Original articles: Current status and behavior modeling on household solid-waste separation: A case study in Da Nang city, Vietnam

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Abstract

This study focused on household solid waste recycling in Da Nang city, Vietnam to assess the existing separation behavior and clarify the factors influencing the separation behavior. The authors conducted a questionnaire survey for 150 households in six urban districts, which consisted of household attributes, separation behavior, and the household's attitude on recycling and the environment.

The waste separation rates were determined for leftover food and 13 recyclable items and the recyclable disposal habit was also assessed. The separation rate of leftover food was 77.3%. Among 13 surveyed recyclable items, plastic bottles and metal cans were two popular items with higher separation rate (72.5% and 63.8%, respectively).

To identify the conscious structure and determinants of separation behavior, the authors developed a predictive model on the separation behavior of leftover food and recyclables by logistic and multiple linear regression analyses. 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 evaluation of trouble. The authors also analyzed the differences in separation rates among attributes. Based on the significant influence factors and attributes, the authors suggested how to promote separation behavior.

Keywords: Household solid waste (HSW); Waste separation at source; Behavior modeling; Factor analysis; Regression analysis.

1. Introduction

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. To address this issue, the Government of Vietnam has considered improving solid waste management (SWM) by promoting 3Rs (reduce, reuse, recycle). The Vietnam Government set the national target for recovery rate (including recycled, reused, recovered energy, or produced organic fertilizer) of household solid waste (HSW) in urban area as 85% in 2020, and 90% in 2025 in Decision No. 2149/QD-TTg [28]. In addition, the responsibility to separate solid wastes at source was mentioned in Article 95 of the Law on Environmental Protection issued in 2014 [29]. This was also specified in the Governmental Decree No. 38/2015/NĐ-CP [30]. In the Decree, HSW was required to classify into three groups; "group of disintegrable organic wastes," "group of reusable and recyclable wastes," and "remaining group." 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?"

The separation behavior of citizens is affected by various factors, which were reported in some past researches. As one of the general behavior models, Ajzen presented the theory of planned behavior, which aims to predict behavior from intentions (i.e., the intention to perform a specific behavior) [1]. In later years, several studies have demonstrated the theory's value in predicting recycling behavior. For example, Hirose suggested the model of environmental-friendly behavior, 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) [8]. In the later studies, Matsui et al. described a structural model for recycling behavior by referring to the model of Hirose [15-17]. In the suggested model shown in Fig. 1, at the first stage, "goal intention" (i.e., the general attitude toward the general waste problem) was indicated while "behavioral intention" was formed in the second stage. As the determinants of "goal intention," Matsui et al. listed "perception of seriousness and responsibility," "perception of coping efficacy," "evaluation of social norm," and "perception of neighbors' participation." The authors also stated that the "behavioral intention" was strengthened by two factors, "goal intention" and "perception of neighbors' participation" while it was weakened by "evaluation of trouble" (i.e., evaluating whether waste collection services satisfy individual's convenience). The abovementioned models were considered as the basic framework of this study.

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 [21]. In Da Nang, the waste separation rate was 77.7% for food residues [9]. The other study in Da Nang showed that about 60% of households could separate waste into organic and inorganic waste [22]. But, the abovementioned studies didn't consider the differences in separation rates among detail recyclable items and leftover food.

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 [10, 20]. The public awareness and attitude toward SWM and the 3R program were also investigated in the Mekong Delta region by Thanh et al. and in Da Nang city by Dao et al. [4, 26]. However, these authors considered limited factors compared with the studies from Matsui et al. [15-17]. 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.

Da Nang is one of the progressive cities in Vietnam regarding SWM. Da Nang People's Committee enacted the Decision on building an environmental city by 2020, of which 70% of solid waste was expected to be recycled in the 2016–2020 period [3]. To date, although there was no official separate collection system, recyclables contained in HSW are primarily handled by the informal sector. The informal sector includes junk buyers, junk shops who collect and buy recyclables from households and any other sources of recyclables (e.g., business sector, institutional sector), or waste pickers who collect recyclables at landfill sites. Some citizens have also been separating leftover food for pig farmers [11].

As the scientific basis for promoting citizens' 3R behavior in Da Nang, this study aimed to investigate the current status of separation behavior of leftover food and recyclables and its influence factors in Da Nang city, Vietnam. First, the waste separation rate and the disposal habits of leftover food and recyclables were clarified. Second, the determinant models for separation of leftover food and recyclables were developed to figure out the psychological factors affecting citizens' separation. Furthermore, the authors also analyzed the difference in separation behavior among the attribute categories including age, gender, household size, income level, working status, and urbanization level (represented by population density). Based on the abovementioned analytical results, the authors suggested the higher-priority waste categories, influence factors, and attribute categories for 3R promotion.

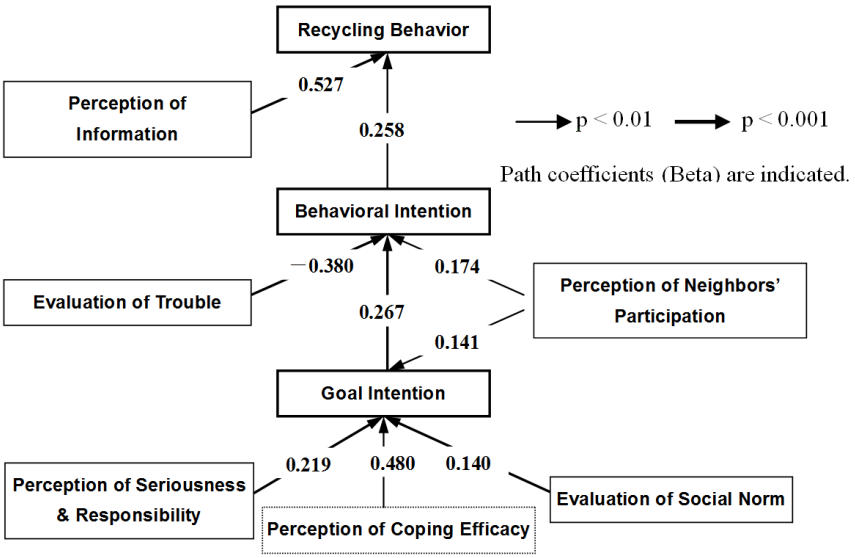


Fig. 1 Structure model of recycling behavior on the curbside collection of cans and bottles [13]

2. Methodology

2.1. Research area and sampling method

Da Nang city belongs to the Central coastal area of Vietnam with a population of 1046.2 thousand persons as of 2016 and an area of 1284.7 km2 [6]. The city of Da Nang is officially divided into eight districts: two rural districts (Hoa Vang and isolated islands), and six urban

districts, namely Cam Le, Hai Chau, Lien Chieu, Ngu Hanh Son, Son Tra, and Thanh Khe (Fig. 2). The authors focused on six urban districts (including 45 wards), which are the main sources of household solid waste in Da Nang city. The sampling points (Fig. 2) were selected by five urbanization levels by the percentile rank of population density; 10th, 30th, 50th, 70th, and 90th percentile categories [13, 14, 26]. Three sampling points were selected for each level and 10 households were selected from each sampling point. A total of 150 households were chosen.

2.2. Outline of the 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. 1 [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 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 1.

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 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."

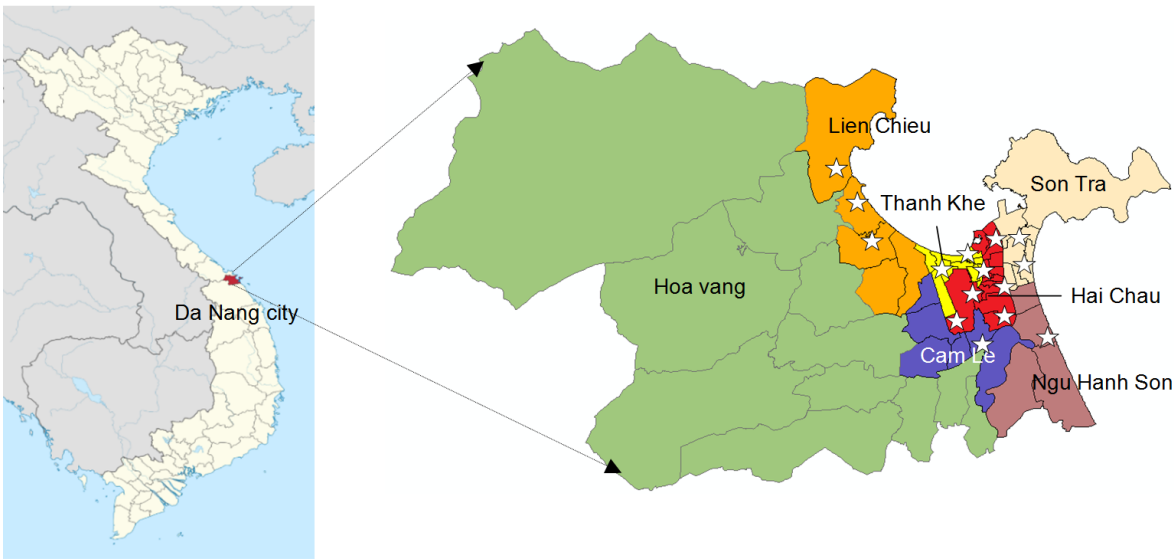


Fig. 2 Map of the mainland districts of Da Nang city, Vietnam and the location of sampling points

Table 1 Outline of the 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.

2.3. 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:

2.3.1. 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. Separation behavior of each recyclable item was defined as a dummy variable. The complete linkage method with simple matching distance as the similarity measures was 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.

2.3.2. 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.

2.3.3. 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.

2.4. 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. Results and Discussion

3.1. Current status of household solid waste separation

The attributes of respondents are summarized in Table 2. 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, Tables 3, and 4.

Regarding leftover food separation, the separation rate was 77.3%. As shown in Table 3, 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 4, 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 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 item.

Table 2 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)

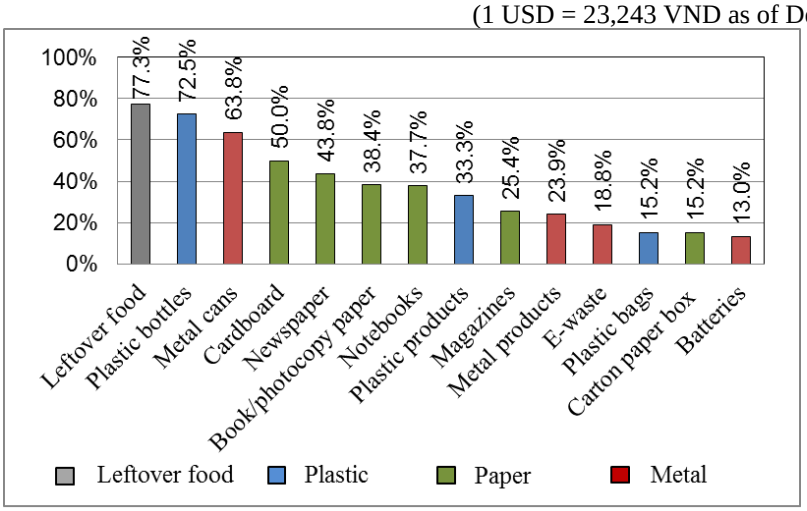


Fig. 3 Separation rate on leftover food and recyclables

Table 3 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 4 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. Waste separation behavior modeling

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

3.2.1. 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. 4. 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 5.

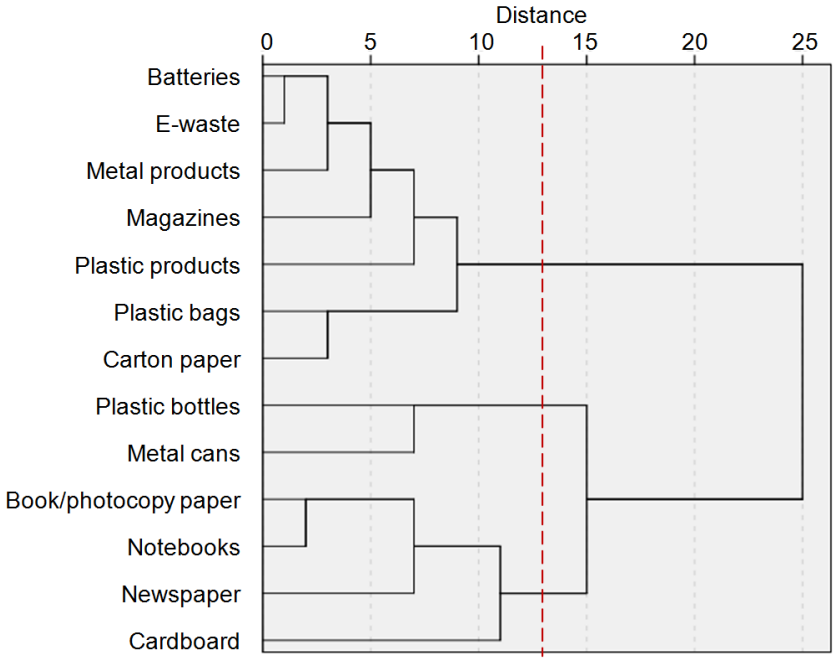


Fig. 4 Dendrogram of recyclable separation clusters

Table 5 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. 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 6 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 6: "Perception of seriousness and responsibility," "Internal norm," "Goal intention," and "Evaluation of trouble." Table 6 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 6 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.

3.2.3. Development of behavior models.

In this study, the model in Fig. 1 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 7 shows Pearson's correlation coefficients between separation behavior, behavioral intention, goal intention, and predictor variables.

According to the assumptions and correlations between variables (Table 7), the authors developed predictive models on separation behavior by logistic regression analysis and multiple linear regression analysis as shown in Table 8. The models on behavioral intention and goal intention by multiple linear regression analysis are also shown in Table 9. According to these results, the authors developed the model on separation behavior as summarized in Figs. 5, 6, 7, and 8.

Regarding leftover separation behavior (Fig. 5), 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. 5, 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 relationship with them as the basis of behavioral intention. There were no studies that examined the effect of sympathy on the behavioral intention. The similar effect would be expected in the areas where the informal sector has established friendly relationship with citizens.

Regarding the low participation group of recyclable separation (Fig. 6), the behavioral intention for plastic bags predicted the separation behavior positively ($\beta = 0.365$, $p < 0.001$). Behavioral intention for plastic bags showed the 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 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 turn into deposit, also reported the positive impact of economic benefit on recycling and waste reduction [8, 19, 32]. It is suggested that economic incentive would promote citizens' recycling activities.

Regarding the moderate participation group of recyclable separation (Fig. 7), 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 the 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. 8), 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 ($R^2 = 0.062$). 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. 8), 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 7 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 8 Predictive models on separation behavior

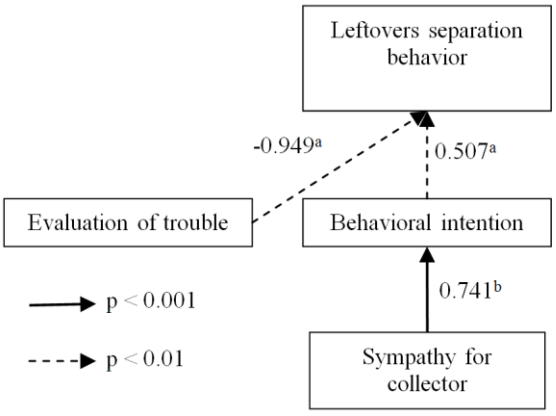
Outcome variables / Predictor variables	Unstandardized coefficients (B) by logistic regression	Unstandardized coefficients (B) by multiple linear regression		
	Leftover food separation	Low participation group of recyclable separation	Moderate participation group of recyclable separation	Higher participation 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 9 Predictive models on behavioral intention and goal intention

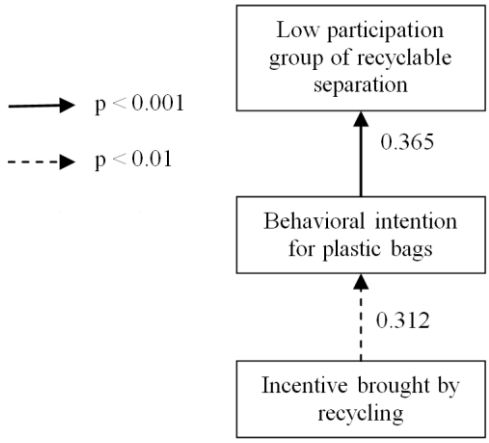
Outcome variables / Predictor variables	Unstandardized coefficients (B) by multiple linear regression				
	Behavioral intention for leftover food	Behavioral intention for recyclables	Behavioral intention for plastic bags	Behavioral intention for paper	Goal intention
Incentive brought by recycling	–	–	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

Fig. 5 Behavior model for leftover separation



Path coefficients (Beta) are indicated.

Fig. 6 Behavior model for low participation group of recyclable separation

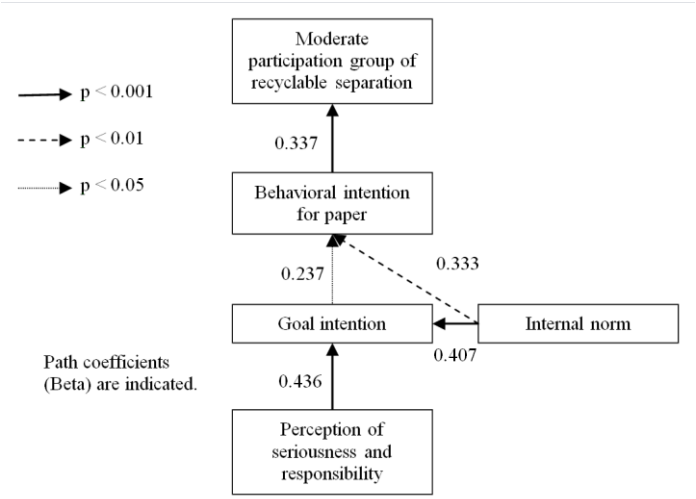


Fig. 7 Behavior model for moderate participation group of recyclable separation

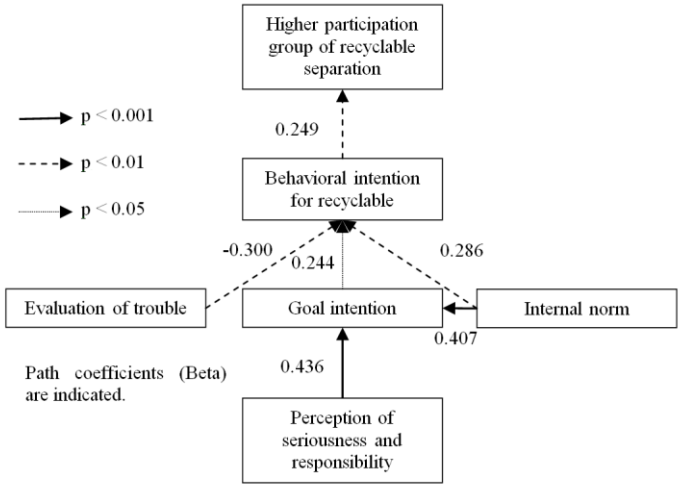


Fig. 8 Behavior model for higher participation group of recyclable separation

3.3. Waste separation rate by household's attributes

The differences on separation rates among attribute categories as shown in Table 2 (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 10. 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 separation behavior of leftover food was urbanization level ($\chi^2 = 10.44$, $p < 0.05$). Separation rate was 92.9% in level 1 of urbanization level, while separation rate in level 5 was 55.0%. Respondents at a high urbanization level were less active on separating leftover food.

For the recyclable separation of the low participation group, the separation rate differed significantly by working status for plastic products ($\chi^2 = 6.47$, $p < 0.05$), metal products ($\chi^2 = 11.82$, $p < 0.01$), and plastic bags ($\chi^2 = 3.97$, $p < 0.05$), and by urbanization level for magazines ($\chi^2 = 16.29$, $p < 0.01$) and metal products ($\chi^2 = 11.22$, $p < 0.05$). 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%).

Table 10 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.

3.4. 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 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 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 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 the behavioral intention by providing sufficient skills of 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.

4. 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:

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

2) 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%).

3) 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.

4) 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.

5) 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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