significant barrier to action if levels were low. Thus, it could be argued that the intentions, perception of information can be seen as direct factors of behaviors.

Evaluation of trouble (perceived difficulties)/Perceived behavioral control (self-efficacy)

Perceived behavioral control (self-efficacy) or evaluation of trouble (perceived difficulties) should be also considered as a significant predictor of the behavior. This reflects the individual's perceived difficulty or ease in performing a particular behavior. As mention in the theory of planned behavior (Ajzen, 1991), behavioral achievement depends directly not only on motivation (intention) but also on ability (behavioral control). The performance of most depends at least on some degree of ability or non-motivational factors such as

opportunities and resources (e.g., time, money, skills, and cooperation of others). Self-efficacy such as time to act, the convenience of behavior, the space to store items was a significant predictor of behavior that has also been found by Gamba and Oskamp (1994), and Barr (2007). Derksen and Gartrell (l993) suggested that when provided with access to a convenient curbside recycling program, even those with relatively low levels of environmental concern would participate. In another example, for explaining recycling behavior, Lindsay and Strathman (1997) identified barriers (perceived difficulties related to recycling) as the variable with the strongest effect on recycling.

By a different approach, perceived behavioral control was examined as an indirect factor of waste management behavior via behavioral intention. In detail, perceived behavioral control was determined as one of the predictors of the intention to perform a particular behavior. This finding was described in some studies by Ajzen (1991), Chu and Chiu (2003), Matsui et al. (2007). Ajzen (1991) and Chu & Chiu (2003) proved that the greater the perceived behavioral control, an individual's intention to perform the behavior is more likely to improve. On the other way, perceived behavioral control was defined as evaluation of trouble – judging whether waste collection services satisfy an individual's convenience, by Matsui et al. (2007), and was determined as evaluation of feasibility by Hirose (1995), situation factor by Boldero (1995) and Tonglet et al. (2004). For example, people might feel difficult to recycle because of lack of time, lack of space for keeping recycled waste at home, or lack of information on how to recycle, collection time or collection place. By this definition, if people get a higher level of evaluation of trouble which means they feel more difficult to separate waste, then they have less intention to participate the recycling (Matsui et al., 2007). The role of difficulty, barriers, or personal convenience in recycling behavior was the most reliable finding.

Perception of neighbor's participation

The term perception of neighbor's participation reflects the perceived information of the participation in a specific behavior of others. Some studies argued the importance of others' recycling behavior. Oskamp et al. (1991) noted that one important predictor of recycling behavior was having friends and neighbors who recycled, suggesting that peer influence is an important consideration in people's decision to recycle. They noted that the degree to which people acknowledged friends' and neighbors' recycling behavior was one significant predictor of recycling behavior. For example, a person might believe that his or her family thinks he or she should recycle household waste. If that person is strongly motivated to comply with the expectations of his or her family, a positive impact on subjective norm might occur. Social influences on the performance of recycling and other environmental behaviors from various

referents (e.g., family, friends, neighbors), have been studied broadly (Oskamp et al., 1991; Taylor & Todd, 1995). Vining and Ebreo (1990) also demonstrated that peer influence or the awareness of recycling behavior of other people is important in people's decision to recycle. In the recycling behavior model by Matsui et al. (2007), perception of neighbor's participation was one of the significant factors affecting behavioral intention and goal intention - the intention to contribute to solving waste problems. The intention is strengthened by a high perception of neighbor's participation.

Moral norms (internal norm)

The moral norm relates to the individual's personal beliefs about the moral correctness or incorrectness of performing a specific behavior. The inclusion of a moral factor has significantly improved the prediction of intention in studies of behaviors. Indeed, Tonglet et al. (2004) showed the significant correlations between moral norm and the intention of recycling behavior. As the recycling of household waste is a behavior likely to contain elements of personal morality and social responsibility, it was considered appropriate to include this variable within the model.

Evaluation of social norm/ Social pressure / Subjective norm

Subjective norm refers to the perceived social pressure to perform or not to perform the behavior. As Fishbein and Ajzen (1975) have argued, the behavior is likely to be modified when individuals are aware of a given social norm and, more crucially, accept this norm. Chan's (1998) study of recycling in Hong Kong also highlighted the importance of subjective norms in encouraging others to participate. Clearly, subjective norms play an important role in shaping recycling behavior.

Perception of seriousness and responsibility

Perception of seriousness and responsibility refers to the degree of general knowledge about environmental risks and the individual's evaluation of the responsibility for waste problems. Environmental and behavioral knowledge has been found to play a significant part in shaping waste management behavior. The former relates to what Schahn and Holzer (1990) have termed abstract knowledge for action, being a representation of general knowledge about the state of the environment and an awareness of environmental problems, such as waste issues. The latter refers to what Schahn and Holzer have termed concrete knowledge, which is essential knowledge for action, for example knowing what and where to recycle waste, that mentioned in the paragraph of perception of information. Vining and Ebreo (1990) have found the relationships between environmental knowledge and behaviors. Oskamp et al. (1991) also claimed that one of the significant predictors of curbside recycling

was respondent's acknowledge of environmental problems, and of intrinsic motives to recycle (e.g., satisfaction from saving natural resources and helping to solve a national problem). Thus, environmental knowledge or perception of seriousness and responsibility plays an important role in shaping behavior.

Demographic factors

Demographic factors refer to the personality characteristics of individuals such as age, gender, housing type, income level, educational level, etc. The relationship between demographic factors and environmental behaviors was pointed out in the previous study of Barr (2007). Demographics only have a small effect on reduction behavior, and recycling behavior. Respondents in older age groups appear to reduce and recycle more. With a small indirect effect via intention, gender has a moderately strong effect on reducing and reuse behavior. It appears that females are more likely intended to reduce and reuse than males, thus leading to the conclusion that this may reflect more regarding the consumption and shopping habits between householders than necessarily a fundamental division in values between females and males. Another study from Tabernero et al. (2015) pointed out that age and educational levels are related to recycling behavior: older people and individuals with a higher educational level recycle most. However, as Tabernero et al. (2015) and Guerin et al. (2001), demographic variables had a modest relationship with recycling behavior and explained only a small percentage of the variance. Indeed, Khan et al. (2019) noted that the impacts on the behavior of all control variables including age, gender, income, and educational level were found insignificant. Therefore, there may have some relationship between social characteristics and environmental behavior.

Past studies on waste separation behavior and its influencing factors in Vietnam

In Vietnam, solid waste management and separation behavior were also discussed in some studies. Some municipalities introduced the trial separate collection for recyclables and food residues, and some surveys reported the citizens' separation rate in Hanoi and Da Nang city. In Hanoi, the waste separation rate was 83.9% for recyclables and 43.3% for food residues (Nguyen et al., 2015). In Da Nang, the waste separation rate was 77.7% for food residues (Kato et al., 2015). The other study in Da Nang showed that about 60% of households could separate waste into organic and inorganic waste (Otoma et al., 2013).

In relation to factors influencing the separation rates of recyclables and leftover food, some studies in Hanoi and Hoi An city suggested that the attitude toward recycling and moral norm (i.e., feeling of guilt not to perform waste separation) were positive factors affecting the recycling behavior, while situational factors or attitude toward the inconvenience of recycling

were negative factors (Loan et al., 2017; Nguyen et al., 2017). The public awareness and attitude toward SWM and the 3R program were also investigated in the Mekong Delta region by Thanh et al. (2012) and in Da Nang city by Dao et al. (2013).

2.1.2 Measuring the effect of a waste separation program

Solid waste management in low and middle-income countries has a lot of potential for improvement. Understanding how a specific decision choice towards improvement will match to enabling local conditions and thereafter impact on the local context, is crucial when identifying the most sustainable solutions. Zurbrugg et al. (2014) indicated that a well-defined assessment method can help evaluate the performance/impact of a project to better understand how and why the performance/impact is as it is. Of which, social impact assessment is one of the methods which measure the impact of a project. Social assessment may include changing behavior, interest, motivation and willingness to participate and contribute to the process and the objectives of the project. On the other hand, every solid waste management project will have an effect and impact on the socio-cultural environment. Social impact criteria may include equity (distribution of impact on different social groups), participation/collaboration, motivation, etc.

Within the purpose of this study, waste separation at source (WSS) program was a target for social impact assessment. As WSS expands, it is indispensable for waste management authorities to review the effect of the WSS program and clarify the weaknesses and strengths of existing systems in order to highlight the factors influencing success and failure.

The effect of a recycling program has been evaluated in some past studies. Previous work in Sweden and China evaluated the effect of a food waste separation campaign by measuring the waste quantity and a questionnaire survey before and after the campaign (Bernstad, 2014; Dai et al., 2015). In Sweden, two types of interventions aiming at increasing food waste source-segregation rates used in the area were: (a) distribution of written information amongst household and (b) installation of equipment aiming at increasing convenience for source-segregation of household food waste inside the household. The results showed that the weekly amounts of separated food waste increased by 12% and the convenience and existence of infrastructure necessary for source-segregation of waste were important factors for household waste recycling (Bernstad, 2014). In China, an intervention used in the research area was distributing posters about the environmental consequences of food waste sorting. The questionnaire was conducted for half of the target households before the intervention and half of them afterward. Dai et al. (2015) noted that a 12.5% increase in the food waste capture rate was found, but there was no significant difference between answers in the questionnaire before and after the intervention. In Vietnam, waste quantity

measurement was also applied for assessing a pilot source separation effort for bio-waste in Hanoi City. Under the project, the waste amount for composting increased from 7% to more than 30% in the 2006−2009 period (Taniguchi & Yoshida, 2011).

As a different approach, Stoeva and Alriksson (2017) developed structural models for waste separation behavior to identify the influencing factors in two countries: Sweden, which had a higher participation rate, and Bulgaria, which had a lower rate. They compared the waste separation behavior and its influencing factors between the two countries and noted that a lack of proper conditions for waste separation can prevent individuals from participating in this process regardless of their positive attitude.

2.2 Remained problems and proposed research

Based on the past literature on modeling of waste separation behavior, the differences in separation rates among detail recyclable items and leftover food have not considered yet. Moreover, there were no past studies using behavior modeling to examine the differences in influence factors of separation behavior among detail recyclable items and leftover food.

By the reviewed studies on measuring the effect of a waste separation program, the interrelationships among waste separation behavior, its influencing factors and the recycling programs were not analyzed statistically. The behaviors need to be surveyed on a case-by-case basis before and after a program to find out who changed and who did not. In other words, the positive change in behavior and the reasons for the change have not considered in detail. Moreover, there have been no studies of this kind of interrelationship in Vietnam.

Therefore, the model for this study was modified to get the better and in-depth view of the waste separation behavior as following points:

1) The waste separation behavior is surveyed for leftover food and detail recyclable items. In addition, the waste disposal habit is determined aimed to understanding how people handle their leftover food and recyclables, such as discharging, sorting for giving to others, sorting for selling, etc.

2) The proposed model in this study incorporates the variables from the theory of planned behavior (Ajzen 1991) and the model by Matsui et al. (2001 and 2007) as shown in Fig. 2−2. The model contains two stages; waste separation behavior and behavioral intention. Several researchers have examined the direct relationships between waste separation behavior and behavioral intention, and perception of information. The present study is also examining the relationships in accordance with the aforementioned studies. The proposed model for behavioral intention contains four independent variables that are evaluation of trouble, perception of

neighbor's participation, internal norm, social pressure, perception of seriousness and responsibility, and the incentive brought by recycling benefits. The incentive brought by recycling benefits, which refers the incentive provided by the economic benefit from selling recyclable items, is considered as the new factor. Moreover, the demographic factors are considered as external factors of waste separation behavior and its influencing factors.

3) Waste separation behavior is surveyed before and after the program for detail recyclable items. The waste separation rates before and after the WSS program are compared to measure the effect of the WSS program on the waste separation behavior.

4) The level of involvement in the WSS program is also clarified by the attendance of respondent in explanatory meeting and the recognition of the leaflet. The differences in waste separation rates and the factors influencing behavior among the respondents' levels of involvement in the WSS program are also examined.

5) Based on the obtained results, some promotion measures are proposed for the expansion of the WSS program. The expected changes in waste separation rate and waste amount by these promotion measures are also calculated.

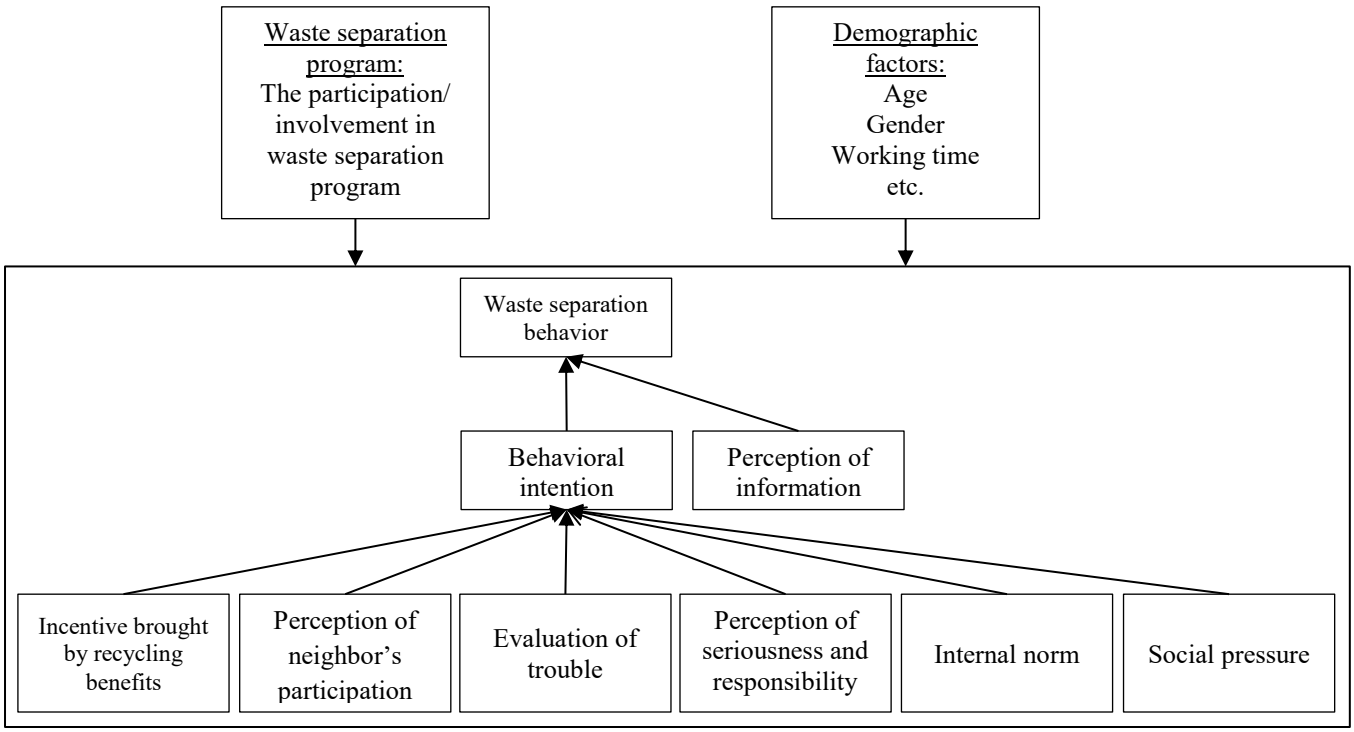

Figure 2-2 The proposed model for waste separation behavior

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CHAPTER 3: CURRENT STATUS AND BEHAVIOR MODELING ON HOUSEHOLD SOLID WASTE SEPARATION

3.1 Methodology

3.1.1 Research areas and sampling method

Da Nang is subdivided into six urban districts, including Lien Chieu, Thanh Khe, Hai Chau, Son Tra, Cam Le, Ngu Hanh Son, and two rural districts, including Hoa Vang and Hoang Sa (Paracel Island). The first survey focused mainly on 6 urban districts that comprised 45 wards which were covered by the waste collection system of Urban Environmental Company (URENCO). The population density for each ward is shown in Table 3−1.

The sample selection in this study was based on the urbanization level. The population density was assumed to be the representative indicator of the urbanization level that was defined into 5 levels by the percentile rank of population density, as 10th, 30th, 50th, 70th, and 90th percentiles. A total of 150 households were chosen in this study, 3 wards were selected for each level of urbanization, and 10 households were selected from each ward. In addition, target households were selected in considering the household size. The description of sampling wards is presented in Table 3−2. Detail locations of target wards are shown in Fig. 3−1.

Table 3-1 Characteristic of 45 wards in Da Nang city

No.	District	Ward's name	Population density (person/km^2)	No.	District	Ward's name	Population density (person/km^2)
1	Lien Chieu	Hoa Hiep Bac	19224.29	24	Hai Chau	Hoa Cuong Nam	32500.00
2	Lien Chieu	Hoa Hiep Nam	15521.98	25	Hai Chau	Hoa Thuan Dong	53876.24
3	Lien Chieu	Hoa Khanh Bac	49151.22	26	Hai Chau	Hoa Thuan Tay	20671.20
4	Lien Chieu	Hoa Khanh Nam	25474.33	27	Hai Chau	Nam Duong	59108.84
5	Lien Chieu	Hoa Minh	13982.62	28	Hai Chau	Phuoc Ninh	52527.81
6	Thanh Khe	An Khe	25145.11	29	Son Tra	An Hai Bac	30698.21
7	Thanh Khe	Chinh Gian	47753.15	30	Son Tra	An Hai Dong	40775.34
8	Thanh Khe	Hoa Khe	37641.21	31	Son Tra	An Hai Tay	29375.74
9	Thanh Khe	Tam Thuan	66483.52	32	Son Tra	Man Thai	29212.80
10	Thanh Khe	Tan Chinh	69921.19	33	Son Tra	Nai Hien Dong	14723.06
11	Thanh Khe	Thac Gian	59179.86	34	Son Tra	Phuoc My	28432.83
12	Thanh Khe	Thanh Khe Dong	40729.34	35	Son Tra	Tho Quang	23215.87
13	Thanh Khe	Thanh Khe Tay	38174.36	36	Cam Le	Hoa An	16212.70
14	Thanh Khe	Vinh Trung	60411.73	37	Cam Le	Hoa Phat	17090.89

15	Thanh Khe	Xuan Ha	45051.67
16	Hai Chau	Hai Chau 1	55350.60
17	Hai Chau	Hai Chau 2	80023.31
18	Hai Chau	Thach Thang	51205.65
19	Hai Chau	Thanh Binh	53629.88
20	Hai Chau	Thuan Phuoc	46700.33
21	Hai Chau	Binh Hien	61372.55
22	Hai Chau	Binh Thuan	44266.24
23	Hai Chau	Hoa Cuong Bac	22742.76

38	Cam Le	Hoa Tho Dong	16761.07
39	Cam Le	Hoa Tho Tay	8552.45
40	Cam Le	Hoa Xuan	5254.61
41	Cam Le	Khue Trung	23439.02
42	Ngu Hanh Son	Hoa Hai	16566.56
43	Ngu Hanh Son	Hoa Quy	5057.52
44	Ngu Hanh Son	Khue My	13057.53
45	Ngu Hanh Son	My An	22425.30

Table 3-2 Target wards by urbanization level

Urbanization Level	Code	District	Ward's name	Population density (person/km^2)	Accumulated percentile rank	Percentile rank categogy (%)
I	Ia	Ngu Hanh Son	Khue My	13057.53	7.3%	10th
	Ib	Lien Chieu	Hoa Minh	13982.62	9.0%	
	Ic	Lien Chieu	Hoa Hiep Nam	15521.98	13.7%	
II	IIa	Hai Chau	Hoa Thuan Tay	20671.20	27.8%	30th
	IIb	Hai Chau	Hoa Cuong Bac	22742.76	30.1%	
	IIc	Cam Le	Khue Trung	23439.02	33.3%	
III	IIIa	Son Tra	An Hai Tay	29375.74	44.7%	50th
	IIIb	Son Tra	An Hai Bac	30698.21	48.1%	
	IIIc	Hai Chau	Hoa Cuong Nam	32500.00	53.1%	
IV	IVa	Hai Chau	Thuan Phuoc	46700.33	68.7%	70th
	IVb	Thanh Khe	Chinh Gian	47753.15	70.6%	
	IVc	Lien Chieu	Hoa Khanh Bac	49151.22	73.3%	
V	Va	Thanh Khe	Thac Gian	59179.86	89.6%	90th
	Vb	Thanh Khe	Vinh Trung	60411.73	91.9%	
	Vc	Hai Chau	Binh Hien	61372.55	93.6%	

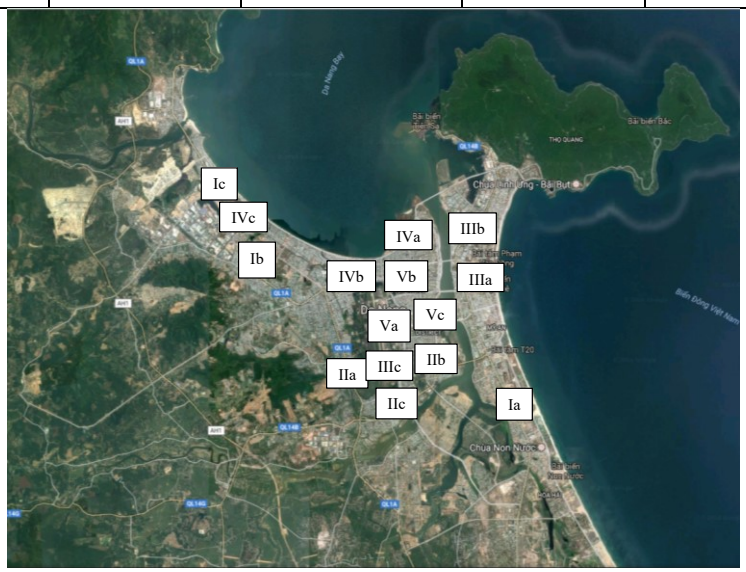


Figure 3-1 Locations of target wards

3.1.2 Outline of the questionnaire survey

A questionnaire survey was conducted by face-to-face interviews for the target households from November 21 to December 5, 2016. The questionnaire was requested to be answered by the persons in charge of waste storage and discharge in the target households. The response rate was 92%. The question items were prepared by referring the past studies, including Matsui et al. and Thanh et al. that were basically based on Fig. 2−1 and 2−2 [15-17, 26]. In Da Nang city, the citizens have been separating not only recyclable waste but also leftover food [11]. Therefore, the authors added some new questions related to leftover food separation through hearing from residents and the community's leaders. The question items included attributes, waste separation behavior, and attitudes (e.g., behavioral intention, sympathy for the collector) as shown in Table 3-3.

Regarding the waste separation behavior, the authors surveyed the separation behavior of leftover food and the following 13 recyclable items:

1) Plastic material: plastic bottles, plastic bags, and plastic products;
2) Paper material: carton paper, cardboard, newspaper, magazines and book/photocopy paper, and notebooks;
3) Metal material: metal cans, metal products, batteries, and e-waste.

The separation behavior was answered by Yes/No questions.

The question items on the intention to separate waste, sympathy for the collector, evaluation of waste separation system, internal norm, recognition, and attitudes about the waste problem in general were answered using the 7-point Likert scale from "1. Strongly disagree" to "7. Strongly agree."

Table 3-3 Outline of questionnaire

Item	Subitem	Description
Attributes		Gender, age, household size, occupation, income
Participation in waste separation	Waste separation behavior	Leftover food separation Recyclable separation
Intention to separate waste	Behavioral intention	Intention to continue to separate leftover food/recyclables.
Incentive brought by recycling benefit		Incentive brought by the money earned from recycling.
Sympathy for the collector		Fellow feeling or the understanding for the work of the collectors.
Evaluation of waste separation system	Evaluation of trouble	Evaluation of trouble/convenience for recycling
Internal norm		Normative conscience on recycling and responsibility for recycling.
Recognition and attitudes about the waste problem in general	Perception of seriousness and responsibility	Perception of environmental risks and responsibility for waste problems.
	Goal intention	General attitude toward the waste problem.

3.1.3 Data analysis for waste separation behavior modeling

To understand the whole picture of relationships between separation behavior and influence factors, the authors intended to develop models of separation behavior. The questionnaire contained many question items: 14 categories for waste separation behavior including leftover food and 13 recyclable items; 18 questions for recycling and pro-environmental attitudes. To simplify the behavior modeling, the authors grouped the separation behavior of 13 recyclable items by cluster analysis, and also made some scales on recycling and pro-environmental attitudes by factor analysis. Then, the behavior models were developed in a hierarchical way based on the grouped separation behavior and the attitude scales. The detailed analytical procedures are described as follows:

3.1.3.1 Classification of recyclable separation behavior by cluster analysis

The hierarchical cluster analysis was applied to classify the separation behavior of 13 recyclable items into groups based on the similarity of separation pattern. The separation behavior of each recyclable item was defined as a dummy variable. The complete linkage method with simple matching distance as the similarity measures were applied to detect the number of groups/clusters [23]. The level of separation behavior of each resultant group was graded by the summation of dummy variables in the group.

3.1.3.2 Construction of attitude scales by factor analysis

The questionnaire consisted of 12 statements of evaluation of the waste separation system, internal norm, and recognition and attitudes about the waste problem in general. The authors intended to construct scales by factor analysis of these statements. Factor analysis has been widely applied to explore the latent factors from a list of variables and to solve the multicollinearity problem in multiple regressions by combining variables that are collinear [5]. In this study, the principal component method was used to extract the factors, and oblique rotation was applied [5]. According to Stevens's recommendation, the authors used 0.4 as the lower limit value to interpret the factors [24]. In addition, the KMO (Kaiser–Meyer–Olkin) measure and Bartlett's test were also examined to verify the sampling adequacy and the suitability of using factor analysis.

After factors were extracted, a reliability analysis was conducted to check the reliability of each factor. Cronbach's alpha indicates the reliability of these factors.

3.1.3.3 Development of behavior models

The authors developed the models for the separation behavior of leftover food and recyclables. The analytical framework was basically referred from Matsui et al. [16]. The

abovementioned scales were used as the candidate predictor variables of the model. Some specific question items added in this study were also analyzed as the candidate predictor variables in the models.

Regarding the leftover food separation behavior measured by a binary variable, logistic regression analysis was applied. For the other quantitative outcome variables, linear regression analysis was applied.

3.1.4 Data analysis for the differences in separation rates by attributes

The authors also analyzed the differences in separation rates by attributes such as gender, age, income level, household size, working status, and urbanization level. The chi-square test was applied for leftover food and recyclable separation behavior.

The IBM SPSS Statistics 20 Software was applied for all the statistical analyses.

3.2 Results and discussion

3.2.1 Waste separation rate

The attributes of respondents are summarized in Table 3-4. In the survey, 76.7% of respondents were female who took charge of HSW in the target households. The average number of people per household of respondents was 4.6.

In Da Nang city, there is no official separate collection system. To understand the original habits of the citizens on recycling activity, questions for the separation behavior and waste disposal habits were asked. The results are summarized in Fig. 3-2, Tables 3-5, and Table 3-6.

Regarding leftover food separation, the separation rate was 77.3%. As shown in Table 3-5, 64.1% of the respondents separated leftover food to give to the pig farmer, 7.0% of them fed their own livestock or pet, and 6.3% kept leftover food for other purposes, such as burying or leaving in the garden. The remaining 22.7% discarded leftover food to the official collection system without separation.

Regarding recyclable separation, plastic bottles and metal cans were two popular items with high separation rates (72.5% and 63.8%, respectively), followed by cardboard (50%), newspaper (43.8%), book/photocopy paper (38.4%), notebooks (37.7%), plastic products (33.3%), magazines (25.4%), metal products (23.9%), e-waste (18.8%), plastic bags (15.2%), carton paper (15.2%), and batteries (13.0%). Regarding the recyclable disposal habit as shown in Table 3-6, 53.6% of the respondents mentioned that they sorted recyclables for giving for free to the people who hope to collect recyclables, such as waste collectors, junk buyers, neighbors, or poor persons. These respondents engaged in recycling without an

economic incentive. 29.7% of them separated recyclables for selling to the informal sector (e.g., junk buyer, junk shop), and 0.7% kept for their own reuse. The remaining 15.9% did not separate any recyclable items.

Table 3-4 Attributes of respondents

	Attributes	Frequency	Percentage (%)
Gender	Male	23	15.3
	Female	115	76.7
	Total	138	100
Age (years)	<30	10	7.3
	30–39	30	21.7
	40–49	26	18.8
	50–59	28	20.3
	≥60	44	31.9
	Total	138	100
Household size (person)	1–2	17	12.3
	3–5	85	61.6
	≥6	36	26.1
	Total	138	100
Income level (1000 VND per capita per month)	<1500	26	25.0
	1500–<2500	31	29.8
	2500–<3500	21	20.2
	3500–<4500	12	11.5
	≥4500	14	13.5
	Total	104	100
Working status	Jobless/Retired	73	48.7
	Working	64	42.7
	Total	137	100

(1 USD = 23,243 VND as of December 17, 2018)

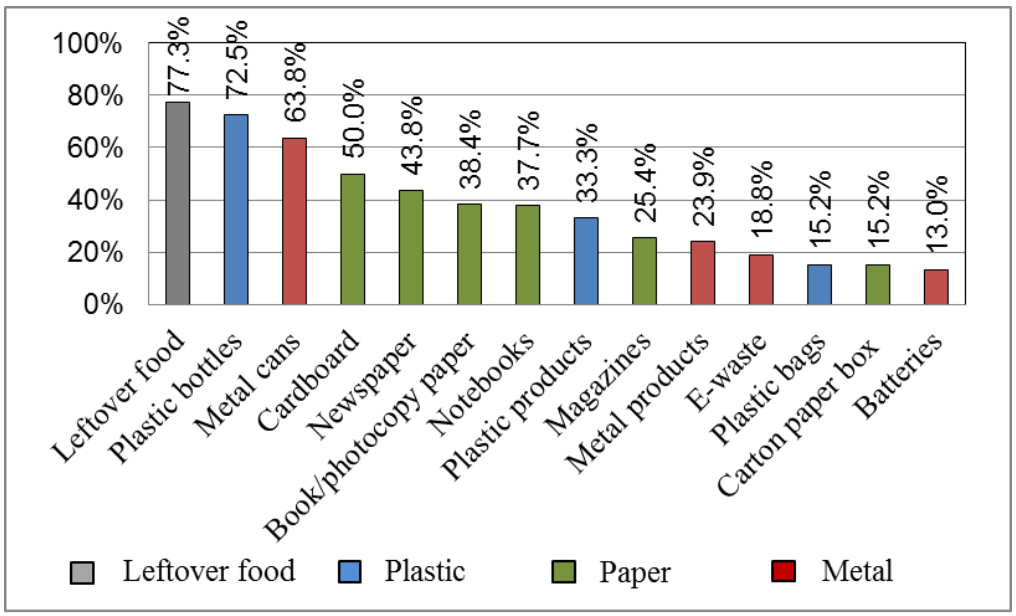


Figure 3-2 Separation rate on leftover food and recyclables

Table 3-5 Current status of Leftover food disposal habit

Leftover food disposal habit	Frequency	Percentage
Give to pig farmer	82	64.1%
Feed to our own livestock/pets	9	7.0%
Others (Bury/leave in garden/field, etc.)	8	6.3%
Discharge	29	22.7%
Total	128	100.0%

Table 3-6 Current status of Recyclables disposal habit

Recyclables disposal habit	Frequency	Percentage
Give to persons who hope to collect recyclables	74	53.6%
Sell to junk buyers	41	29.7%
Keep for own reuse	1	0.7%
Discharge	22	15.9%
Total	138	100.0%

3.2.2 Waste separation behavior modeling

The authors intended to develop models for the separation behavior of leftover food and recyclables.

3.2.2.1 Classification of recyclable separation behavior by cluster analysis

The separation rates of recyclables differed widely among the surveyed 13 recyclables, from the lowest 13.0% for Batteries to the highest 72.5% for Plastic bottles. To simplify the behavior modeling, the authors first intended to group 13 recyclables with similar separation rates by a cluster analysis of separation behavior by recyclables. The results are illustrated by a dendrogram in Fig. 3-3. The dendrogram presented all 13 separation behavior variables in the vertical axis and indicated the distance between clusters in the horizontal axis. Three clusters were detected based on the result of cluster analysis and the similarity of separation rates. In this way, cluster 1 included seven recyclable items; batteries, e-waste, metal products, magazines, plastic products, plastic bags, and carton paper which represented the "Low participation group." Cluster 2 included two recyclable items; plastic bottles and metal cans which expressed the "Higher participation group." Cluster 3 included four recyclable items; book/photocopy paper, notebooks, newspaper, and cardboard which described the "Moderate participation group." The score of each group was calculated by counting the number of recyclable items that respondents separated. As the outcome variables of the models, the separation behavior including leftover food separation, low participation group, moderate participation group, and higher participation group of recyclable separation are indicated in Table 3-7.

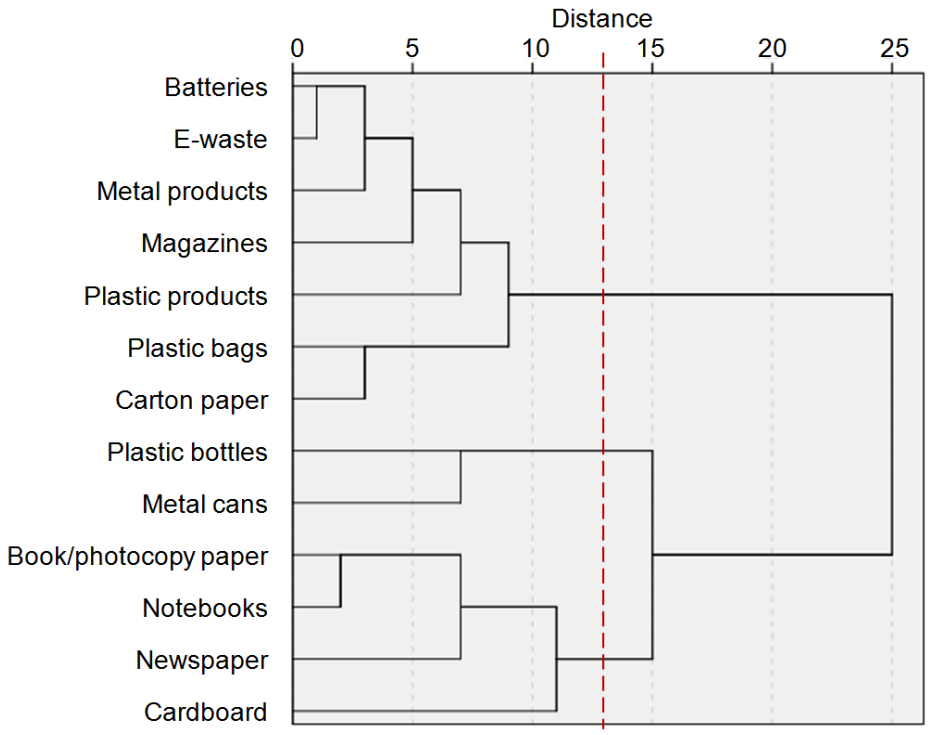


Figure 3-3 Dendrogram of recyclable separation clusters

Table 3-7 Separation behavior variables

Separation behavior	Range of variables
Leftover food separation	No separation = 0/Separation = 1
Low participation group of recyclable separation	No separation = 0 ~ Separation of all 7 items in low participation group = 7
Moderate participation group of recyclable separation	No separation = 0 ~ Separation of all 4 items in moderate participation group = 4
Higher participation group of recyclable separation	No separation = 0 ~ Separation of all 2 items in higher participation group = 2

3.2.2.2 Construction of attitude scales by factor analysis

By the factor analysis on the 12 items, evaluation of the waste separation system, internal norm, recognition, and attitudes about the waste problem in general, two factors were extracted. Table 3-8 shows a summary of factor loadings by pattern matrix after rotation. The KMO value was 0.85 and Bartlett's test was highly significant ($p < 0.001$), which indicated that the data are consistent with the conditions of using factor analysis. According to the original meaning of statements as referred from a previous study [16], the authors additionally separated the first factor into three scales, thus applied four scales including the second factor for further modeling as presented in Table 3-8: "Perception of seriousness and responsibility," "Internal norm," "Goal intention," and "Evaluation of trouble." Table 3-8

also shows the reliability coefficients by Cronbach's alpha for each scale, which were equal to or higher than 0.74. These scales indicated adequate reliability [5].

Table 3-8 Summary of exploratory factor analysis

Scales	Statements	Factor loadings		Cronbach 's alpha
		1	2	
Perception of seriousness and responsibility	The company that manufactures or sells things is responsible for the waste problem.	**.89**	–.00	0.88
	The consumers who buy things are responsible for the waste problem.	**.88**	–.05	
	The waste problem is a serious problem.	**.88**	.22	
	The landfill site will be full of waste and there will be no place to dispose of waste in the near future.	**.78**	.19	
Internal norm	Citizens should individually share the responsibility for recycling.	**.81**	–.03	0.74
	I hesitate to discharge leftover to waste collection without use.	**.63**	–.19	
Goal intention	I can reduce the waste amount dumped at landfill site effectively by recycling.	**.74**	–.21	0.74
	I want to do as much as possible for solving waste problems.	**.69**	–.24	
Evaluation of trouble	It's burdensome to spend time on recyclable separation.	–.07	**.82**	0.78
	It's burdensome to separate leftover food.	.21	**.79**	
	It's burdensome to separate recyclables.	–.15	**.77**	
	It's burdensome to spend time for leftover food separation.	–.16	**.65**	

Note: Factor loadings over .40 appear in bold.

3.2.2.3 Development of behavior models

In this study, the model in Fig. 2−1 and 2−2 was considered as the basic framework. The authors intended to develop predictive models for separation behavior, behavioral intention, and goal intention. The behavioral intention was assumed to be the significant factor of separation behavior, while goal intention was assumed as the factor affecting behavioral intention. Table 3-9 shows Pearson's correlation coefficients between separation behavior, behavioral intention, goal intention, and predictor variables.

According to the assumptions and correlations between variables (Table 3-9), the authors developed predictive models on separation behavior by logistic regression analysis and multiple linear regression analysis as shown in Table 3-10. The models on behavioral intention and goal intention by multiple linear regression analysis are also shown in Table 3-11. According to these results, the authors developed the model on separation behavior as summarized in Figs. 3-4, 3-5, 3-6, and 3-7.

Regarding leftover separation behavior (Fig. 3-4), behavioral intention was a significant positive predictor ($B = 0.507$, $p < 0.01$). This finding is similar to earlier researches that if the intention is strong, people are more likely to perform separation behavior [1, 2, 7, 15, 16, 25]. Evaluation of trouble was a significant negative predictor of separation behavior ($B = -0.949$, $p < 0.01$). If people feel more inconvenience to separate waste such as the burden of waste separation and lack of time, they are less active to participate in recycling. This is consistent with the study by Ajzen and several recent studies on behavioral modeling [1, 10, 20, 25]. In the next step of the model in Fig. 3-4, the behavioral intention was predicted by sympathy for the collector ($\beta = 0.741$, $p < 0.001$), which was defined by the statement "I want to support persons who hope to collect leftovers by separation of leftovers." This could be explained by the past habit in Vietnamese families. In the past, there were many small piggeries and leftover food separation for swine breeding was common in most Vietnamese families [9, 21]. It was suggested that citizens felt sympathy with pig farmers by the long history of friendly relationships with them as the basis of behavioral intention. There were no studies that examined the effect of sympathy on behavioral intention. A similar effect would be expected in the areas where the informal sector has established a friendly relationship with citizens.

Regarding the low participation group of recyclable separation (Fig. 3-5), the behavioral intention for plastic bags predicted the separation behavior positively ($\beta = 0.365$, $p < 0.001$). Behavioral intention for plastic bags showed a lower mean (4.39) compared to the means of behavioral intention for other groups (5.50-5.88). And, the low participation group included recyclable items, which were less frequently discarded waste in daily life (except for the plastic bags). These would explain the lower separation rate of these recyclables. For plastic bags, even though they were much lighter by weight and easier to store than other recyclables, citizens were not willing to separate them. Plastic bags used in daily life were generally smeared with dripping from food and beverage, and they would cause a bad smell when stored at home. To recycle plastic bags, citizens need to spend some time to wash and dry them. Furthermore, plastic bags had a relatively low value for selling than other recyclables and were bulky [11]. In the next step of the model, the behavioral intention for plastic bags was motivated positively by the incentive brought by recycling ($\beta = 0.312$, $p < 0.01$). The economic benefit from selling these recyclable items would enhance the intention for separation behavior. Some studies on "Waste Bank", where recyclables can be turned into the deposit, also reported the positive impact of economic benefit on recycling and waste reduction [8, 19, 32]. It is suggested that the economic incentive would promote citizens' recycling activities.

Regarding the moderate participation group of recyclable separation (Fig. 3-6), the behavioral intention for paper ($\beta = 0.337$, $p < 0.001$) was a significant positive factor. Respondents with a higher level of behavioral intention for paper are more likely to recycle. Next, internal norm ($\beta = 0.333$, $p < 0.01$) was a significant positive predictor of behavioral intention for paper. The individual's internal norm was indicated by the hesitation for not recycling or the responsibility for waste separation. The stronger internal norm would improve behavioral intention. In addition, the behavioral intention for paper was also predicted by the goal intention ($\beta = 0.237$, $p < 0.05$). The goal intention was positively motivated by internal norm ($\beta = 0.407$, $p < 0.001$) and perception of seriousness and responsibility ($\beta = 0.436$, $p < 0.001$). These results are consistent with earlier findings from Matsui et al. and the assumptions of this study [15, 16].

Regarding the higher participation group of recyclable separation (Fig. 3-7), the behavioral intention was a significant positive predictor ($\beta = 0.249$, $p < 0.01$) in line with the previous studies [1, 7, 12, 16, 17]. However, the coefficient of determination was very low ($R2 = 0.062$). This could be explained that two recyclable items in the higher participation group (plastic bottles and metal cans) were very common in daily life and the recycling behavior of these items was a habit with little conscious thinking. This separation behavior was more likely affected by the original habit of citizens than their intention [27]. In addition, the separation behavior was also influenced by sympathy for the collector and evaluation of trouble. These two variables, however, did not appear in the predictive model on separation behavior in Table 8. In the lower part of model (Fig. 3-7), goal intention ($\beta = 0.244$, $p < 0.05$), evaluation of trouble ($\beta = -0.300$, $p < 0.01$), and internal norm ($\beta = 0.286$, $p < 0.01$) were significant predictors of behavioral intention as expected. And goal intention was significant influenced by perception of seriousness and responsibility ($\beta = 0.436$, $p < 0.001$) and internal norm ($\beta = 0.407$, $p < 0.001$). These results are consistent with earlier findings from Matsui et al. and the assumptions of this study [15, 16].

Table 3-9 Result of correlation analysis between separation behavior and predictor variables

Predictor variables	Explanation	Separation behavior				Behavioral intention				Goal intention
		Leftover food separation	Low participation group of recyclable separation	Moderate participation group of recyclable separation	Higher participation group of recyclable separation	Behavioral intention for leftover food	Behavioral intention for recyclables	Behavioral intention for paper	Behavioral intention for plastic bags	
Behavioral intention for leftover food	The intention to continue to separate leftover food.	0.410***								0.336**
Behavioral intention for recyclables	The intention to continue to separate recyclables.		–	0.278**	0.249**					0.513***
Behavioral intention for paper	The intention to separate paper such as cardboard, newspaper, book, and notebooks.			0.337***						0.439***
Behavioral intention for plastic bags	The intention to separate plastic shopping bag with cleaning dirty plastic bags.		0.365***							–
Goal intention	The general attitude toward the waste problem.	–	–	0.272**	–	0.336**	0.513***	0.439***	–	
Incentive brought by recycling	Incentive brought by the money earned from recycling.	–	–	0.218*	–	–	0.337***	0.237*	0.312**	0.306**
Sympathy for the collector	Fellow feeling or the understanding for the work of collectors.	0.327**	–	–	0.210*	0.741***	0.523***	0.219*	–	0.544***
Evaluation of trouble	The judging whether joining in recycling satisfies individual's convenience.	-0.433***	–	-0.213*	-0.199*	-0.424***	-0.507***	-0.248**	–	-0.321**
Perception of seriousness and responsibility	The perceived environmental risks and responsibility for the cause of waste problems.	–	–	–	–	0.211*	0.385***	–	–	0.626***
Internal norm	The normative conscience on recycling and responsibility for recycling.	–	–	–	–	0.397***	0.448***	0.459***	0.200*	0.611***

Correlation analysis using Pearson

–: No significant correlation, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 3-10 Predictive models on separation behavior

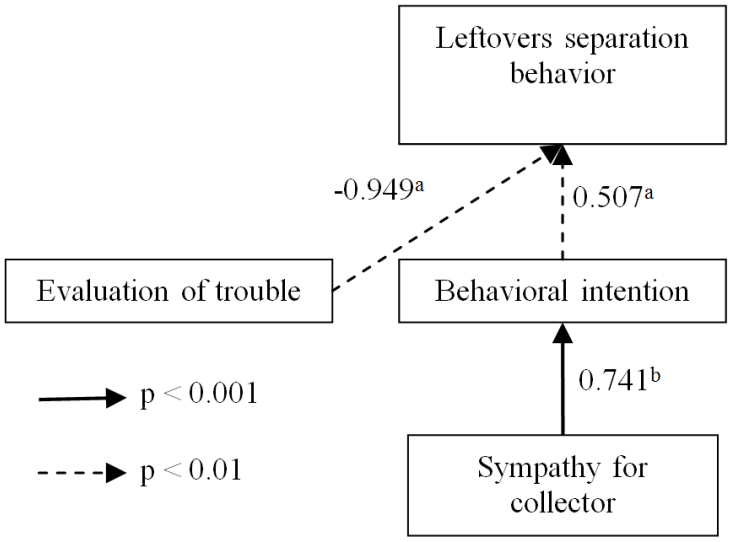
Outcome variables / Predictor variables	Unstandardized coefficients (B) by logistic regression	Unstandardized coefficients (B) by multiple linear regression		
	Leftover food separation	Low participation group of recyclable separation	Moderate participation group of recyclable separation	Higher participation group of recyclable separation
Behavioral intention for leftover food	0.507**	–	–	–
Behavioral intention for recyclables	–	–	–	0.165**
Behavioral intention for plastic bags		0.401***	–	
Behavioral intention for paper	–	–	0.474***	–
Evaluation of trouble	–0.949**	–	–	–
Constant	2.756†	–0.237	–0.961*	0.54
Correct percentage	87.4%	–	–	–
R Square	–	0.133***	0.114***	0.062**
Number of Cases (N)	103	126	125	114

–: Excluded variables, †: $p < 0.1$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 3-11 Predictive models on behavioral intention and goal intention

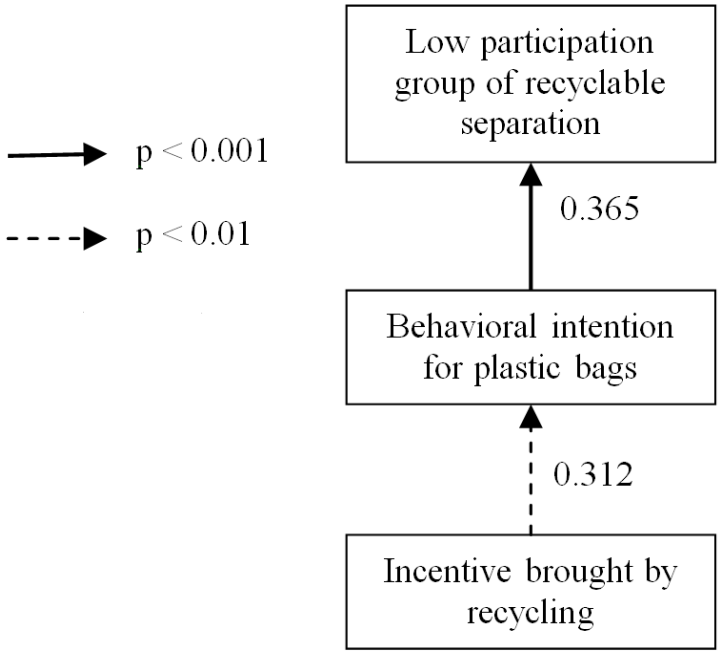
Outcome variables / Predictor variables	Unstandardized coefficients (B) by multiple linear regression				
	Behavioral intention for leftover food	Behavioral intention for recyclables	Behavioral intention for plastic bags	Behavioral intention for paper	Goal intention
Incentive brought by recycling	–	–	0.336**	–	–
Sympathy for the collector	0.816***	–	–	–	–
Evaluation of trouble	–	–0.244**	–	–	–
Perception of seriousness and responsibility	–	–	–	–	0.448***
Internal norm	–	0.253**	–	0.260**	0.364***
Goal intention	–	0.250*	–	0.209*	–
Constant	0.810†	3.670***	2.869***	3.277***	0.826†
R Square	0.549***	0.419***	0.097**	0.262***	0.522***
Number of Cases (N)	102	97	107	103	105

–: Excluded variables, †: $p < 0.1$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$



[a] Unstandardized coefficients (B) by logistic regression
[b] Path coefficients (Beta) by multiple regression

Figure 3-4 Behavior model for leftover separation



Path coefficients (Beta) are indicated.

Figure 3-5 Behavior model for low participation group of recyclable separation

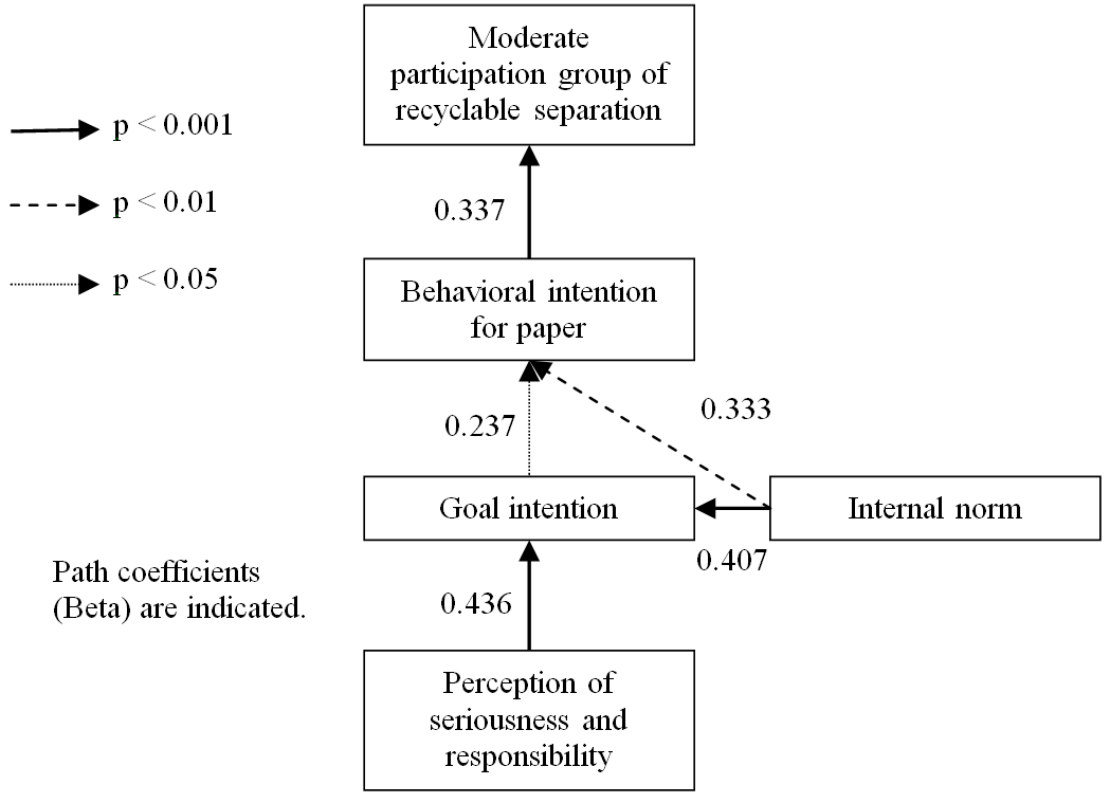


Figure 3-6 Behavior model for moderate participation group of recyclable separation

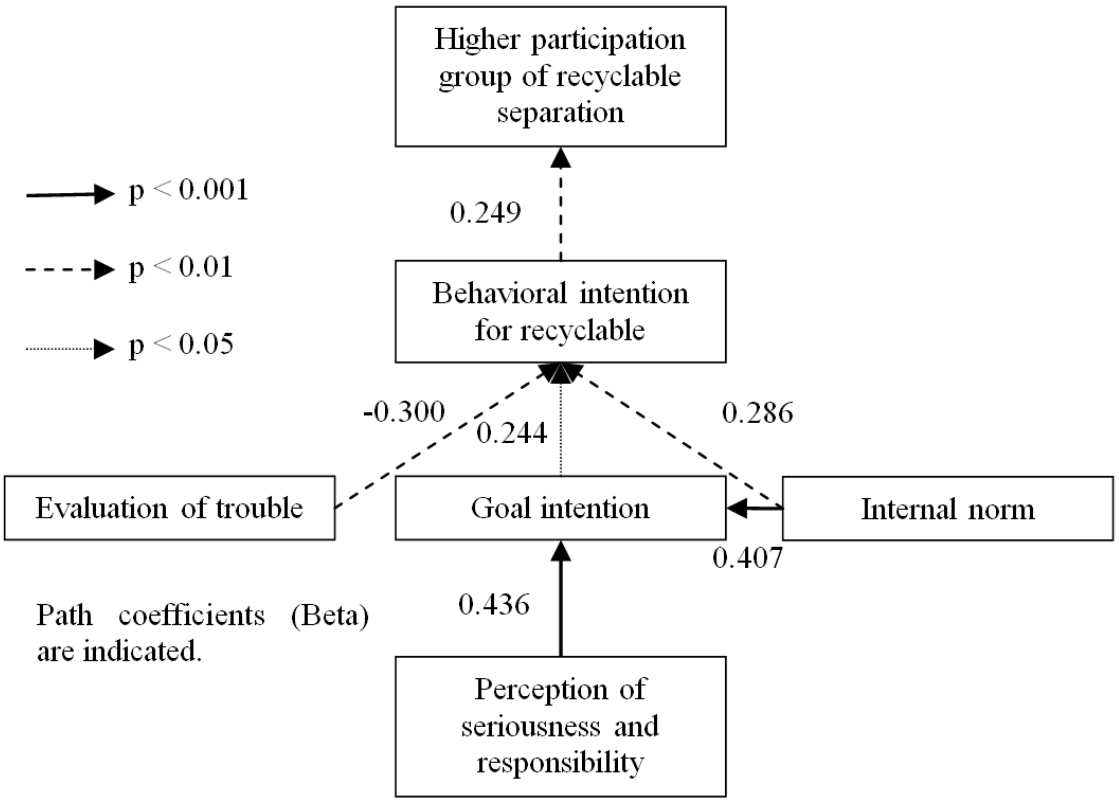


Figure 3-7 Behavior model for higher participation group of recyclable separation

3.2.3 Household recognition and attitude of separation behavior

For understanding household recognition and attitude toward separation behavior, the responses are summarized in Fig. 3−8. The percentages of positive/neutral/negative answers for all influencing factors were calculated. Positive answers included answers "1- Strongly disagree" ~ "3- Disagree" for evaluation of trouble, and "5- Agree" ~ "7- Strongly agree" for other influencing factors, represented the responses affecting separation behavior in a positive way. Negative answers included answers "5- Agree" ~ "7- Strongly agree" for evaluation of trouble, and "1- Strongly disagree" ~ "3- Disagree" for other influencing factors, represented the responses affecting separation behavior in a negative way. Neutral answers included answers "4- Neither agree nor disagree".

For the factors influencing leftover food separation behavior, 78.7% of respondents provided positive answers for behavioral intention, 85.6% for sympathy for the collector. For the factors influencing recyclable separation behavior, over 90% of respondents showed a strong positive intention to continue to separate waste for moderate participation group, followed by behavioral intention for higher participation group (86.8%), and behavioral intention for low participation group (only 55.6%). Over 60% of respondents provided positive answers on evaluation of trouble and the incentive brought by recycling benefit. In addition, 89.2% and 94.1% of respondents had positive answers for internal norm and for perception of responsibility and seriousness, respectively. Respondents had a high level of perception of responsibility and seriousness even they didn't join waste separation.

3.2.4 Waste separation rate by household's attributes

The differences in separation rates among attribute categories as shown in Table 3−4 (i.e., gender, age, household size, income level, working status, and urbanization level) were analyzed by the chi-square test. The results are indicated in Table 3-12. Household size, working status, and urbanization level were significant factors influencing separation behavior, while other factors such as gender, age, and income level were not significant.

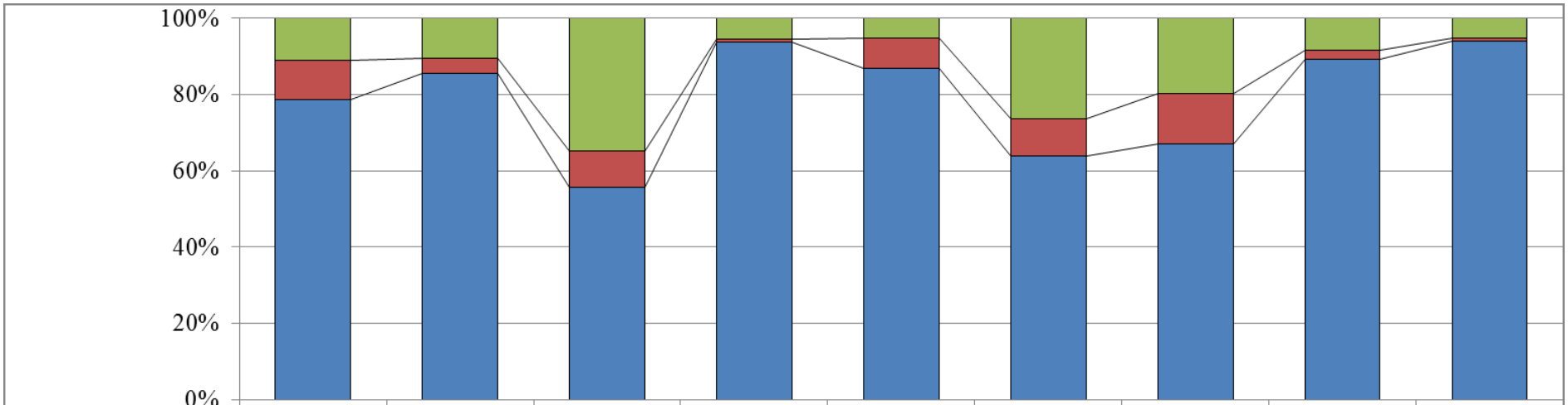
The significant influence factor for the separation behavior of leftover food was the urbanization level ($\chi2 = 10.44$, $p < 0.05$). The separation rate was 92.9% in level 1 of the urbanization level, while the separation rate in level 5 was 55.0%. Respondents at a high urbanization level were less active in separating leftover food.

For the recyclable separation of the low participation group, the separation rate differed significantly by working status for plastic products ($\chi2 = 6.47$, $p < 0.05$), metal products ($\chi2 = 11.82$, $p < 0.01$), and plastic bags ($\chi2 = 3.97$, $p < 0.05$), and by urbanization level for magazines ($\chi2 = 16.29$, $p < 0.01$) and metal products ($\chi2 = 11.22$, $p < 0.05$). Respondents

who were jobless or retired and those in level 4 of urbanization level indicated the lowest separation rate.

For recyclable separation of the moderate participation group, household size ($\chi 2 = 7.18$, $p < 0.05$) and urbanization level ($\chi 2 = 10.02$, $p < 0.05$) were significant factors for cardboard separation rate. The respondents who live in families with six or more persons and those in level 4 showed the lowest separation rate; 33.3% and 26.7%, respectively.

For recyclable separation of the higher participation group, the separation rate was only affected significantly by household size for plastic bottles ($\chi 2 = 13.62$, $p < 0.01$). Respondents in 1–2 person families showed the lowest separation rate (52.9%).



	Behavioral intention for leftover food	Sympathy for the collector	Behavioral intention for low participation group	Behavioral intention for moderate participation group	Behavioral intention for higher participation group	Evaluation of trouble	Incentive brought by recycling	Internal norm	Perception of seriousness and responsibility
Negative answers	11.1%	10.6%	34.9%	5.6%	5.3%	26.2%	19.6%	8.3%	5.1%
Neutral answers	10.2%	3.8%	9.5%	0.8%	7.9%	9.8%	13.4%	2.5%	0.8%
Positive answers	78.7%	85.6%	55.6%	93.7%	86.8%	63.9%	67.0%	89.2%	94.1%

Figure 3-8 Percentages of positive/neutral/negative answers for the factors influencing leftover food and recyclable separation behavior

Table 3-12 Chi-square results of separation rates and household attributes

Household attributes	Categories	Leftover food separation		Low participation group of recyclable separation													
				Plastic products		*Magazines*		*Metal products*		*E-waste*		*Plastic bags*		*Carton paper box*		*Batteries*	
		Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2
	Total	77.3%		33.3%		25.4%		23.9%		18.8%		15.2%		15.2%		13.0%	
Household size (person)	1–2	81.8%	5.78	17.6%	2.15	17.6%	4.88	5.9%	3.52	5.9%	3.67	5.9%	3.98	11.8%	0.22	0.0%	3.55
	3–5	82.9%		35.3%		31.8%		27.1%		23.5%		20.0%		15.3%		16.5%	
	≥6	62.9%		36.1%		13.9%		25.0%		13.9%		8.3%		16.7%		11.1%	
Working status	Jobless/Retired	81.8%	1.69	**23.3%**	6.47*	20.5%	2.05	**12.3%**	11.82**	13.7%	2.83	**9.6%**	3.97*	11.0%	2.30	8.2%	3.31
	Working	72.1%		43.8%		31.2%		37.5%		25.0%		21.9%		20.3%		18.8%	
Urbanization level	Level 1	92.9%	10.44*	27.6%	8.10	17.2%	16.29**	17.2%	11.22*	24.1%	5.15	13.8%	4.84	13.8%	3.43	17.2%	3.89
	Level 2	72.0%		44.4%		37.0%		33.3%		14.8%		14.8%		14.8%		11.1%	
	Level 3	82.8%		46.7%		46.7%		40.0%		26.7%		26.7%		23.3%		16.7%	
	Level 4	76.9%		16.7%		**6.7%**		**6.7%**		6.7%		6.7%		6.7%		3.3%	
	Level 5	**55.0%**		31.8%		18.2%		22.7%		22.7%		13.6%		18.2%		18.2%	

Household attributes	Categories	Moderate participation group of recyclable separation								Higher participation group of recyclable separation			
		Cardboard		*Newspaper*		*Book/photocopy paper*		*Notebooks*		*Plastic bottles*		*Metal cans*	
		Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2
	Total	50.0%		43.8%		38.4%		37.7%		72.5%		63.8%	
Household size (person)	1–2	41.2%	7.18*	35.3%	4.93	23.5%	5.32	17.6%	5.47	**52.9%**	13.62**	58.8%	4.85
	3–5	58.8%		51.2%		45.9%		44.7%		83.5%		70.6%	
	≥6	**33.3%**		30.6%		27.8%		30.6%		55.6%		50.0%	
Working status	Jobless/Retirement	52.1%	0.18	43.1%	0.01	34.2%	1.30	34.2%	0.91	72.6%	0.01	68.5%	1.68
	Working	48.4%		43.8%		43.8%		42.2%		73.4%		57.8%	
Urbanization level	Level 1	55.2%	10.02*	44.8%	1.45	44.8%	5.79	41.4%	3.93	86.2%	6.28	75.9%	3.60
	Level 2	66.7%		44.4%		40.7%		37.0%		63.0%		59.3%	
	Level 3	50.0%		51.7%		46.7%		46.7%		80.0%		66.7%	
	Level 4	**26.7%**		36.7%		20.0%		23.3%		63.3%		53.3%	
	Level 5	54.5%		40.9%		40.9%		40.9%		68.2%		63.6%	

* $p < 0.05$, **$p < 0.01$

The lowest value of separation rate appears in bold.

3.3 Conclusions

3.3.1 Policy implication/Suggestions

In Vietnam, waste separation at source has been introduced in the national government regulation, and the Vietnam Government set the national target for a recovery rate of HSW as 85% in 2020, and 90% in 2025 [28, 29, 30]. Vietnamese authorities of MSW promptly need to establish the explicit strategy and guidelines for waste separation at the local level. The findings of this study would support a strategy formulation aimed to enhance waste separation activities at the household level. Based on the obtained results, the authors suggest as follows:

First, regarding leftover food separation, it is important to reduce the difficulties of leftover food separation and strengthen the intention to engage in separation by providing knowledge and skills during the educational program. The guidelines for waste separation should highlight the ease of waste separation and citizens need to perceive that it does not take much time to join the recycling movement. Especially, such programs should be disseminated extensively to households located in high urbanization areas.

Second, concerning the low participation group of recyclable separation, information about the received amount that residents can earn from selling recyclables needs to be announced aiming to motivate them to recycle their household waste. Regarding the effect of attributes on recycling participation, waste authorities should verify that sufficient information about the program needs to be delivered to households with jobless or retired residents and those in level 4 of the urbanization level.

Third, with respect to the moderate participation group of recyclable separation, the establishment of the information channel where citizens would be facilitated to communicate and share knowledge and experiences on waste separation is essential to enhance the intention, the individual moral norm, the citizens' awareness, and responsibility for waste separation. In terms of the effects of attributes, household size and urbanization level had a crucial impact on the separation rate of this group, in which families with six or more persons and those in level 4 should be put in high priority to promote recycling.

Lastly, for the higher participation group of recyclable separation, it is essential to make clear the importance and benefits of waste separation, such as solving waste problems and reducing the waste amount to the landfill site by education programs. Although the separation rate of this group was more likely affected by citizens' existing habits, the dissemination of such programs would increase the positive attitude on the recycling of those who did not join recycling, especially in 1–2 person families. The difficulties of waste separation should also

be reduced to strengthen behavioral intention by providing sufficient skills for waste sorting. In addition, to avoid the depletion of behavioral intention, waste authorities should consider to provide incentive policies such as awards for individuals or communities with outstanding achievements on waste separation.

3.3.2 Conclusion

This study focused on the current status of household solid waste recycling behavior and its conscious modeling. The authors conducted a questionnaire survey in 150 households in six urban districts of Da Nang city, Vietnam. The major findings were indicated as follows:

The separation rate of leftover food separation was 77.3%. Most people participated in leftover food separation voluntarily without material benefits.

For recyclables, plastic bottles and metal cans were two popular items with higher separation rate (72.5% and 63.8%, respectively), followed by cardboard, newspaper, book/photocopy paper, notebooks, plastic products, magazines, metal products, e-waste, plastic bags, carton paper, and batteries. More than half of the respondents separated recyclables for giving to others for free (53.6%).

The authors categorized the separation behavior of 13 recyclables into three categories by cluster analysis. The authors also developed four attitudinal scales based on the 12 statements of pro-environmental attitudes by factor analysis.

The authors developed models for separation behavior for leftover food separation, low, moderate, and higher participation group of recyclable separation, and clarified the positive and negative factors. The positive factors included behavior intention, sympathy for the collector, incentive brought by recycling, goal intention, internal norm, and perception of responsibility and seriousness. The negative factor was the evaluation of trouble.

Regarding the effects of attributes on separation behavior, the authors found the attribute categories with lower participation rates as follows:

- Households located in high urbanization areas for leftover food separation;
- Households with jobless or retired residents for the low participation group of recyclable separation;
- Families with six or more persons for the moderate participation group of recyclable separation;
- One or two person families for the higher participation group of recyclable separation.

The information obtained from this study would be necessary to contribute to city planning in terms of solid waste management, which will lead to a sustainable society with the 3R approach in the near future under the new Decree [30]. These results would be important to design the recycling promotion program that will be the basic framework for expanding to the whole city.

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[33] Wijayanti DR, Suryani S (2015) Waste Bank as Community-based Environmental Governance: A Lesson Learned from Surabaya. Procedia - Social and Behavioral Sciences 184:171 – 179

[34] Wikimedia Commons (2010) Location map of Vietnam

CHAPTER 4: MEASURING THE EFFECT OF A PROGRAM OF WASTE SEPARATION AT SOURCE

4.1 Methodology

4.1.1 Research areas and sampling method

Before the introduction of the WSS program in Da Nang City, recycling activity was carried out by informal sectors such as junk buyers, waste pickers, and junk shops. Recyclables are primarily collected by junk buyers visiting households or by waste pickers collecting items from landfill sites/the street.

At the start of the WSS program, the community's leadership explained the WSS program to the residents through explanatory meetings and distributed a leaflet (Fig. 4-1). The target categories of recyclables were plastic, paper, and metal.

Under the program, the residents were encouraged to separate recyclables for donating to their community or for independent direct sale to informal sectors. For donations, the women's union or youth union of the community collected recyclables from households and sold them to the junk shop for fundraising. Normally, recyclables were collected every week or every 2 weeks via door-to-door or drop-off collection.

The authors focused on 6 target areas for the WSS program: 4 wards in Hai Chau District (Thuan Phuoc, Thach Thang, Hoa Cuong Bac, and Hoa Thuan Tay) and 2 wards in Thanh Khe District (Thac Gian and Tam Thuan).

Figure 4-1 The explanatory meeting in Hai Chau District and the leaflet for the WSS program [16]

4.1.2 Outline of the questionnaire survey

A questionnaire survey was conducted via face-to-face interviews with 602 households (100 or 101 households for each area) from September 24th to October 26th, 2018. The persons in the target households in charge of waste storage and discharge were answered the questionnaire. The outline of the questionnaire is shown in Table 4−1.

Compare to the survey in 2016, there are some improvement points as following:

1) To understand the household's current waste separation activity and to measure the effect of the WSS program, the interviewer asked about leftover food separation behavior, waste separation behavior of 14 recyclable items and provided three options, namely, "I had already separated it before the WSS program", "I started separation after the WSS program", and "I don't separate it".

- Plastic material: plastic bottles, plastic shopping bags, and plastic products;
- Paper material: carton paper, cardboard, newspaper, magazines and book/photocopy paper, and notebooks;
- Metal material: aluminum cans, steel cans, metal products, batteries, and e-waste.

2) The interviewee's level of involvement in the WSS program was also characterized, with the interviewee selecting from 3 levels, namely, "I attended the explanatory meeting and received the leaflet", "I attended the explanatory meeting", and "I didn't know about the WSS program".

3) The questionnaire items also covered attitudes and perceptions (e.g., behavioral intention, perception of information, evaluation of trouble) referred from past studies of the authors [12, 13, 22]. The different point from the survey in 2016 is that behavior intention and perception of information were surveyed for each recyclable item. In addition, the questions were answered using the 5-point Likert scale from "1. Strongly disagree" to "5. Strongly agree".

Table 4-1 Outline of questionnaire

Items	Questions/ Statements	Description	Answers
Attributes	Gender, age, household size, occupation, working time		
Waste separation behavior	Q1.1: Separation behavior for leftover food Q1.2−Q1.15: Separation behavior for 14 recyclable items		1- I had already separated it before the WSS program. 2- I started separation after the WSS program. 3- I don't separate it.
The involvement in the WSS program	Q2: Participation in the explanatory meeting and recognition of the leaflet.	Participation of respondents on WSS program	1- I attended the explanatory meeting and received the leaflet. 2- I attended the explanatory meeting. 3- I didn't know about the WSS program.
Behavioral intention	Q3.1: Behavioral intention for leftover food Q3.2−Q3.15: Behavioral intention for 14 recyclable items	Intention to continue to separate leftover food/recyclables.	1- Strongly disagree ~ 5- Strongly agree
Perception of information	Q4.1: Perception of information for separation of leftover food Q4.2−Q4.15: Perception of information for 14 recyclable items	Perception of how to separate waste and what to separate.	Yes/No
Evaluation of trouble	Q5.1: It's burdensome to separate leftover food. Q5.2: It's burdensome to spend time for leftover food separation. Q5.3: It's burdensome to spend space to store leftover food inside the house.	Evaluation of trouble/convenience for recycling.	1- Strongly disagree ~ 5- Strongly agree

Items	Questions/ Statements	Description	Answers
	Q5.4: It's burdensome to store leftover food because of its bad smell. Q6.1: It's burdensome to separate recyclables. Q6.2: It's burdensome to spend time on recyclable separation. Q6.3: It's burdensome to spend space to storage recyclables inside the house.		
Perception of responsibility and seriousness	Q7: The waste problem is serious. Q8: The landfill site will be full of waste and there will be no place to dispose of waste in the near future. Q9: Consumers are responsible for the waste problem. Q10: The company side is responsible for the waste problem.	Perception of environmental risks and responsibility for waste problems.	1- Strongly disagree ~ 5- Strongly agree
Internal norm	Q11: I hesitate to discharge leftover food to waste collection without use. Q12: I hesitate to discharge recyclables to waste collection without use.	Normative conscience on recycling and responsibility for recycling.	1- Strongly disagree ~ 5- Strongly agree
Incentive provided by recycling benefit	Q13: I can earn some money from recyclables.	Incentive brought by the money earned from recycling.	1- Strongly disagree ~ 5- Strongly agree
Sympathy for the collector	Q14: I want to support persons who hope to collect leftovers by separation of leftovers.	Fellow feeling or the understanding of the work of the collectors.	1- Strongly disagree ~ 5- Strongly agree
Social pressure	Q15: If I didn't join leftover food separation, my community will call for participation. Q16: If I didn't join recyclable separation, my community will call for participation.		1- Strongly disagree ~ 5- Strongly agree

4.1.3 Analytical procedure

To define the analytical framework for measuring effects on waste separation behavior and its influencing factors, the authors first developed a structural model of waste separation behavior.

4.1.3.1 Data analysis for waste separation behavior modeling

The detailed analytical procedures are described as section 3.1.3 with 3 steps: Classification of recyclable separation behavior by cluster analysis; Construction of attitude scales by factor analysis; Development of behavior models.

The authors developed the models for the separation behavior of leftover food and recyclables. Regarding the leftover food separation behavior measured by a binary variable, logistic regression analysis was applied. For the other quantitative outcome variables, linear regression analysis was applied.

The candidate predictor variables for the models are defined from factor analysis. The reliabilities of factor scores were examined using Cronbach's alpha. Some specific question items added in this study (behavior intention, perception of information, sympathy for the collector, incentive brought by recycling) were also analyzed as the candidate predictor variables in the models. For the factors represented by more than one question with a five-point scale answer, the factor scores were calculated as the average score of the questions.

4.1.3.2 Data analysis for measuring the effects of WSS program on waste separation behavior and its influencing factors

From the responses that involved characterizing waste separation behavior from among three options, the authors calculated the waste separation rates before and after the WSS program and used McNemar's test to measure the effect of the WSS program on the waste separation behavior. The differences in the factors influencing behavior among the respondents' levels of involvement in the WSS program were also examined using the chi-squared test and ANOVA.

4.1.3.3 Data analysis for the differences in separation rates by attributes

The authors also analyzed the differences in separation rates by attributes such as gender, age, household size, working status, and area. The chi-square test was applied for leftover food and recyclable separation behavior.

All of the statistical analyses were conducted using SPSS Statistics 20.

4.2 Results and discussion

4.2.1 Waste separation rate

The attributes of respondents are summarized in Table 4−2. The waste separation behavior of the respondents is presented in Fig. 4−2. Regarding leftover food separation, the separation rate was 76.1%. As shown in Table 4−3, 68.7% of the respondents separated leftover food to give to the pig farmer, 3.9% of them fed their own livestock or pet, and 1.7% kept leftover food for other purposes, such as burying or leaving in the garden. The remaining 25.8% discarded leftover food to the official collection system. These values are similar to the previous study in Da Nang city in 2016 [22].

Regarding recyclable separation, the separation rates before the WSS program were higher for group of recyclable items including aluminum cans, plastic bottles, magazines, plastic products, cardboard, newspaper, steel cans, book or photocopy paper, notebooks, and metal products (70.3%−72.3%), followed by carton (56.0%), e-waste (45.9%), plastic shopping bags (34.3%), and batteries (20.9%). The promotion effects of the WSS program, represented by the increase in participation in waste separation after the WSS program, were 12.5%−13.9% for recyclable items with higher separation rates, 7.9% for carton, 11.9% for e-waste, 6.5% for plastic shopping bags and 1.5% for batteries. The results of McNemar's test indicate that the waste separation rates of these recyclables before and after the WSS program were significantly different with p value lower than 0.05 for batteries and lower than 0.001 for others.

Regarding the recyclable disposal habit as shown in Table 4−4, for recyclable items with higher separation rates, about 50.0% of the respondents mentioned that they sorted recyclables for giving for free to the people who hope to collect recyclables, such as waste collectors, junk buyers, neighbors, or poor persons (49.5%−53.3%) and more than 18% of respondents separated recyclable for giving to Woman union/ Youth union of their community (18.1%−18.9%). These respondents engaged in recycling without economic incentive (67.9%−71.9%). 12.0%−12.9%% of them separated recyclables for selling to the informal sector (e.g., junk buyer, junk shop), and 0.4%−2.7% kept for other purposes. The remaining did not separate any recyclable item. For recyclable items with lower separation rates, the percentages of respondents who gave their recyclables for free were 46.3% for carton, 46.4% for e-waste, and 15.9% for batteries. The percentages of respondents who sold their recyclables were 6.5% for carton, 8.0% for e-waste, and 1.9% for batteries. For plastic shopping bags, 97.7% of respondents discarded it mixed with other kinds of waste to the official collection system, and only 2.3% of them kept it for giving to someone or selling even though the separation rate for plastic bags is 40.8% (Fig. 4−2). This means that 38.5%

of respondents separated their plastic bags, not for recycling (40.8% minus 2.3%). Citizens had a habit to keep their plastic shopping bags and use them as garbage bags.

Table 4-2 Attributes of respondents

	Attributes	Frequency	Percentage (%)
Gender	Male	162	26.9
	Female	440	73.1
	Total	602	100
Age (years)	< 30	58	9.6
	30–39	103	17.1
	40–49	136	22.6
	50–59	138	22.9
	60−69	119	19.8
	≥ 70	48	8.0
	Total	602	100
Household size (person)	1–2	70	11.6
	3–4	284	47.2
	≥ 5	248	41.2
	Total	602	100
Working time (hours/ day)	0	277	54.5
	≤ 8	187	36.8
	> 8	44	8.7
	Total	508	100
Working status	Jobless/Retired	254	42.4
	Working	345	57.6
	Total	599	100

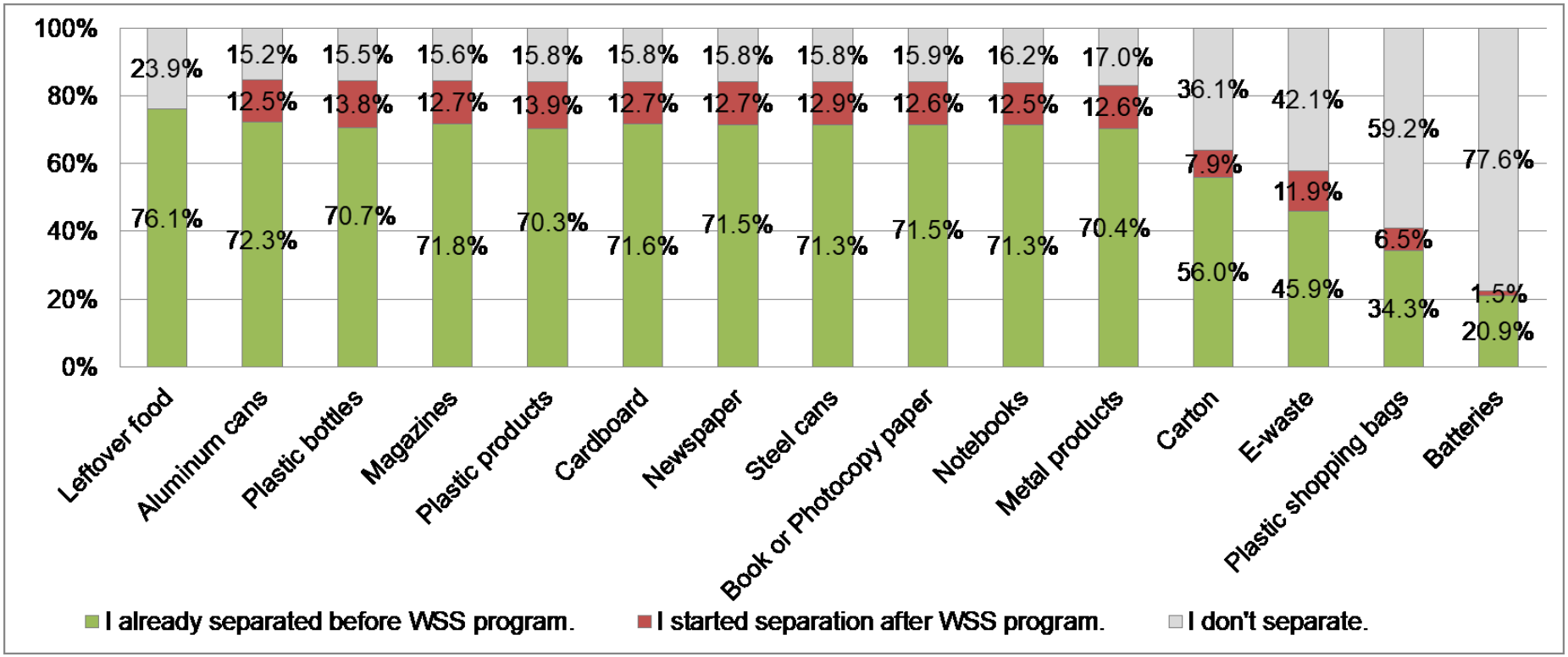


Figure 4-2 Separation rate on leftover food and recyclables

Table 4-3 Current status of Leftover food disposal habit

Leftover food disposal habit	Frequency	Percentage
Give to pig farmer	410	68.7%
Feed to our own livestock/pets	23	3.9%
Others (Bury/leave in garden/field, etc.)	10	1.7%
Discharge	154	25.8%
Total	597	100.0%

Table 4-4 Current status of Recyclables disposal habit

Recyclables disposal habit	Aluminum cans		Plastic bottles		Magazines		Plastic products		Cardboard		Newspaper		Steel cans	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Sell to junk buyers	77	12.9%	72	12.0%	75	12.5%	72	12.0%	75	12.5%	75	12.5%	77	12.9%
Give to persons who hope to collect recyclables	311	52.0%	319	53.3%	303	50.7%	316	52.8%	306	51.1%	306	51.1%	302	50.7%
Give to Woman union/ Youth union	113	18.9%	112	18.7%	108	18.1%	113	18.9%	111	18.5%	109	18.2%	110	18.5%
Others (keep for own reuse, etc.)	6	1.0%	2	0.4%	21	3.5%	4	0.7%	14	2.3%	16	2.7%	15	2.5%
Discharge	91	15.2%	94	15.7%	91	15.2%	94	15.7%	93	15.5%	93	15.5%	92	15.4%
Total	598	100.0%	599	100.0%	598	100.0%	599	100.0%	599	100.0%	599	100.0%	596	100.0%
Recyclables disposal habit	Book or Photocopy paper		Notebooks		Metal products		Carton		E-waste		Plastic shopping bags		Batteries	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Sell to junk buyers	76	12.7%	76	12.7%	75	12.5%	39	6.5%	47	8.0%	1	0.2%	11	1.9%
Give to persons who hope to collect recyclables	304	50.8%	307	51.3%	296	49.5%	207	34.6%	196	33.6%	3	0.5%	77	13.2%
Give to Woman union/ Youth union	109	18.2%	109	18.2%	110	18.4%	70	11.7%	75	12.8%	3	0.5%	16	2.7%
Others (keep for own reuse, etc.)	16	2.7%	10	1.7%	16	2.7%	7	1.1%	27	4.6%	7	1.1%	27	4.6%
Discharge	93	15.6%	96	16.1%	101	16.9%	276	46.1%	239	40.9%	586	97.7%	454	77.6%
Total	598	100.0%	598	100.0%	598	100.0%	599	100.0%	584	100.0%	600	100.0%	585	100.0%

4.2.2 Waste separation behavior modeling

4.2.2.1 Classification of recyclable separation behavior by cluster analysis

The authors intended to develop models for the separation behavior of leftover food and recyclables. To simplify the behavior modeling, the authors first intended to group 14 recyclables with similar separation rates by a cluster analysis of separation behavior by recyclables. The results are illustrated by a dendrogram in Fig. 4−3. Two clusters were detected. Cluster 1 included ten recyclable items; book/photocopy paper, notebooks, cardboard, newspaper, magazines, steel cans, metal products, aluminum cans, plastic bottles, and plastic products which expressed the "Higher participation group". Cluster 2 included four recyclable items; plastic shopping bags, batteries, cartons, and e-waste which represented the "Low participation group". The score of each group was a binary score, i.e., 'participants' (respondents who separated at least one of the recyclable items) and 'non-participants' (respondents who didn't separate any recyclable items). As the outcome variables of the models, the separation behavior including leftover food separation, low participation group, and higher participation group of recyclable separation are indicated in Table 4−5.

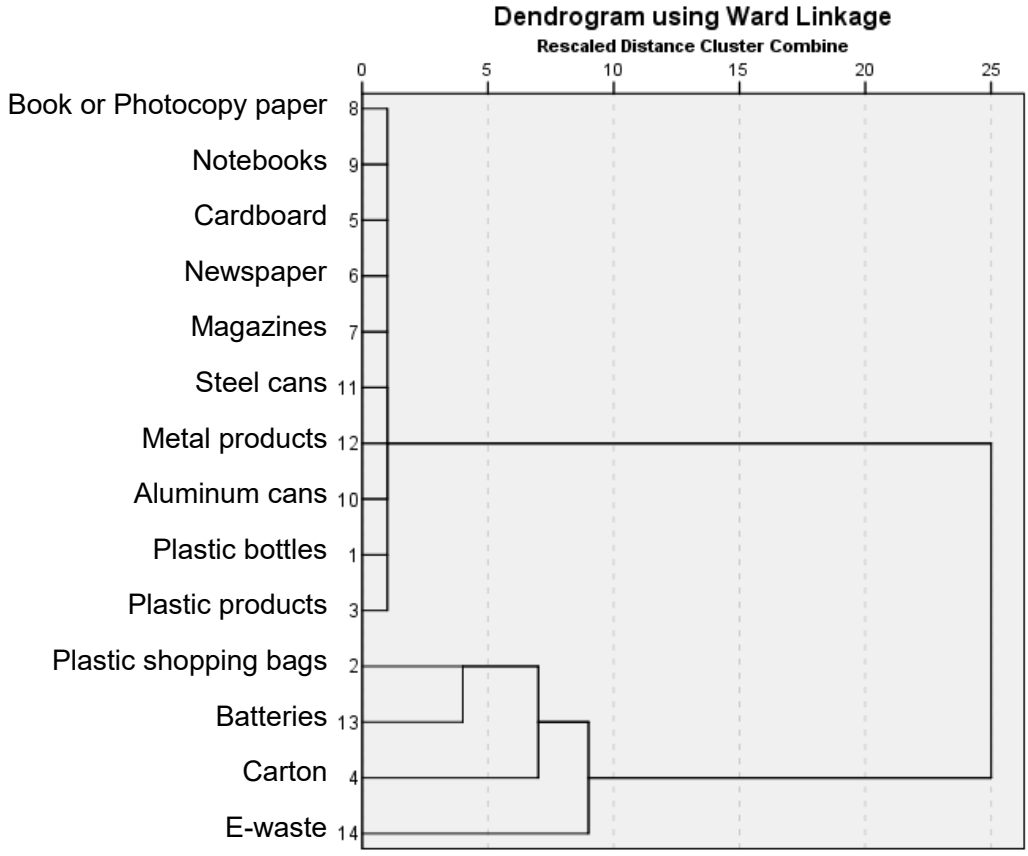


Figure 4-3 Dendrogram of recyclable separation clusters

Table 4-5 Separation behavior variables

Separation behavior	Range of variables
Leftover food separation	No separation = 0/Separation = 1
Higher participation group of recyclable separation	No separation = 0/Separation = 1
Low participation group of recyclable separation	No separation = 0/Separation = 1

Table 4-6 Summary of exploratory factor analysis and Cronbach's alpha

Scales	Statements	Factor loadings				Cronbach's alpha
		1	2	3	4	
Social pressure	Q16	**.866**	.059	.123	.000	0.85
	Q15	**.842**	-.049	-.044	-.044	
Internal norm	Q11	**.694**	.054	-.040	-.012	0.60
	Q12	**.561**	.232	.079	.228	
Evaluation of trouble for recyclable separation	Q6.2	-.080	**-.913**	.003	.020	0.88
	Q6.1	.010	**-.876**	.048	.069	
	Q6.3	-.059	**-.829**	.059	-.085	
Evaluation of trouble for leftover food separation	Q5.2	.242	-.146	**.789**	-.010	0.78
	Q5.1	.178	-.127	**.787**	.023	
	Q5.4	-.418	.133	**.728**	-.069	
	Q5.3	-.452	.140	**.706**	-.005	
Perception of seriousness and responsibility	Q8	-.055	-.040	-.038	**.856**	0.75
	Q9	-.158	-.049	-.104	**.824**	
	Q7	.182	-.036	.030	**.723**	
	Q10	.046	.119	.107	**.588**	

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

4.2.2.2 Construction of attitude scales by factor analysis

By the factor analysis, four factors were extracted. Table 4−6 shows a summary of factor loadings by pattern matrix after rotation and the Cronbach's alpha. According to the original meaning of statements, the authors additionally separated the first factor into two scales, thus the total of five scales as presented in Table 4−6: "Social pressure", "Internal norm", "Evaluation of trouble for recyclable separation", "Evaluation of trouble for leftover food separation", and "Perception of seriousness and responsibility". The reliability coefficients by Cronbach's alpha for each scale were equal to or higher than 0.6. These scales indicated adequate reliability [8].

Perception of information was defined corresponding to separation behavior variables (Table 4−5); Perception of information for leftover food, Perception of information for low participation group, and Perception of information for higher participation group. Perception of information for low participation group and higher participation group represented by

more than one question were defined as the binary score (Yes/No). It was categorized into two groups: respondents who answered “yes” for at least one of the recyclable items and respondents who answered “no” for all recyclable items.

The behavioral intention was also defined corresponding to separation behavior variables; Behavioral intention for leftover food, Behavioral intention for low participation group, and Behavioral intention for higher participation group.

For behavioral intention and other factors represented by more than one question with a five-point scale answer, the factor scores were calculated as the average score of the questions.

4.2.2.3 Development of behavior models

According to the correlations between variables (Table 4−7), the authors developed predictive models on separation behavior and behavioral intention by logistic regression analysis and multiple linear regression analysis. The results of the predictive models are shown in Table 4−8 and 4−9. The structural models for waste separation behavior are summarized in Fig. 4−4, 4−5, and 4−6.

Regarding leftover separation behavior (Fig. 4−4), behavioral intention ($B = 2.96$, $p < 0.001$) and perception of information ($B = 4.33$, $p < 0.001$) were significant positive predictors. Evaluation of trouble was a significant negative predictor of separation behavior ($B = -0.84$, $p < 0.01$). If people have a higher level of the intention and understanding of how to separate leftover food, and have a lower level of evaluation of trouble, they are more probable to participate in recycling. In the next step of the model in Fig. 4−4, the behavioral intention was predicted by sympathy for the collector ($\beta = 0.47$, $p < 0.001$), which expressed the fellow feeling or the understanding of the work of the collectors. These findings are similar to the previous survey in 2016 (presented in section 3.2.2.3) which determined behavioral intention, evaluation of trouble, and sympathy for the collector as the influencing factors of leftover separation behavior [22]. Furthermore, in this model, the perception of information was added and defined as the most important factor.

Regarding the higher participation group and the low participation group of recyclable separation (Fig. 4−5 and 4−6), the results of the behavior model showed that behavioral intention ($p < 0.001$) and perception of information ($p < 0.001$) were significant positive predictors of waste separation behavior. Lower behavioral intention and a lack of knowledge about waste separation tended to prevent respondents from separating their waste. This result is similar to previous studies related to waste separation behavior [3, 4, 12, 17, 20] and other environmental behavior [1, 9].

Evaluation of trouble, which refers to the space taken up for recyclables storage and the time spent on waste separation, was the strongest negative predictor of behavioral intention ($p < 0.001$). According to the interviews, some respondents commented that they didn't want to keep any waste in their houses for longer than one day. Some of them didn't have enough time for waste separation because of their full-time job. The results indicate that if residents evaluate waste separation as requiring a large amount of trouble, they have a lower intention to participate in waste separation. This finding is consistent with previous findings [3, 12, 15, 20]. In some studies on waste separation with the official collection, the satisfaction with local facilities, which means positive evaluation for waste separation, was considered as a predictor of behavioral intention [2, 17, 20]. So, the positive or negative evaluation of waste separation would be a significant influencing factor for behavioral intention. The effect of this factor on the behavioral intention of the higher participation group was also proved in the previous survey (presented in section 3.2.2.3) [22].

The other three influencing factors—internal norm, perception of responsibility and seriousness, and the incentive provided by recycling's benefit —were also significant, but weaker, predictors of behavioral intention. The internal norm was also an important factor influencing the behavioral intention of the higher participation group in the survey in 2016 (section 3.2.2.3) [22]. The tendency for people who perceive greater waste separation participation has been reported in some past studies on attitude [12, 17, 20]. The incentive provided by recycling's benefit, which related to the money earned from selling recyclables, was also reported to be a predictor in the model of low participation group of recyclable separation in a past study (section 3.2.2.3) [22].

Table 4-7 Result of correlation analysis between separation behavior and predictor variables

Predictor variables		Separation behavior			Behavioral intention		
		Leftover food separation	Higher participation group of recyclable separation	Low participation group of recyclable separation	Behavioral intention for leftover food	Behavioral intention for higher participation group	Behavioral intention for low participation group
Behavioral intention for leftover food	Correlation	.776***					
	N	540					
Behavioral intention for higher participation group	Correlation		.874***	.803***			
	N		549	526			
Behavioral intention for low participation group	Correlation		.671***	.739***			
	N		549	526			
Perception of information for leftover food separation	Correlation	.632***			.404***		
	N	590			544		
Perception of information for higher participation group	Correlation		.671***	.572***		.638***	.503***
	N		558	535		590	590
Perception of information for low participation group	Correlation		.482***	.617***		.514***	.522***
	N		558	535		590	590
Evaluation of trouble for leftover food separation	Correlation	-.547***			-.380***		
	N	590			544		
Evaluation of trouble for recyclable separation	Correlation		-.660***	-.651***		-.595***	-.501***
	N		557	535		589	589
Sympathy for the collector	Correlation	.402***			.471***		
	N	560			529		
Perception of neighbor participation for leftover food separation	Correlation	.278***			.223***		
	N	349			346		
Perception of neighbor participation for recyclable separation	Correlation		.364***	.318**		.369***	.168***
	N		421	398		444	444
Social pressure	Correlation	.099*	.204***	.115***	.199***	.160***	-.060
	N	580	549	527	536	581	581
Internal norm	Correlation	.260***	.413***	.406***	.413***	.401***	.258***
	N	589	557	534	544	589	589

Perception of seriousness and responsibility	Correlation	.009	.320***	.356**	.045	.371***	.342***
	N	586	556	535	540	588	588
Incentive brought by recycling	Correlation		.304***	.192***		.304***	.206***
	N		541	519		575	575

Correlation analysis using Pearson

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 4-8 Predictive models on separation behavior

Outcome variables / Predictor variables	Unstandardized coefficients (B) by logistic regression		
	Leftover food separation	Higher participation group of recyclable separation	Low participation group of recyclable separation
Behavioral intention for leftover food	2.96***	–	–
Perception of information for leftover food separation	4.33***	–	–
Evaluation of trouble for leftover food separation	-0.84**	–	–
Behavioral intention for low participation group	–	–	1.80***
Perception of information for low participation group	–	–	2.55***
Behavioral intention for higher participation group	–	2.83***	–
Perception of information for higher participation group	–	3.08***	–
Constant	-12.75***	-10.40***	-6.33***
Correct percentage	98.1	96.9	95.2
Number of Cases (N)	540	549	526

–: Excluded variables, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 4-9 Predictive models on behavioral intention

Outcome variables / Predictor variables	Unstandardized coefficients (B) by multiple linear regression		
	Leftover food separation	Higher participation group of recyclable separation	Low participation group of recyclable separation
Sympathy for the collector	0.27***	–	–
Evaluation of trouble for recyclable separation	–	-0.56***	-0.54***
Incentive brought by recycling benefit	–	0.08***	0.05*
Internal norm	–	0.31***	0.15*
Perception of seriousness and responsibility	–	0.49***	0.66***
Constant	3.55***	1.29**	0.92
R Square	0.22	0.43	0.28
Number of Cases (N)	529	574	574

–: Excluded variables, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

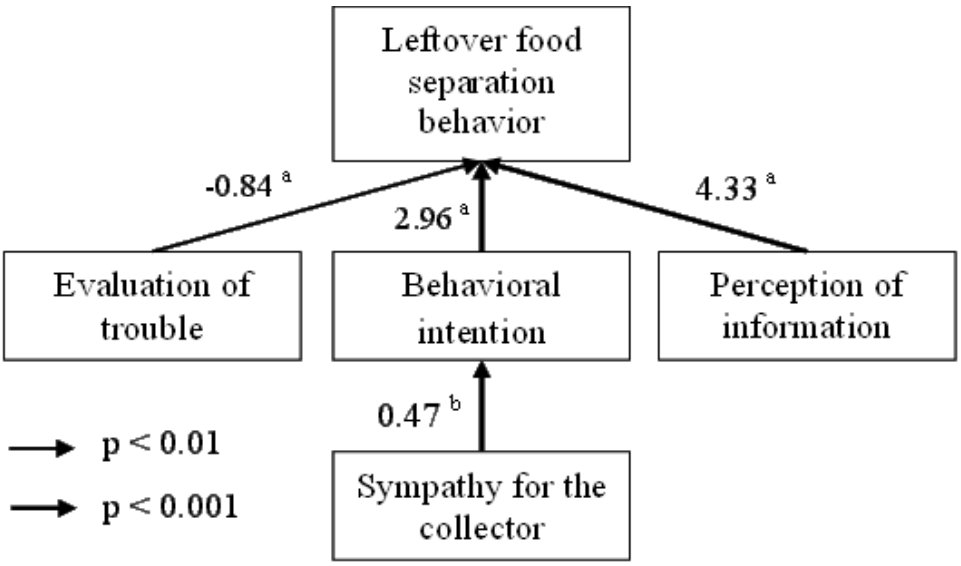


Figure 4-4 Behavior model for leftover separation

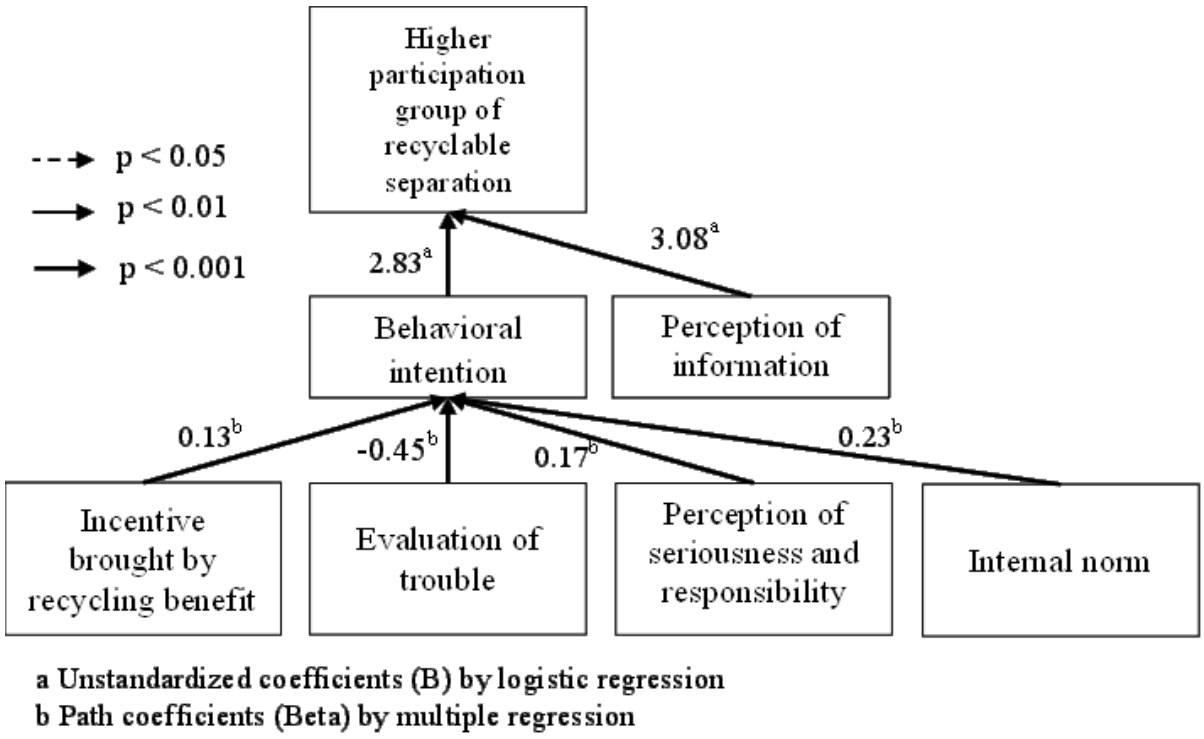


Figure 4-5 Behavior model for higher participation group of recyclable separation

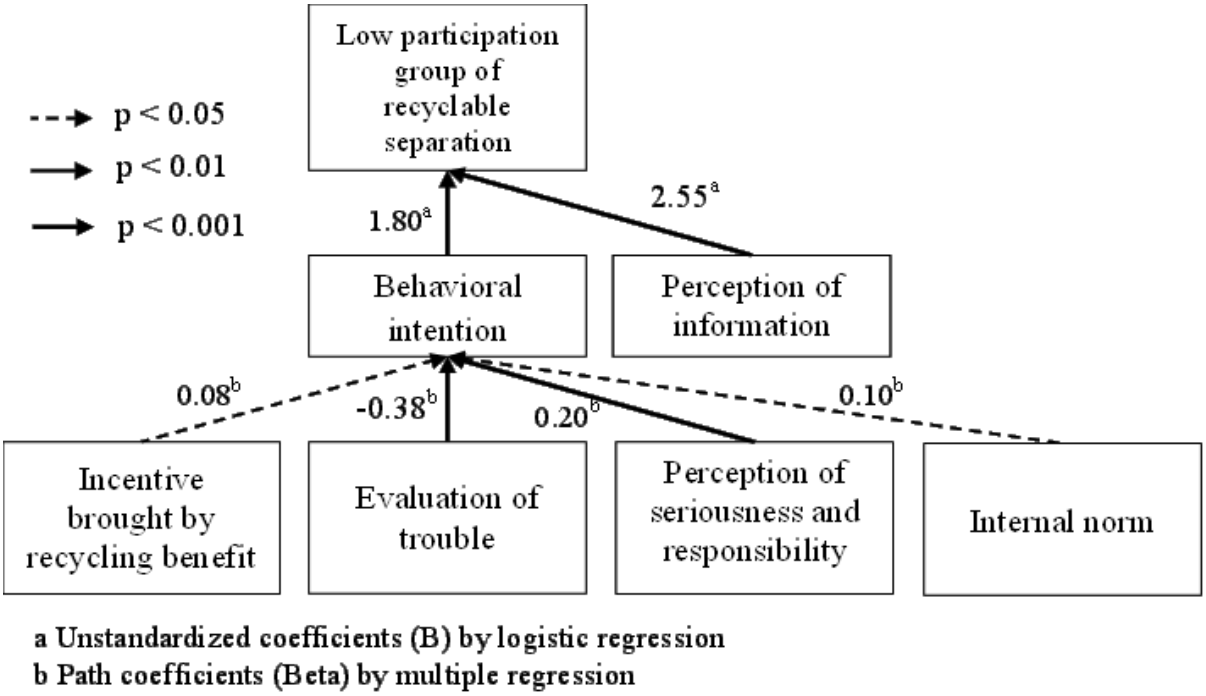


Figure 4-6 Behavior model for low participation group of recyclable separation

4.2.3 Household recognition and attitude of separation behavior

For understanding household recognition and attitude toward separation behavior, the responses are summarized in Fig. 4−7 for the factors influencing leftover food separation behavior and Fig. 4−8 for the factors influencing recyclable separation behavior. The percentages of positive/neutral/negative answers for all influencing factors were calculated. Positive answers included answers “Yes” for perception of information, “1- Strongly disagree” and “2- Disagree” for evaluation of trouble, and “4- Agree” and “5- Strongly agree” for other influencing factors, represented the responses affecting separation behavior in a positive way. Negative answers included answers “No” for perception of information, “4- Agree” and “5- Strongly agree” for evaluation of trouble, and “1- Strongly disagree” and “2- Disagree” for other influencing factors, represented the responses affecting separation behavior in a negative way. Neutral answers included answers “3- Neither agree nor disagree”.

For the factors influencing leftover food separation behavior (Fig. 4−7), over 80% of respondents provided positive answers for behavioral intention, perception of information, and sympathy for the collector. For evaluation of trouble, 53.9% were satisfied with leftover food separation and no trouble found when sorting waste; 25.5% were neutral, and 20.5% were not satisfied.

For the factors influencing recyclable separation behavior (Fig. 4−8), over 80% of respondents showed a strong positive intention to continue to separate waste and had

knowledge of how to separate waste and what to separate. In which, the behavioral intention for higher participation group showed a higher percentage of positive answers (up to 87.6%). The majority of respondents (88.0%−89.0%) provided positive answers on evaluation of trouble and internal norm. The percentage of positive answers for the incentive brought by recycling benefit was lower than other influencing factors (64.3%). This can be interpreted by the habit of waste discharge. Concerning the habit of waste discharge (Table 4−4), only about 12.0% of respondents sold recyclables to make money. The other participants gave recyclables to others without caring for money. In addition, 99.7% of respondents had positive answers for perception of responsibility and seriousness. Respondents had a high level of perception of responsibility and seriousness even they didn't join waste separation.

4.2.4 Effect measurement of the WSS program

4.2.4.1 The involvement of respondents in the WSS program

The authors categorized the level of involvement of respondents in the WSS program based on their participation in the explanatory meeting about the WSS program and whether they had received the leaflet for the program. Respondents who responded "I attended the explanatory meeting and received the leaflet" and "I attended the explanatory meeting" accounted for 16.7% and 53.0% of total respondents, respectively. Thus 69.7% of respondents attended the explanatory meeting, while the remaining 30.3% of respondents didn't know about the program.

4.2.4.2 The effect of the WSS program on waste separation rate

The authors compared the waste separation rates for respondents with different levels of involvement in the WSS program, as shown in Table 4−10. Based on the chi-squared test, the total separation rates after the WSS program differed significantly among the levels of involvement in the WSS program for all 14 recyclables.

The respondents who answered "I attended the explanatory meeting and received the leaflet" achieved almost total participation of higher participation group after the WSS program; their separation rates were 95.9% for aluminum cans, 97.0% for plastic bottles, 92.9% for magazines, 94.0% for plastic products, 92.9% for cardboard, 92.9% for newspaper, 93.8% for steel cans, 92.9% for book or photocopy paper, 92.9% for notebooks, and 91.8% for metal products. The separation rates were lower for the low participation group; 87.8% for carton, 52.0% for e-waste, 41.0% for plastic shopping bags, and 11.6% for batteries.

Meanwhile, the separation rates of higher participation group of the respondents who answered "I attended the explanatory meeting" were approximately 4.0%−8.6% lower (87.6%−88.9%). For the low participation group, the separation rates were 61.4% for carton,

67.7% for e-waste, 43.4% for plastic shopping bags, and 26.1% for batteries. Overall, for the WSS program, attendance of the explanatory meeting raised the waste separation rates of higher participation group by nearly 20% (from 68.5%−70.1% to 87.6%−88.9%).

4.2.4.3 The effect of the WSS program on the factors influencing waste separation behavior

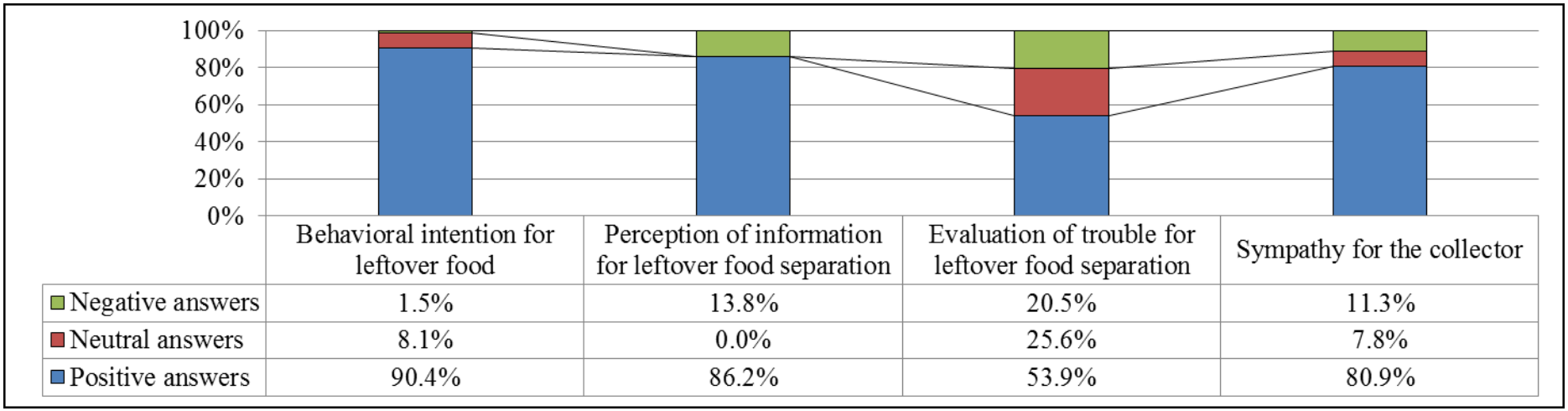
The factors influencing waste separation behavior were compared among the levels of involvement in the WSS program, as shown in Table 4−11. All of the influencing factors differed significantly among the levels of involvement: behavioral intention for low participation group ($F = 27.93$, $p < 0.001$), perception of information for low participation group ($\chi2 = 127.14$, $p < 0.001$), behavioral intention for higher participation group ($F = 44.42$, $p < 0.001$), perception of information for higher participation group ($\chi2 = 143.88$, $p < 0.001$), evaluation of trouble for recyclable separation ($F = 11.20$, $p < 0.001$), incentive brought by recycling benefit ($F = 10.02$, $p < 0.001$), internal norm ($F = 10.52$, $p < 0.001$), perception of responsibility and seriousness ($F = 8.73$, $p < 0.001$). The respondents who answered "I attended the explanatory meeting and received the leaflet" indicated the highest positive values for all of the influencing factors, followed by the respondents who answered "I attended the explanatory meeting".

In the previous study, the authors also surveyed some of the influencing factors in Da Nang City in 2016, including behavioral intention, evaluation of trouble, the incentive provided by recycling benefit, internal norm, and perception of responsibility and seriousness (excluding perception of information) as shown in Chapter 3. The data from 2016 represent the status in Da Nang City before the WSS program (section 3.2.3). In order to understand the change in the influencing factors before and after the program, the authors compared the data from 2016 with the data obtained in this study in 2018 as shown in Table 4−12 and Fig. 4−9 [21, 22]. The percentages of positive answers for all factors were calculated for both of the datasets (aggregated by the data in 2016 measured by a 7-point scale and that in 2018 by a 5-point scale).

Behavioral intention for low participation group ($\chi2 = 38.81$, $p < 0.001$), evaluation of trouble for recyclable separation ($\chi2 = 43.41$, $p < 0.001$), and perception of responsibility and seriousness ($\chi2 = 24.88$, $p < 0.001$) differed significantly before and after the WSS program, while behavioral intention for higher participation group, incentive provided by recycling benefit, and internal norm showed no significant differences (Table 4−12). Considering the percentage of positive answers by the level of involvement in the WSS program (Fig. 4−9), respondents who attended the explanatory meeting and received the leaflet showed higher percentages than those who didn't know about the WSS program. Besides, the percentages of

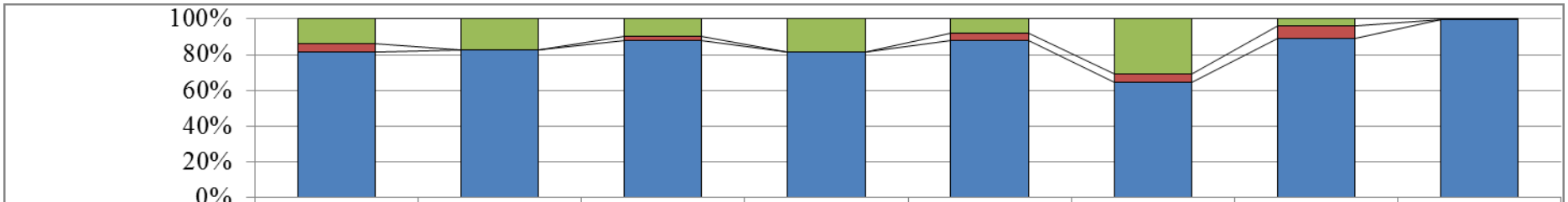
respondents provided positive answers for behavioral intention of low participation group (55.6%), evaluation of trouble (63.9%), and perception of responsibility and seriousness (94.1%) by data in 2016 were even lower than those who didn't know about the WSS program by data in 2018 (63.5%, 79.4%, and 99.4%, respectively).

The abovementioned results suggested the possibility of promotion effects of the WSS program on the influencing factors of waste separation behavior. The comparison between the data in 2016 and 2018 also provided evidence of promotion effects on behavioral intention and evaluation of trouble. Attendance of the explanatory meeting strengthened the influencing factors of waste separation behavior in the positive direction and receiving the leaflets resulted in additional enhancement of the positive effects. These promotion effects of the WSS program on the influencing factors would be the reasons for the increase in waste separation rates.



	Behavioral intention for leftover food	Perception of information for leftover food separation	Evaluation of trouble for leftover food separation	Sympathy for the collector
Negative answers	1.5%	13.8%	20.5%	11.3%
Neutral answers	8.1%	0.0%	25.6%	7.8%
Positive answers	90.4%	86.2%	53.9%	80.9%

Figure 4-7 Percentages of positive/neutral/negative answers for the factors influencing leftover food separation behavior



	Behavioral intention for low participation group	Perception of information for low participation group	Behavioral intention for higher participation group	Perception of information for higher participation group	Evaluation of trouble for recyclable separation	Incentive brought by recycling	Internal norm	Perception of seriousness and responsibility
Negative answers	13.9%	17.4%	10.0%	18.8%	8.0%	30.7%	4.0%	0.2%
Neutral answers	4.7%	0.0%	2.4%	0.0%	4.0%	5.0%	7.0%	0.2%
Positive answers	81.4%	82.6%	87.6%	81.2%	88.0%	64.3%	89.0%	99.7%

Figure 4-8 Percentages of positive/neutral/negative answers for the factors influencing recyclable separation behavior

Table 4-10 Waste separation rates by the level of involvement in the WSS program

Category	Level of involvement in the WSS program	n	Participants			Non-participants	Chi-square ($\chi 2$)
			I had already separated it before the WSS program	I started separation after the WSS program	Total percentage of participants	I don't separate it	
Aluminum cans	Total	590	72.2%	12.5%	84.7%	15.3%	62.79***
	I attended the explanatory meeting and received the leaflet	99	81.8%	14.1%	95.9%	4.0%	
	I attended the explanatory meeting	316	69.9%	18.7%	88.6%	11.4%	
	I didn't know about the WSS program	175	70.9%	0.6%	71.5%	28.6%	
Plastic bottles	Total	600	70.7%	13.8%	84.5%	15.5%	66.28***
	I attended the explanatory meeting and received the leaflet	100	77.0%	20.0%	97.0%	3.0%	
	I attended the explanatory meeting	318	69.2%	19.2%	88.4%	11.6%	
	I didn't know about the WSS program	182	69.8%	1.1%	70.9%	29.1%	
Magazines	Total	576	71.7%	12.7%	84.4%	15.6%	56.71***
	I attended the explanatory meeting and received the leaflet	98	79.6%	13.3%	92.9%	7.1%	
	I attended the explanatory meeting	311	69.8%	19.0%	88.8%	11.3%	
	I didn't know about the WSS program	167	70.7%	0.6%	71.3%	28.7%	
Plastic products	Total	595	70.3%	13.9%	84.2%	15.8%	60.67***
	I attended the explanatory meeting and received the leaflet	100	75.0%	19.0%	94.0%	6.0%	
	I attended the explanatory meeting	317	69.1%	19.6%	88.7%	11.4%	
	I didn't know about the WSS program	178	69.7%	1.1%	70.8%	29.2%	
Cardboard	Total	583	71.5%	12.7%	84.2%	15.8%	56.83***

	I attended the explanatory meeting and received the leaflet	99	78.8%	14.1%	92.9%	7.1%	
	I attended the explanatory meeting	315	69.8%	18.7%	88.5%	11.4%	
	I didn't know about the WSS program	169	70.4%	0.6%	71.0%	29.0%	
Newspaper	Total	581	71.4%	12.7%	84.1%	15.8%	58.85***
	I attended the explanatory meeting and received the leaflet	98	78.6%	14.3%	92.9%	7.1%	
	I attended the explanatory meeting	314	70.1%	18.8%	88.9%	11.1%	
	I didn't know about the WSS program	169	69.8%	0.6%	70.4%	29.6%	
Steel cans	Total	574	71.3%	12.9%	84.2%	15.9%	56.03***
	I attended the explanatory meeting and received the leaflet	97	79.4%	14.4%	93.8%	6.2%	
	I attended the explanatory meeting	309	68.9%	19.1%	88.0%	12.0%	
	I didn't know about the WSS program	168	70.8%	0.6%	71.4%	28.6%	
Book or Photocopy paper	Total	578	71.5%	12.6%	84.1%	15.9%	55.95***
	I attended the explanatory meeting and received the leaflet	98	78.6%	14.3%	92.9%	7.1%	
	I attended the explanatory meeting	311	69.8%	18.6%	88.4%	11.6%	
	I didn't know about the WSS program	169	70.4%	0.6%	71.0%	29.0%	
Notebooks	Total	584	71.2%	12.5%	83.7%	16.3%	59.34***
	I attended the explanatory meeting and received the leaflet	98	78.6%	14.3%	92.9%	7.1%	
	I attended the explanatory meeting	312	69.9%	18.6%	88.5%	11.5%	
	I didn't know about the WSS program	174	69.5%	0.6%	70.1%	29.9%	
Metal products	Total	580	70.3%	12.6%	82.9%	17.1%	58.27***
	I attended the explanatory meeting	97	79.4%	12.4%	91.8%	8.2%	

	and received the leaflet						
	I attended the explanatory meeting	314	68.5%	19.1%	87.6%	12.4%	
	I didn't know about the WSS program	169	68.6%	0.6%	69.2%	30.8%	
Carton	Total	594	56.1%	7.9%	64.0%	36.0%	43.01***
	I attended the explanatory meeting and received the leaflet	98	73.5%	14.3%	87.8%	12.2%	
	I attended the explanatory meeting	316	51.6%	9.8%	61.4%	38.6%	
	I didn't know about the WSS program	180	54.4%	1.1%	55.5%	44.4%	
E-waste	Total	552	45.8%	12.0%	57.8%	42.2%	43.11***
	I attended the explanatory meeting and received the leaflet	98	41.8%	10.2%	52.0%	48.0%	
	I attended the explanatory meeting	294	49.3%	18.4%	67.7%	32.3%	
	I didn't know about the WSS program	160	41.9%	1.2%	43.1%	56.9%	
Plastic shopping bags	Total	599	34.4%	6.5%	40.9%	59.1%	26.04***
	I attended the explanatory meeting and received the leaflet	100	25.0%	16.0%	41.0%	59.0%	
	I attended the explanatory meeting	318	36.8%	6.6%	43.4%	56.6%	
	I didn't know about the WSS program	181	35.4%	1.1%	36.5%	63.5%	
Batteries	Total	540	20.9%	1.5%	22.4%	77.6%	19.53**
	I attended the explanatory meeting and received the leaflet	95	7.4%	4.2%	11.6%	88.4%	
	I attended the explanatory meeting	287	24.7%	1.4%	26.1%	73.9%	
	I didn't know about the WSS program	158	22.2%	0.0%	22.2%	77.8%	

* The percentages in this table indicate the rates corresponding to the number of respondents indicated in the column “n”.

Table 4-11 Factors influencing waste separation behavior for different levels of involvement in the WSS program

Level of involvement in the WSS program	n	Behavioral intention for higher participation group		Perception of information for higher participation group		Behavioral intention for low participation group		Perception of information for low participation group	
		Mean	ANOVA (F)	Percentage (%)	$\chi 2$	Mean	ANOVA (F)	Percentage (%)	$\chi 2$
Total	600	4.49		81.20%		4.11		82.50%	
I attended the explanatory meeting and received the leaflet	100	4.88	44.42***	98.00%	143.88***	4.48	27.93***	98.00%	127.14***
I attended the explanatory meeting	318	4.71		92.50%		4.30		92.80%	
I didn't know about the WSS program	182	3.89		52.50%		3.58		56.30%	
Level of involvement in the WSS program	n	Evaluation of trouble for recyclable separation		Incentive brought by recycling		Internal norm		Perception of seriousness and responsibility	
		Mean	ANOVA (F)	Mean	ANOVA (F)	Mean	ANOVA (F)	Mean	ANOVA (F)
Total	600	1.44		3.50		4.62		4.74	
I attended the explanatory meeting and received the leaflet	100	1.25	11.20***	4.14	10.02***	4.95	10.52***	4.88	8.73***
I attended the explanatory meeting	318	1.35		3.48		4.58		4.72	
I didn't know about the WSS program	182	1.70		3.17		4.50		4.70	

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 4-12 Percentages of positive answers for the factors influencing waste separation behavior before and after the WSS program

Comparable data	n	Behavioral intention for low participation group		Behavioral intention for higher participation group		Evaluation of trouble for recyclable separation		Incentive brought by recycling		Internal norm		Perception of seriousness and responsibility	
		%	χ2	%	χ2	%	χ2	%	χ2	%	χ2	%	χ2
After WSS program (Data in 2018)	600	81.3%	38.81***	87.6%	0.05	88.0%	43.41***	64.3%	0.29	89.0%	0.00	99.7%	24.88***
Before WSS program (Data in 2016)	150	55.6%		86.8%		63.9%		67.0%		89.2%		94.1%	

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

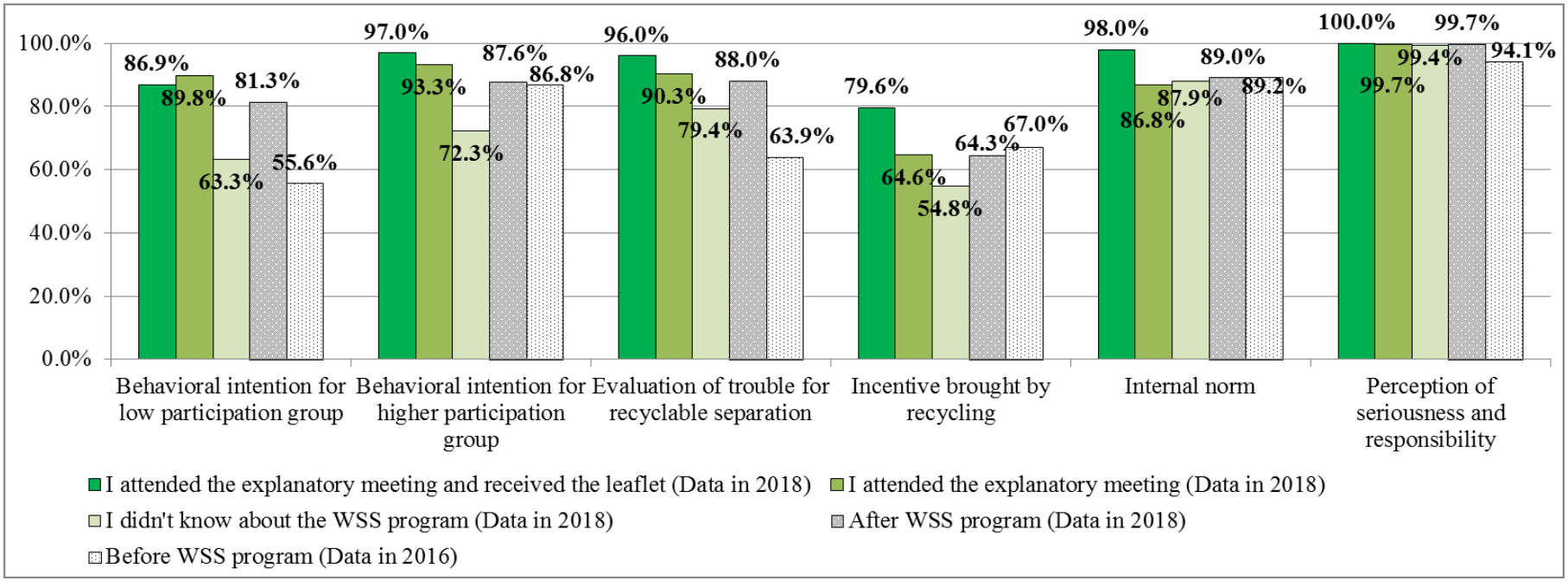


Figure 4-9 Percentages of positive answers for the factors influencing waste separation behavior before and after the WSS program

4.2.5 Waste separation rate by household's attributes

The differences in separation rates among attribute categories as shown in Table 4−2 were analyzed by the chi-square test. The results are indicated in Table 4−13. Gender, household size, working time, and ward were significant factors influencing separation behavior.

The significant influence factor for the separation behavior of leftover food was gender and household size. Male respondents and respondents in 1−2 persons families were less active in separating leftover food.

For recyclable separation of the higher participation group, the separation rate was affected significantly by gender, household size, working time, and ward. Male respondents were less active in separating these recyclable items. Respondents in 3−4 person families showed the lowest separation rate (nearly 80.0%). Indeed, 12.9% of respondents in 3−4 person families worked for a long time per day compared to only 1.6% and 6.1% of those in 1−2 person families and ≥ 5 person families, respectively. In addition, the results proved that respondents who worked more than 8 hours per day seem to separate less than others. The separation rate was over 90% in Thuan Phuoc Ward, while the separation rate in Thach Thang Ward was lowest with around 75.0%.

For the recyclable separation of the low participation group, the separation rate differed significantly by gender for carton, e−waste, and batteries, by ward for carton, e−waste, and plastic shopping bags, by working time for plastic shopping bags, and batteries, by household size for carton. Male respondents and respondents in 3−4 person families indicated the lowest separation rate. Opposite to higher participation group, respondents, who did not have job, showed the lowest separation rate.

Table 4-13 Chi-square results of separation rates and household attributes

Household attributes	Categories	Leftover food separation		Higher participation group of recyclable separation													
				Aluminum cans		*Plastic bottles*		*Magazines*		*Plastic products*		*Cardboard*		*Newspaper*		*Steel cans*	
		Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2
	Total	76.1		84.8		84.5		84.4		84.2		84.2		84.2		84.2	
Gender	Male	**68.8**	6.29**	**79.1**	5.35*	**79.5**	4.24*	**78.7**	5.22*	**79.4**	3.88*	**79.1**	4.30*	**79.0**	4.39*	**78.5**	5.30*
	Female	78.8		86.8		86.4		86.5		86.0		86.2		86.1		86.3	
Household size (person)	1–2	**68.1**	10.47**	86.4	9.86**	87.1	10.54**	86.6	10.67**	87.0	11.17**	86.8	11.23**	86.6	9.28*	85.9	10.20**
	3–4	72.3		**80.0**		**79.5**		**79.3**		**79.0**		**79.0**		**79.4**		**79.2**	
	≥5	82.7		89.8		89.5		89.7		89.4		89.6		89.1		89.5	
Working time (hours/ day)	0	79.8	1.70	86.3	16.72***	85.6	16.28**	84.8	13.98**	85.0	13.63**	84.8	13.43**	84.6	16.04***	85.2	12.82**
	≤ 8	74.7		87.4		87.7		88.1		87.6		87.7		88.2		86.9	
	> 8	79.5		**63.6**		**63.6**		**65.1**		**65.1**		**65.1**		**63.6**		**65.1**	
Ward	Thuan Phuoc	76.0	2.10	91.0	9.57	91.0	8.83	90.8	12.25*	91.0	10.14	90.9	12.68*	90.8	12.76*	90.8	11.13*
	Thach Thang	71.9		76.8		79.0		**74.2**		76.0		**74.2**		**74.2**		**75.0**	
	Hoa Cuong Bac	75.8		82.3		79.2		82.6		81.6		81.3		80.9		81.7	
	Hoa Thuan Tay	74.7		88.0		88.0		87.9		88.0		87.9		88.0		87.6	
	Thac Gian	80.0		83.7		84.0		83.8		84.0		84.0		84.0		83.0	
	Tam Thuan	78.1		86.7		86.0		86.7		84.7		86.7		86.7		86.6	

Household attributes	Categories	Higher participation group of recyclable separation						Low participation group of recyclable separation							
		Book or Photocopy paper		*Notebooks*		*Metal products*		*Carton*		*E-waste*		*Plastic shopping bags*		*Batteries*	
		Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2	Separation rate (%)	χ^2
	Total	84.1		83.8		83.0		63.9		57.9		40.8		22.4	
Gender	Male	**78.7**	4.62*	**79.1**	3.44*	**78.3**	3.24*	**57.2**	4.14*	65.8	5.06*	39.1	0.26	29.0	4.97*
	Female	86.1		85.5		84.7		66.3		**55.0**		41.5		**19.9**	
Household size (person)	1–2	85.7	11.53**	86.9	10.78**	86.2	8.28*	73.9	6.81*	61.7	0.55	46.4	5.90	26.3	1.09
	3–4	**78.9**		**78.6**		**78.3**		**58.9**		56.6		35.7		20.6	
	≥5	89.8		89.2		87.5		66.7		58.3		45.2		23.3	
Working time (hours/ day)	0	84.9	12.79**	84.6	14.30**	83.5	10.38**	63.0	1.30	54.9	3.19	**35.6**	14.44**	**15.1**	26.02***
	≤ 8	87.1		86.8		85.6		68.1		62.5		51.9		33.5	
	> 8	**65.1**		**63.6**		**65.1**		63.6		51.2		54.5		41.5	
Ward	Thuan Phuoc	90.7	12.60*	90.7	13.51*	89.8	13.82*	78.0	14.01*	63.2	13.33*	39.0	12.53*	17.9	10.72
	Thach Thang	**74.2**		**74.2**		**75.3**		**54.1**		58.1		38.0		26.9	
	Hoa Cuong Bac	80.9		78.9		**75.3**		64.4		**46.4**		50.5		12.6	
	Hoa Thuan Tay	88.0		88.0		87.9		58.6		67.8		36.0		30.5	
	Thac Gian	83.7		83.7		82.5		63.0		62.8		50.0		24.2	
	Tam Thuan	86.7		86.7		86.6		64.9		49.4		**31.3**		23.5	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The lowest value of separation rate appears in bold.

4.3 Conclusions and comments

4.3.1 Political implications/suggestions

The WSS program consisting of an explanatory meeting and the distribution of leaflets played an important role in improving the waste separation rate. However, the program could be well-organized by considering the following suggestions:

Regarding involvement in the WSS program, one-third of respondents were not informed about the WSS program, and the leaflets were received only by 16.7% of respondents. To improve the waste separation rate, it is important to promote participation in the WSS program and raise awareness of the leaflets through enhanced efforts such as more frequent and convenient explanatory meetings and leaflet distribution to all residents.

Regarding the effect of the WSS program on waste separation behavior and its influencing factors, the perception of information and behavioral intention were two important factors. A stronger behavioral intention and increased knowledge about waste separation would promote the waste separation rate. This suggests that the understanding of the waste separation method should be enhanced via repeated and close (e.g., face-to-face) communication with residents. Moreover, a higher evaluation of trouble could prevent respondents from participating in waste separation. WSS should focus on providing services to make the waste separation more convenient (e.g., having a place for recyclable storage outside of the house, flexible times for disposing of recyclables, and a collection system based on discussion with residents and recyclers).

Regarding the effects of attributes on waste separation behavior, male residents, residents in 3−4 persons families, residents who did not have job and who worked more than 8 hours per day should be put in high priority for the expansion of WSS program. Waste management authorities should verify that sufficient information about the program needs to be delivered to the abovementioned residents.

The investigation and comparison of the influencing factors of waste separation behavior through a two-phase panel survey before and after implementation of the WSS program would provide clearer analysis. As a future task, effect measurement through the collection of two-phase survey data should be implemented.

4.3.2 Conclusion

This study focused on the effects of a WSS program on waste separation behavior and its influencing factors. The authors conducted a questionnaire survey of 602 households in 6 wards with a WSS program administered by the local community in Da Nang City, Vietnam.

The major findings were indicated as follows:

1) The WSS program was introduced by organizing an explanatory meeting and distributing a leaflet about the program. Two-thirds of respondents had attended the explanatory meeting, while the remaining one-third didn't know about the program.

2) The separation rate of leftover food separation was 76.1%. Most people participated in leftover food separation voluntarily without material benefits.

3) The separation rate before the WSS program was 70.3%−72.3% for aluminum cans, plastic bottles, magazines, plastic products, cardboard, newspaper, steel cans, book or photocopy paper, notebooks, and metal products, followed by carton (56.0%), e-waste (45.9%), plastic shopping bags (34.3%), and batteries (20.9%). After the WSS program, the separation rate significantly increased by 12.5%−13.9% for recyclable items with higher separation rates, 7.9% for carton, 11.9% for e-waste, 6.5% for plastic shopping bags and 1.5% for batteries..

4) Based on the behavior modeling, the positive factors of leftover food separation behavior included behavior intention, perception of information, and sympathy for the collector. The negative factor was the evaluation of trouble. Regarding the behavior of recyclable separation, the factors with a positive influence were the behavioral intention, perception of information, the incentive provided by recycling benefit, internal norm, and perception of responsibility and seriousness. The negative factor was the evaluation of trouble.

5) In this WSS program, attendance of the explanatory meeting raised the separation rates by nearly 20% and also shifted the influencing factors of waste separation behavior in a positive direction. Receiving the leaflets in addition to attending the meeting enhanced the separation rate and also had positive effects on the influencing factors.

6) Regarding the effects of attributes on separation behavior:

   - For the recyclable separation of the low participation group, the separation rate differed significantly by gender, working time, and household size. Male respondents and respondents in 3−4 person families indicated the lowest separation rate. Opposite to higher participation group, respondents, who did not have job, showed the lowest separation rate.

   - For recyclable separation of the higher participation group, the separation rate was affected significantly by gender, household size, and working time. Male respondents and respondents in 3−4 person families were less active in separating

these recyclable items. In addition, respondents who worked more than 8 hours per day seem to separate less than others.

As the obtained results suggest, it is important to promote participation in the WSS program and raise awareness of the leaflets. Understanding of the waste separation method should be enhanced through repeated and close (e.g., face-to-face) communication with residents and more convenient services for waste separation should be carefully designed and provided.

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CHAPTER 5: THE PREDICTION OF THE EFFECT OF PROMOTION MEASURES ON WASTE SEPARATION BEHAVIOR

5.1 Methodology

Based on the results of effect measurement in Chapter 4, the relationship between promotion measures and the waste separation behavior and its influencing factors was suggested as shown in Fig. 5−1. This indicated that:

(1) The provision of information (through frequent and convenient explanatory meetings, and leaflet on the knowledge of waste separation, the benefits of waste separation, etc.) affected the perception of information, the incentive brought by recycling benefit;

(2) The provision of collection services (through designing the place for recyclable storage outside of the house, flexible times for disposing of recyclables, etc.) affected the evaluation of trouble;

(3) The promotion of environmental awareness (through public relations, etc.) affected the perception of seriousness and responsibility, the internal norm.

These proposed promotion measures were assumed to affect the exogenous factors, including *perception of information, the incentive brought by recycling benefit, evaluation of trouble, the perception of seriousness and responsibility, and the internal norm*, which impacted the waste separation behavior directly or via the behavioral intention.

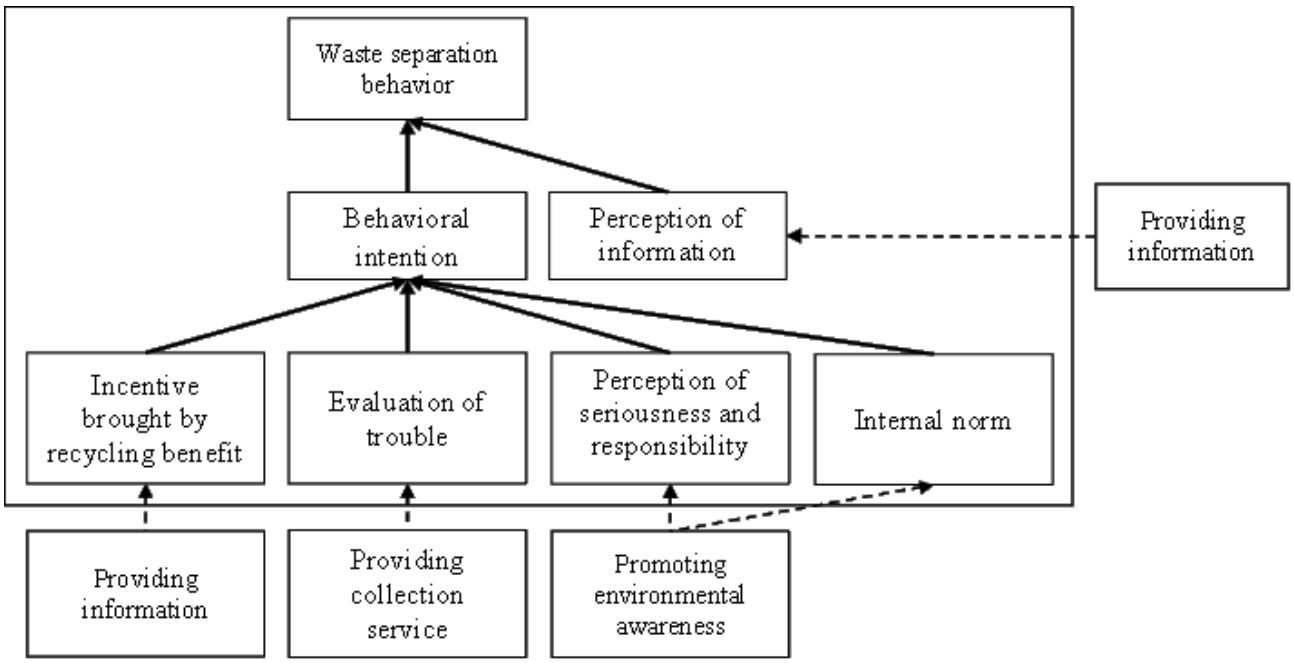

Figure 5-1 Relationship between promotion measures and influencing factors of waste separation behavior

Analytical procedure

Based on the data on waste separation behavior and its influencing factors provided in Chapter 4, the predictive models by logistic regression analysis were developed for 14 recyclable items. The exogenous factors were used as candidate's predictors of the models. The models predicted the probability of individuals participating in waste separation. The logistic regression equation from which the probability of *y* is predicted is given by:

$$\textit{Equation 1:} \quad P(y) = \frac{1}{1+e^{-(w_0+w_1*x_1^{(i)}+w_2*x_2^{(i)}+\cdots+w_n*x_n^{(i)})}}$$

in which *P(y)* is the probability of *y* occurring, *e* is the base of natural logarithms, w_0 is the constant, w_n is the regression coefficient of the corresponding predictor variable x_n, x_n is the value of the predictor variables.

The potential effects of promotion measures on waste separation rate were estimated through sensitivity analysis of the predictive models. This aimed to find out how separation rate changed when each predictor variable (value of x_n) was maximized or minimized.

In addition, the waste generation amount by these 14 recyclable categories in Da Nang City was shown based on surveyed data in 2016. The potential amount of separated waste by promotion measures was estimated by multiplying "the predicted waste separation rate by promotion measures" by "the waste generation amount of corresponding recyclable category". The equation is:

$$\textit{Equation 2:} \quad WG_n^i = P_n^i \times WGR_n^i$$

in which, *WG* is the potential amount of separated recyclable waste by promotion measures, *P* is the predicted waste separation rate by promotion measures, *WGR* is the waste generation amount of corresponding recyclable category, *n* is recyclable categories, *i* is the promotion measures.

5.2 Results and discussion

5.2.1 Predictive models on separation behavior for 14 recyclable items

The predictive models on separation behavior were developed by logistic regression as shown in Table 5−1.

For higher participation group including aluminum cans, plastic bottles, magazines, plastic products, cardboard, newspaper, steel cans, book/photocopy paper, notebooks, and metal products, the positive predictors were perception of information, incentive brought by recycling benefit, perception of seriousness and responsibility, and internal norm. The negative predictor included evaluation of trouble.

The separation behavior of carton was predicted by perception of information, evaluation of trouble, and perception of seriousness and responsibility, while the separation behaviors of e-waste, plastic shopping bags, and batteries were predicted by perception of information and evaluation of trouble

5.2.2 Effects of proposed promotion measures for recycling on waste separation rate

According to the relationship between promotion measures and the influencing factors of waste separation behavior in Fig. 5−1, the following assumptions were considered as calculated conditions for sensitivity analysis:

1) Perception of information is maximized – the knowledge of how to separate waste and what to separate is complete perceived by all respondents. The value is "1−Yes".
2) Incentive brought by recycling benefit is maximized – the understanding of recycling benefit provides the incentive for participation in the waste separation of all respondents. The value is "5− Strongly agree".
3) Evaluation of trouble is minimized – the convenience for recycling is secured for all respondents. The value is "1− Strongly disagree".
4) Perception of seriousness and responsibility is maximized − the environmental risks and responsibility for waste problems are complete perceived by all respondents. The value is "5− Strongly agree".
5) Internal norm is maximized − Normative conscience on recycling and responsibility for recycling are complete perceived by all respondents. The value is "5− Strongly agree".

The sensitivity analysis of predictive models was conducted and the predicted waste separation rates were calculated as indicated in Table 5−2. The results indicated that the "Maximization of Perception of information" have the largest impact on waste separation rate of all 14 recyclable categories; an increase by 6.1%−9.5% for higher participation group, 29.0% for carton, 26.5% for e-waste, 33.5% for plastic shopping bags, and 49.0% for batteries. The highest priority should be given to ensure that the knowledge related to waste separation is fully provided to everyone.

The second largest effect is shown by "Minimization of Evaluation of trouble"; an increase by 4.4%−5.8% for higher participation group, 1.6% for carton, 2.5% for e-waste, 5.1% for plastic shopping bags, and 7.7% for batteries. By "Maximization of Incentive brought by recycling benefit", the waste separation rate is expected to increase by

2.4%−5.9%. The smaller effect is defined by “Maximization of Perception of seriousness and responsibility” and “Maximization of Internal norm” with an increase by 1.5%−3.1% and 1.6%−3.4%, respectively. To further promote waste separation behavior, additional promotion measures aimed to minimize the trouble, maximize the perception and internal norm should be considered.

Table 5-1 Predictive models on waste separation behavior by logistic regression analysis

Outcome variables / Predictor variables		Unstandardized coefficients (B) by logistic regression						
		Aluminum cans	Plastic bottles	Magazines	Plastic products	Cardboard	Newspaper	Steel cans
Perception of information (x_1)	w_1	4.37***	5.37***	4.66***	4.80***	4.74***	4.71***	4.55***
Evaluation of trouble (x_2)	w_2	-1.68***	-1.88***	-1.63***	-1.66***	-1.63***	-1.65***	-1.64***
Incentive brought by recycling benefit (x_3)	w_3	0.48**	0.47**	0.42**	0.42**	0.44**	0.43**	0.48**
Perception of seriousness and responsibility (x_4)	w_4	1.48**	2.09***	1.80**	1.73**	1.74**	1.79**	1.67**
Internal norm (x_5)	w_5	1.05***	1.11***	1.04***	1.06***	1.02***	1.04***	0.95***
Constant	w_0	-10.50***	-13.56***	-11.97***	-11.84***	-11.78***	-11.97***	-11.20***
Correct percentage		95.1	94.8	94.5	94.5	94.7	94.5	94.8
Number of Cases (N)		573	581	559	578	566	564	557
Outcome variables / Predictor variables		Unstandardized coefficients (B) by logistic regression						
		Book or Photocopy paper	Notebooks	Metal products	Carton	E-waste	Plastic shopping bags	Batteries
Perception of information (x_1)	w_1	4.68***	4.43***	4.40***	4.58***	2.78***	3.41***	3.22**
Evaluation of trouble (x_2)	w_2	-1.63***	-1.55***	-1.55***	-1.13***	-0.89***	-0.74***	-0.84**
Incentive brought by recycling benefit (x_3)	w_3	0.44**	0.47***	0.53***	–	–	–	–
Perception of seriousness and responsibility (x_4)	w_4	1.72**	1.54**	1.23*	1.17**	–	–	–
Internal norm (x_5)	w_5	1.03***	0.94***	0.79**	–	–	–	–
Constant	w_0	-11.68***	-10.63***	-8.89***	-5.86**	-0.26	-1.73***	-1.99***
Correct percentage		94.3	94.4	94.0	90.6	80.7	78.8	84.1
Number of Cases (N)		561	567	563	593	553	599	540

–: Excluded variables, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 5-2 Effect of promotion measures on waste separation rate through sensitivity analysis of the models

Calculated condition of predictor variables		Predicted waste separation rate						
		Aluminum cans	Plastic bottles	Magazines	Plastic products	Cardboard	Newspaper	Steel cans
Predicted waste separation rate by original data		88.7%	88.6%	88.9%	88.8%	87.8%	88.7%	88.0%
Providing information	Maximization of Perception of information (x_1 = 1 for all respondents)	94.8% (+6.1%)	95.7% (+7.1%)	95.7% (+6.8%)	95.7% (+6.9%)	95.7% (+7.9%)	95.7% (+7.0%)	95.5% (+7.5%)
	Maximization of Incentive brought by recycling benefit (x_3 = 5 for all respondents)	92.1% (+3.4%)	91.0% (+2.4%)	91.7% (+2.8%)	91.4% (+2.6%)	91.7% (+3.9%)	91.7% (+3.0%)	91.6% (+3.6%)
Providing collection service	Minimization of Evaluation of trouble (x_2 = 1 for all respondents)	94.5% (+5.8%)	93.5% (+4.9%)	94.5% (+5.6%)	94.3% (+5.5%)	92.9% (+5.1%)	94.5% (+5.8%)	92.8% (+4.8%)
Promoting environmental awareness	Maximization of Perception of seriousness and responsibility (x_4 = 5 for all respondents)	90.2% (+1.5%)	91.0% (+2.4%)	90.9% (+2.0%)	91.0% (+2.2%)	90.9% (+3.1%)	90.7% (+2.0%)	90.7% (+2.7%)
	Maximization of Internal norm (x_5 = 5 for all respondents)	92.1% (+3.4%)	90.2% (+1.6%)	91.4% (+2.5%)	91.4% (+2.6%)	90.4% (+2.6%)	91.2% (+2.5%)	90.2% (+2.2%)
Calculated condition of predictor variables		Predicted waste separation rate						
		Book or Photocopy paper	Notebooks	Metal products	Carton	E-waste	Plastic shopping bags	Batteries
Predicted waste separation rate by original data		88.8%	87.7%	85.8%	62.1%	61.7%	52.1%	28.7%
Providing information	Maximization of Perception of information (x_1 = 1 for all respondents)	95.7% (+6.9%)	95.5% (+7.8%)	95.3% (+9.5%)	91.1% (+29.0%)	88.2% (+26.5%)	85.6% (+33.5%)	77.7% (+49.0%)
	Maximization of Incentive brought by recycling benefit (x_3 = 5 for all respondents)	91.7% (+2.9%)	91.7% (+4.0%)	91.7% (+5.9%)	–	–	–	–
Providing collection service	Minimization of Evaluation of trouble (x_2 = 1 for all respondents)	94.5% (+5.7%)	92.9% (+5.2%)	90.2% (+4.4%)	63.7% (+1.6%)	64.2% (+2.5%)	57.2% (+5.1%)	36.4% (+7.7%)
Promoting environmental awareness	Maximization of Perception of seriousness and responsibility (x_4 = 5 for all respondents)	90.9% (+2.1%)	90.7% (+3.0%)	88.6% (+2.8%)	62.6% (+0.5%)	–	–	–
	Maximization of Internal norm (x_5 = 5 for all respondents)	91.4% (+2.6%)	90.2% (+2.5%)	87.9% (+2.1%)	–	–	–	–

* The predicted effects of each promotion measure on waste separation rate are indicated in parenthesis.

5.2.3 Estimation of separated waste amount by proposed promotion measures

As the basis for estimation of separated waste amount by proposed promotion measures, the waste generation rate (WRG) of Da Nang city was presented in previous study in 2016. WGR by 10 physical compositions for 7 consecutive days is presented in weight (g/capita/day) and percentage as shown in Table 5−3. The average of total HSW generation was 231.49 g/cap/day for an average of 4.6 residents per household of 150 target samples. Regarding the physical categories, food waste contributed the largest part of the total HSW generation with around 157.95 g/cap/day (68.23%), following by plastic (10.95%), paper (9.4%), grass and wood (5.87%), textile (1.58%), miscellaneous (1.3%), glass (1.18%), metal (0.95%), rubber and leather (0.32%), and ceramic (0.23%). The HSW categories, generation rate, and percentage by 66 detailed compositions are also illustrated in Table 5−4.

Table 5-3 WGR by physical categories

Physical categories	WGR (g/cap/day)		
	Mean	SD	%
Plastic	25.34	32.57	10.95%
Paper	21.75	32.57	9.40%
Kitchen waste (Food waste)	157.95	143.27	68.23%
Rubber and leather	0.74	3.77	0.32%
Grass and wood	13.59	40.03	5.87%
Textile	3.66	11.19	1.58%
Metal	2.20	4.39	0.95%
Glass	2.72	8.09	1.18%
Ceramic	0.54	2.97	0.23%
Miscellaneous	3.01	7.92	1.30%
Total waste	231.49	186.99	100.00%

Table 5-4 Household solid waste categories and generation rate

Category	Sub-category	Code	Detail	g/cap/day	%
Plastic	*Container & Packaging*	*101*	PET bottle (colorless)	1.55	0.67%
		102	Other plastic bottle (recyclable)	1.32	0.57%
		102a	Other plastic bottle (non-recyclable)	0.02	0.01%
		103	Foam tray	0.50	0.22%
		104	Tube	0.12	0.05%
		105	Other shape of containers (recyclable)	0.16	0.07%
		105a	Other shape of containers (non-recyclable)	0.47	0.20%
		106	Shopping plastic bags (recyclable)	12.33	5.33%
		107	Other plastic packaging (recyclable)	3.41	1.47%
		107a	Other plastic packaging (non-recyclable)	2.67	1.15%
		108	Other containers and packaging	0.24	0.10%
	Plastic product	*109*	Plastic product	0.26	0.11%
		109a	Plastic product (non-recyclable)	1.08	0.47%
		110	Plastic bags for waste	0.14	0.06%
	Other plastics	*111*	Other plastics	1.07	0.46%
Paper	*Container & Packaging*	*201*	Carton (beverage and food)	2.72	1.18%
		202	Containers	2.03	0.88%

Category	Sub-category	Code	Detail	g/cap/day	%
		203	Cardboard	0.92	0.40%
		204	Packaging	0.06	0.03%
		205	Other containers and packaging	0.26	0.11%
	Product	*206*	Newspapers/Advertising (Ad supplied with newspaper)/ Magazines	2.64	1.14%
		207	Books	0.17	0.07%
		208	Notebooks	0.25	0.11%
		209	Photocopy paper/OA paper	1.29	0.56%
		210	Disposal paper products	2.65	1.15%
		210a	Nappies/Diapers	6.88	2.97%
		211	Other paper product	0.45	0.20%
	Other Paper	*212*	Other Paper	1.43	0.62%
Kitchen waste (food waste)	Compostable	301	Kitchen waste (food waste)	152.65	65.94%
		301a	Unused food (expired food)	4.45	1.92%
	Non-compostable	*302*	Large/hard bones of animal or shell	0.84	0.36%
Rubber and leather		*401*	Rubber and leather (recyclable)	0.70	0.30%
		401a	Rubber and leather (non-recyclable)	0.04	0.02%
Grass and wood	Garden waste	501	Garden waste	8.97	3.87%
	Containers and Packaging	*502*	Containers and packaging by grass	2.30	0.99%
		502a	Containers and packaging by wood	0.11	0.05%
	Products and Others	*503*	Grass products and others	0.00	0.00%
		504	Wood products and others	2.21	0.96%
Textile		*601*	Textile	3.66	1.58%
Metal	*Aluminum*	*701*	Containers	0.98	0.42%
		701a	Other containers and packaging	0.05	0.02%
		702	Durable Products and others	0.06	0.03%
		703	Consumable products and others	0.00	0.00%
	Steel	*704*	Containers	0.18	0.08%
		705	Durable Products and others	0.04	0.02%
		706	Consumable products and others	0.02	0.01%
	Stainless	*707*	Products and others	0.12	0.05%
	Lead	*708*	Products and others	0.06	0.02%
	Other metals	*709*	Other metals (recyclable)	0.40	0.17%
		709a	Other metals (Non-recyclable)	0.10	0.04%
		709b	Batteries (small)	0.06	0.02%
		709c	Accumulator	0.06	0.03%
		709d	E-waste	0.07	0.03%
Glass	*Container*	*801*	Returnable bottle	0.89	0.39%
		802	Disposable bottle	0.91	0.39%
		803	Other containers	0.55	0.24%
	Products and others	*804*	Products and others	0.20	0.09%
		804a	Thermometers, Fluorescent lamp, broken glass [Hazardous waste]	0.17	0.07%
Ceramic	*Container*	*901*	Containers	0.03	0.02%
	Products and Others	*902*	Products and others	0.51	0.22%
Miscellaneous		*1001*	Other combustibles	0.86	0.37%
		1002	Other liquids	0.53	0.23%
		1003	Other incombustibles (excluding ash)	0.69	0.30%
		1003a	Ash	0.50	0.22%
		1004	Medical care (syringe, needle, …)	0.03	0.01%
		1005	Others	0.39	0.17%
Total				231.49	

Based on the data in Table 5−4, the author summarized the generation amount by g/cap/day for 14 recyclable categories which surveyed in the questionnaire as shown in Table 5−5. The expected amount of separated recyclable waste by promotion measures was

calculated based on equation 2. The results were indicated in Fig. 5−2. Providing the information would have the largest potential of separated recyclables amount. By providing the information, the total amount of recyclable can be separated was up to 22.15 g/cap/day, equivalent to 9.6% of total waste generation amount (231.49 g/cap/day). By providing collection service, the total amount of recyclable can be separated was about 17.86 g/cap/day, equivalent to 7.7% of total waste generation amount. By other promotion measures, the total amount of separated recyclable waste was 4%−4.5%.

Table 5-5 Recyclable generation amount per capita (g/cap/day)

Recyclable categories	Aluminum cans	Plastic bottles	Plastic products	Cardboard	Magazines	Newspaper	Steel cans
Generation amount (g/cap/day)	0.98	2.87	0.26	0.92	2.64		0.18
Recyclable categories	Book or Photocopy paper	Notebooks	Metal products	Carton	E-waste	Plastic shopping bags	Batteries
Generation amount (g/cap/day)	1.46	0.25	0.52	2.03	0.07	12.33	0.06

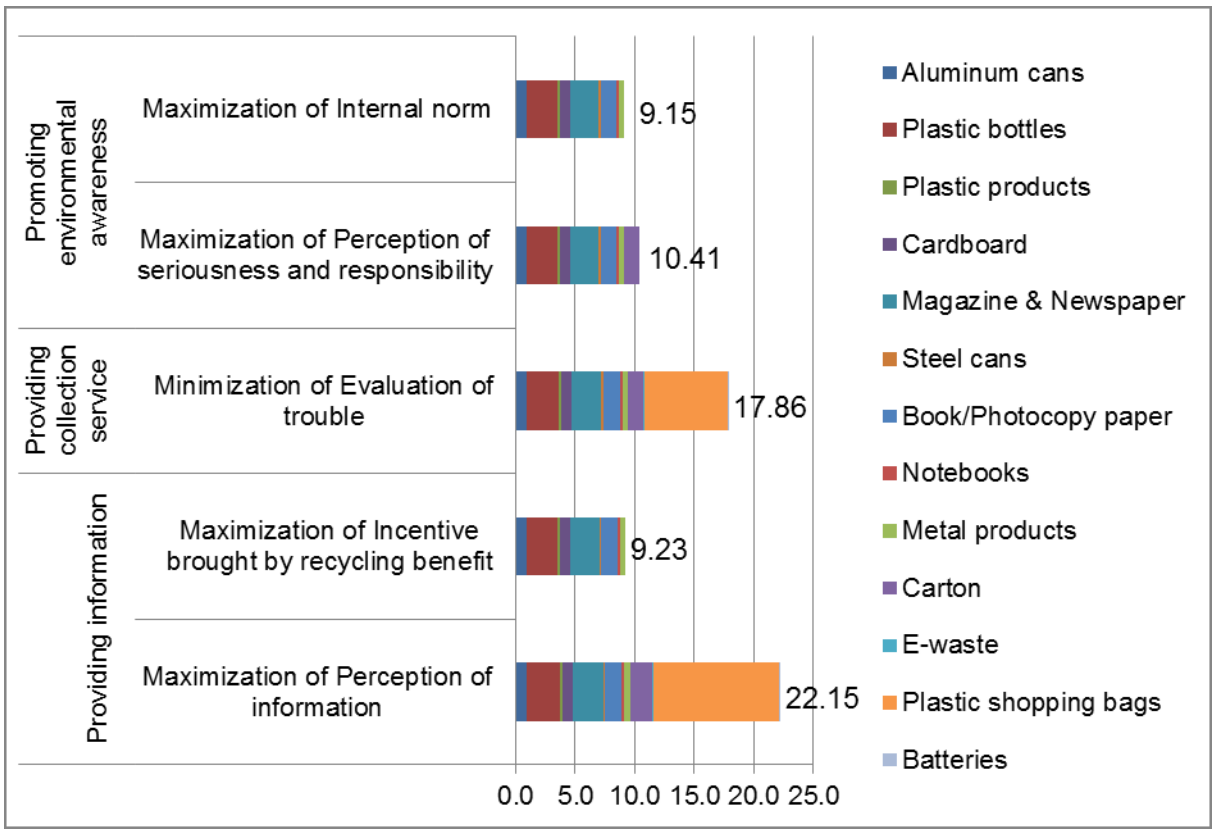

Figure 5-2 The expected amount of separated recyclable waste by promotion measures (g/cap/day)

5.3 Conclusion

The major findings were indicated as follows:

1) Promotion measures were proposed as follows: (1) The provision of information (through frequent and convenient explanatory meetings, and leaflet on the knowledge of waste separation, the benefits of waste separation, etc.); (2) The provision of collection services (through designing the place for recyclable storage outside of the house, flexible times for disposing of recyclables, etc.); (3) The promotion of environmental awareness (through public relations, etc.).

2) These proposed promotion measures were assumed to affect the exogenous factors, including *perception of information, the incentive brought by recycling benefit, evaluation of trouble, the perception of seriousness and responsibility, and the internal norm*, which impacted the waste separation behavior directly or via the behavioral intention.

3) The predictive models by logistic regression analysis were developed for 14 recyclable items based on the exogenous factors. The potential effects of promotion measures on waste separation rate were estimated through sensitivity analysis of the predictive models. The results indicated that the "Maximization of Perception of information" have the largest impact on waste separation rate of all 14 recyclable categories with an increase by 6.1%−9.5% for higher participation group and 26.4%−49.0% for low participation group. The second largest effect is shown by "Minimization of Evaluation of trouble" with an increase by 4.4%−5.8% for higher participation group and 1.6%−7.7% for low participation group; followed by "Maximization of Incentive brought by recycling benefit" with an increase by 2.4%−5.9%; "Maximization of Perception of seriousness and responsibility" with an increase by 1.5%−3.1%; and "Maximization of Internal norm" with an increase by 1.6%−3.4%.

4) Based on the generation amount by g/cap/day for 14 recyclable categories, the expected amount of separated recyclable waste by promotion measures was calculated. By providing the information, the total amount of recyclable can be separated was up to 22.15 g/cap/day, equivalent to 9.6% of total waste generation amount (231.49 g/cap/day). By providing collection service, the total amount of recyclable can be separated was about 17.86 g/cap/day, equivalent to 7.7% of total waste generation amount. By other promotion measures, the total amount of separated recyclable waste was 4%−4.5%.

5) The highest priority should be given to ensure that the knowledge related to waste separation is fully provided to everyone. To further promote waste separation behavior, additional promotion measures aimed to minimize the trouble, maximize the perception and internal norm should be considered.

5.4 References for chapter 5

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CHAPTER 6: CONCLUSION

6.1 Summary of key points

In Vietnam, waste separation at source has been introduced in the national government regulation, and the Vietnam Government set the national target for a recovery rate of HSW. Vietnamese authorities of MSW promptly need to establish the explicit strategy and guidelines for waste separation at the local level. The findings of this study would support a strategy formulation aimed to enhance waste separation activities at the household level.

This study focused on the current status of household solid waste recycling behavior and its conscious modeling in Da Nang city, Vietnam. The authors conducted a questionnaire survey in 150 households in six urban districts in 2016 and 602 households in 6 wards with a WSS program administered by the local community in 2018. The major findings were indicated as follows:

The leftover food separation behavior:

1) The separation rate of leftover food separation was 77.3% in 2016 and 76.1% in 2018. No significant difference was found by time.
2) Most people participated in leftover food separation voluntarily without material benefits (nearly 70%).
3) The positive factors included behavior intention, perception of information, and sympathy for the collector. The negative factor was the evaluation of trouble.
4) Households located in high urbanization areas, male respondents and respondents in 1−2 persons families were less active in separating leftover food.

The recyclable separation behavior:

1) Waste separation rate
    - In 2016, the separation rates of recyclables differed widely among the surveyed 13 recyclables, from the lowest 13.0% for Batteries to the highest 72.5% for plastic bottles. The recyclable categories were divided into three groups: “higher participation group” including plastic bottles (72.5%) and metal cans (63.8%), “moderate participation group” including cardboard (50%), newspaper (43.8%), book/photocopy paper (38.4%), and notebooks (37.7%), and “low participation group” including plastic products (33.3%), magazines (25.4%), metal products (23.9%), e-waste (18.8%), plastic bags (15.2%), carton paper (15.2%), and batteries (13.0%).

- In 2018, the recyclable categories including aluminum cans, plastic bottles, magazines, plastic products, cardboard, newspaper, steel cans, book or photocopy paper, notebooks, and metal products were categorized as “higher participation group” with the participation rate more than 80%. Besides, 4 recyclable categories including carton (63.9.0%), e-waste (57.8%), plastic shopping bags (40.8%), and batteries (22.4%) were still defined as “low participation group”.

2) The recyclable waste disposal habit

   - In 2016, more than half of the respondents separated recyclables for giving to others for free (53.6%) and about 30% of them separated recyclables for selling to the informal sector.
   - In 2018, up to 70% of respondents engaged in waste separation without economic incentive and only about 12% of them sold recyclable waste to the informal sector.

3) The influencing factors of waste separation behavior

   - The factors with a positive influence on waste separation behavior were the behavioral intention, perception of information, the incentive provided by recycling benefit, internal norm, and perception of responsibility and seriousness. The perception of information and behavioral intention were two important factors. A stronger behavioral intention and increased knowledge about waste separation would promote the waste separation rate.
   - The negative factor was the evaluation of trouble. A higher evaluation of trouble could prevent respondents from participating in waste separation.

4) The current WSS program in 2018

   - The WSS program consisting of an explanatory meeting and the distribution of leaflets played an important role in improving the waste separation rate. Two-thirds of respondents had attended the explanatory meeting, while the remaining one-third didn’t know about the program.
   - Under the program, the residents were encouraged to separate recyclables for donating to their community or for independent direct sale to informal sectors. For donations, the women’s union or youth union of the community collected recyclables from households and sold them to the junk shop for fundraising. Normally, recyclables were collected every week or every 2 weeks via door-to-door or drop-off collection.

- By the data in 2018, the separation rates for before the WSS program were higher for "*higher participation group*" were about 70.3%−72.3%, followed by carton (56.0%), e-waste (45.9%), plastic shopping bags (34.3%), and batteries (20.9%). The promotion effects of the WSS program, represented by the increase in participation in waste separation after the WSS program, were 12.5%−13.9% for recyclable items in "*higher participation group*", 7.9% for carton, 11.9% for e-waste, 6.5% for plastic shopping bags and 1.5% for batteries.
- In this WSS program, attendance of the explanatory meeting raised the separation rates by nearly 20% and also shifted the influencing factors of waste separation behavior in a positive direction. Receiving the leaflets in addition to attending the meeting enhanced the separation rate and also had positive effects on the influencing factors.

5) The effects of attributes on waste separation behavior:
   - For the recyclable separation of the low participation group, the separation rate differed significantly by gender, working time, and household size. Male respondents and respondents in 3−4 persons families indicated the lowest separation rate. Opposite to higher participation group, respondents, who did not have job, showed the lowest separation rate.
   - For recyclable separation of the higher participation group, the separation rate was affected significantly by gender, household size, and working time. Male respondents and respondents in 3−4 persons families were less active in separating these recyclable items. In addition, respondents who worked more than 8 hours per day seem to separate less than others.
6) The potential effects of recycling promotion measures on waste separation behavior
   - Promotion measures were proposed as follows: (1) The provision of information (through frequent and convenient explanatory meetings, and leaflet on the knowledge of waste separation, the benefits of waste separation, etc.); (2) The provision of collection services (through designing the place for recyclable storage outside of the house, flexible times for disposing of recyclables, etc.); (3) The promotion of environmental awareness (through public relations, etc.).
   - The provision of information has the largest impact on waste separation rate with an increase by 6.1%−9.5% for higher participation group and 26.4%−49.0% for low participation group. The total amount of recyclable can be separated was up to 22.15 g/cap/day, equivalent to 9.6% of total waste generation amount. The highest priority

should be given to ensure that the knowledge related to waste separation is fully provided to everyone.

- By providing collection service, waste separation rate is expected to increase by 4.4%−5.8% for higher participation group and 1.6%−7.7% for low participation group. The total amount of recyclable can be separated was about 17.86 g/cap/day, equivalent to 7.7% of total waste generation amount. By other promotion measures, waste separation rate is expected to increase by1.5%−5.9%. The total amount of separated recyclable waste was 4%−4.5%. Therefore, to further promote waste separation behavior, additional promotion measures aimed to minimize the trouble, maximize the perception and internal norm should be considered.

The information obtained from this study would be necessary to contribute to city planning in terms of solid waste management, which will lead to a sustainable society with the 3R approach in the near future under the new Decree. These results would be important to design the recycling promotion program that will be the basic framework for expanding to the whole city. The program could be well-organized by considering the suggestions in Table 6−1.

Table 6-1 Remained problems of the current waste separation activities by interviews and observations, and the corresponding suggestions

Remained problems	Political implications/suggestions
(1) Problems relating to the involvement of residents in the current WSS program	
(1-1) Lack of participation in the explanatory meetings and recognition of the leaflet	(1-1) Organize more frequent and convenient explanatory meetings and leaflet distribution to all residents.
(2) Problems relating to perception of information and attitude towards waste separation	
(2-1) Poor understanding of waste separation method	(2-1) Provide sufficient skills for waste sorting, e.g. patient (repeated) and close (face-to-face) communication with residents.
(2-2) Low attitude towards waste separation (recycling benefit, internal norm, perception of responsibility and seriousness)	(2-2) Inform the information about the received amount that residents can earn from selling recyclables to promote transparency in revenue. (2-2) Establish of the information channel where citizens would be facilitated to communicate and share knowledge and experiences on waste separation to enhance the intention, the individual moral norm, the citizens' awareness, and responsibility for waste separation. (2-2) Raise awareness for 3Rs, e.g. by experience-based and attractive promotion events (2-2) Provide incentive policies such as awards for individuals or communities with outstanding achievements on waste separation to avoid the depletion of behavioral intention.
(3) Sanitary problems relating to waste separation from residents	
(3-1) Bad smell because of long storage (1−2 weeks)	(3-1) Guide resident to wash and clean recyclables before storing.
(3-2) Lack of space for storage recyclable waste inside the house and lack of time for waste separation	(3-2) Provide services to make the waste separation more convenient (e.g., having a place for recyclable storage outside of the house, flexible times for disposing of recyclables, and a collection system based on discussion with residents and recyclers).

Remained problems	Political implications/suggestions
(4) Problems relating to the collection system by communities	
(4-1) Bad odor from unwashed recyclables	(4-1) Accept only washed and clean recyclables. This enables operation in residential area.
(4-2) Unorganized and inconvenient collection system, and lack of resources for the collection system by communities: Lack of space for storage in the street, lack of equipment and vehicles, limited human resource by volunteer, i.e. lack of finance needed for recycling activity itself	(4-2) Fair allocation of revenue from recyclables among recyclers, cooperators, and community including finance for recycling and social activities. (4-2) Establish organized and convenient collection system based on the discussion with residents and junk-buyers. o Cooperate with junk-buyers for collecting recyclables door-to-door by their own vehicles. o Design collection frequency based on the discussion with residents and junk-buyers.
(5) Limitation in residents' cooperation with collectors and junk-buyers	
(5-1) Rejection for providing information and recyclables for free	(5-1) Same as (4-2) Record the collected waste amount, secure some benefits for cooperators, e.g. waste bank (recycling depot).
(5-2) Lack of cooperative attitude towards the collectors and the junk-buyers	(5-2) Foster cooperative attitude for the collectors and the junk-buyers, e.g. contraction with specific recyclers and its announcement from community leader or authorities
(6) Instability in recycling activity	
(6-1) Limited recycling activity in rain, i.e., the amount of recyclables	(6-1) Provision of equipment/vehicles workable in rain condition, cooperation from households for longer storage
(6-2) Unstable income of junk-buyers by weak negotiation power	(6-2) Enhancement of negotiation power of recyclers by networking, e.g. establishment of association for recyclers and collective negotiation
(6-3) Unstable income of junk-buyers by instable market prices of recyclables	(6-3) Reservation to mitigate market fluctuation, governmental support for compensation to recyclers in emergency case (at minimum, current cost for MSWM in Da Nang)

Remained problems	Political implications/suggestions
(7) Differences in participation by demographic characteristics	
(7-1) Lack of participation in WSS of some residents with different demographic characteristics	(7-1) Male residents, residents in 3−4 persons families, residents who did not have job and who worked more than 8 hours per day should be put in high priority for the expansion of WSS program. Waste management authorities should verify that sufficient information about the program needs to be delivered to the abovementioned residents.

6.2 Recommendation for future researches

This dissertation dealt with questionnaire survey, evaluation of the HSW separation behavior, the WSS program, and prediction of effect of recycling promotion measures with the focus on Da Nang city. Some shortcomings with regard to data and method identified, and future research of these was recommended. Some recommendations were given out for future researches, listed as follows:

1) For target sample selection, this study recommends that target households should be chosen according to the demography characteristics of the study area such as the share of household size, household income, household expenditure, etc.
2) The investigation and comparison of the influencing factors of waste separation behavior through a two-phase panel survey before and after implementation of the WSS program would provide clearer analysis. As a future task, effect measurement through the collection of two-phase survey data should be implemented.
3) Reduce and reuse behavior should be considered more in future survey.
4) 3R behavior modification project should be conducted based on the suggested promotion measures
5) Together with a questionnaire survey, a HSW quantification and characterization should be conducted. For classification categories of HSW, it was recommended that HSW should be classified into 10 physical categories and many subcategories. The classification subcategories of HSW should be also based on the classification of recycling market.