

**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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