Waste Management through Waste Segregation: Survey Analysis of a North Delhi Locality

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ABSTRACT: Waste generation and its management is a critical crosscutting concern given its impact on health, climate change, poverty reduction, food and resource security, sustainable production and consumption, environment and the concomitant economic costs associated with it. This comprehensive study using data from 708 households of a North Delhi locality examines factors that influence household behaviours related to waste segregation through a multifaceted analysis employing crosstabulation analysis and logistic regression analysis. The research explores factors influencing awareness and adoption of waste segregation practices, providing nuanced insights for effective policy formulation. Key findings highlight the intricate relationships among demographic characteristics, education, awareness, and economic factors in shaping household waste management practices. The analysis of determinants reveals the impact of household size, education levels, and the presence of senior citizens and working members on awareness about waste segregation. Additionally, infrastructure elements, such as the availability of coloured dustbins and waste disposal methods, significantly influence awareness. Waste segregation adoption patterns exhibit diverse influences, with larger households and higher self-reported awareness positively affecting practices. Policy implications derived from the analysis emphasise targeted educational programmes, income-related strategies, and tailored outreach for specific demographic groups. In conclusion, the study underscores the need for a comprehensive, multifaceted approach that considers demographic, educational, and economic factors in waste management policies. The findings contribute to fostering a culture of responsible waste management, offering practical insights for policymakers and communities striving towards environmental sustainability.

KEYWORDS: Waste management, Waste segregation, Solid Waste, Environment

1. INTRODUCTION

Economic development, coupled with urbanisation and population growth, inevitably results in increased waste generation. The simultaneous factors of growing prosperity, larger populations, increased trade, access to a variety of products, and move towards a culture of disposable consumption contribute to countries producing larger quantities of waste. Effectively managing this waste through proper disposal and/or treatment has become a critical and multifaceted concern due to its impacts on health, climate change, poverty reduction, food and resource security, sustainable production and consumption, and the associated economic costs (Van den Bergh, 2008; Wilson et al., 2015; Luttenberger, 2020).

The worlds' cities generated 1.3 billion tonnes of solid waste in 2012, which grew to 2.01 billion tonnes in 2016. Generation of solid waste is expected to go up by about 30 per cent (compared to its levels in 2016) and reach 2.59 billion tonnes in 2030 and further increase to 3.4 billion tonnes in 2050. Asia with 61 per cent of the world population, is the largest waste generating continent. Given the strong correlation between per capita waste generation and gross national income (GNI), Asian cities alone are expected to generate 1.8 billion tonnes of waste in year 2025, compared to 0.28 billion tonnes in 2012 (Hoornweg and Bhada-Tata, 2012; Modak et al., 2017).

South Asia contributed about 17 per cent of the total waste generated in the World in 2016. This amounted to 334 million tonnes of solid waste in 2016 which is projected to increase to 466 million tonnes in 2030 and further to 661 million tonnes in 2050 under a business-as-usual scenario (Figure 1). Waste generation is growing at a very rapid rate in South Asia and it is projected to double by 2050.
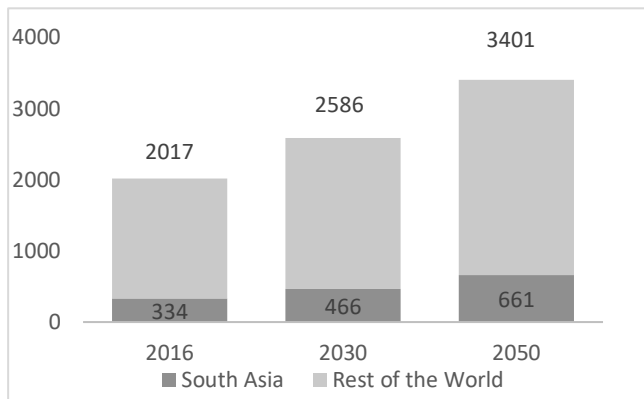
Figure 1: Projected Waste Generated by the World and South Asia

Source: Based on data from What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Kaza et al., 2018)

The waste generated averaged at about 0.74 kilograms per person per day (based on data for 2016) or about 5 per cent of global greenhouse gas emissions (UNEP, 2019). For South Asia the average was smaller at 0.52 kilograms per person per day with Maldives having the highest waste generation of 1.44 kilograms per person per day and Nepal the lowest at 0.17 kilograms per person per day (Figure 2). India had a marginally greater than the South Asian average waste generation of 0.57 kilograms per person per day.
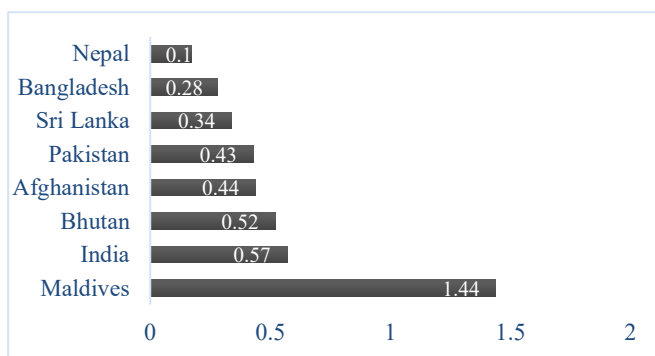
Figure 2: Waste Generation Rates (kg/per capita/ per day) for South Asia, 2016

Source: Based on data from What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Kaza et al., 2018)

Waste generation and its management is a critical crosscutting concern given its impact on health, climate change, poverty reduction, food and resource security, sustainable production and consumption, environment and the concomitant economic costs associated with it.

Simply burying waste in the ground, or creation of unpleasant landfills is not sustainable. Management of waste- from waste collection to final treatment and disposal of waste, is an indispensable component of urban development accentuating synchronization across all levels of government and stakeholders. Adopting an integrating approach especially involving the most critical stakeholders- the households is essential (Gupta et al, 2022, Visvanathan et al., 2004, Zhuang et al., 2008).

Waste segregation in terms of sorting and separation of solid waste into biodegradable and non-biodegradable components has gained immense attention given the preference for promotion of reduction and recycling practices along with composting (Mittal, 2020). The waste management challenge is particularly daunting in developing nations like India wherein 377 million people living in rapidly growing unplanned towns and cities, generate an annual municipal solid waste of 62 million tonnes. Effective segregation of waste at its source is crucial for diverting waste through diverse recycling and resource recovery channels. This process aids municipal authorities in more efficient solid waste management by facilitating the recycling of non-biodegradable components and composting of organic waste. The 2016 Solid Waste Management Rules mandate waste generators to segregate waste at the source into three categories: wet, dry, and hazardous.

This study focuses on understanding household behaviour in terms of adoption of waste segregation practices and the factors influencing the same based on a sample from a north-western locality in Delhi, India. We start by analysing existing literature on the determinants of household engagement in waste segregation in the next section. This is followed by a brief layout of the objectives of our study along with an overview of our sample households and the methodology adopted in our analysis in section 3. Our results are discussed in the subsequent section. We conclude the study by listing pertinent policy implications in section 5.

2. REVIEW OF LITERATURE

The act of waste segregation, separating wet and dry wastes, is a fundamental practice that ensures recyclability of the latter and composting of the former. The section explores existing literature on the factors influencing household participation in waste sorting, emphasizing the importance of waste management improvement. Developed higher-income countries exhibit a per capita waste generation rate at least twice that of developing countries. The consumption patterns in higher-income countries involve more resource-intensive and complex goods, such as appliances, electronic items, and durable goods like cars. In contrast,

residents of developing countries contribute to over half of the global solid waste volume in terms of aggregate production.

Saphores and Nixon (2014) conducted a study on the American economy using a 2006 national survey dataset to assess the effectiveness of household recycling policies. They found that people's attitudes toward recycling, particularly the convenience of curb-side recycling and nearby drop-off collection centres, were crucial determinants. Socio-economic variables were not statistically significant, but the study suggested revisiting deposit–refund systems to boost recycling. Wan, Shen, and Yu (2014) collected data through a primary survey to study the relationships between socio-demographic variables and recycling attitudes. Their findings, analysed using SEM, indicated that perceived policy effectiveness negatively moderated the positive relationships between subjective norms and recycling intention.

In Borås, Sweden, Rousta et. al. (2015) quantified the effects of interventions in a source separation system. They focused on decreased distance to drop-off points and improved sorting information, leading to considerable improvements in recycling behaviour. Arı and Yılmaz (2016) analysed the attitudes and behaviours of housewives in Eskişehir, Turkey, using SEM. They found positive impacts of recycling intentions on behaviours, with perceived behavioural control and subjective norms as key determinants.

Fan, Yang, and Shen (2019) employed the theory of planned behaviour to construct a theoretical model for household solid waste sorting behaviour. Using data from Shanghai and Singapore, they discovered that general and specific environmental motivations, along with contextual and habitual factors, significantly influenced behavioural intentions. Aprile and Fiorillo (2019) used the 1998 Multipurpose Household Survey to explore the impact of egoistic, altruistic, and biospheric concerns on recycling behaviour. Socio-economic variables also played a significant role in influencing household recycling actions.

In an Italian study, Bucciol et al., (2019) investigated the effect of the visibility of individual action on free riding using field data on household waste sorting. They found that peer monitoring could promote virtuous behaviour when monetary incentives were not effective in solving social dilemmas.

Batu, Admasu, and Tolosa (2016) conducted a study in Jimma, Ethiopia, involving 200 randomly selected households. Their analysis revealed that many households expressed dissatisfaction with existing solid waste management services and were willing to pay for improved door-to-door waste collection. The study recommended supporting entrepreneurs and innovators to enhance waste collection arrangements and urged the government to extend support and monitoring to businesses engaged in solid waste management.

Nsimbe et al., (2018) conducted a cross-sectional study in Masaka municipality, Central Uganda, based on data from 368 residents. Their primary survey focused on "knowledge, perceptions, and practices of composting." Using logistic regression, they identified factors influencing household-level composting behaviour and found factors such as possession of a garden, participant age, waste segregation behaviour, and peri-urban residence significantly influencing composting adoption. The study recommended targeted campaigns to promote composting, especially among younger individuals and urban residents.

Adzawla et al., (2019) investigated factors driving households' adoption of specific solid waste disposal methods, using a multinomial logit approach with a sample of 16,767 households in Ghana. Their findings emphasized the importance of educating households on solid waste management to influence waste segregation behaviour positively. Other household characteristics, such as gender, marital status, urban or rural residence, dwelling type, and location, also played a role in shaping waste disposal choices. The study advocated for improved solid waste management systems and educational initiatives by authorities and District Assemblies.

Takahashi, Nomura, and Yabe (2019) developed two home composting (HC) behaviour models based on data from 202 rural households in Hoi An, Vietnam. Using Logit and Ordered Logit models, they identified factors influencing households' decisions to participate in a HC scheme and the level of HC participation. The study highlighted the impact of factors like knowledge about HC, attitude toward it, and owning a garden.

Alhassan et al., (2020) explored factors influencing households' source separation behaviour in Accra, Ghana, involving 525 randomly selected respondents. Their analysis, employing logit and multinomial logit regression models, identified critical factors such as gender, income, monetary incentives, attitude, dwelling type, service provider, and other household location variables influencing waste segregation actions. The study recommended intensifying waste separation efforts, implementing waste minimization policies promoting the 3Rs (reduce, reuse, recycle), making waste separation mandatory, and improving the accessibility of waste separation facilities in Accra.

As per the review of literature undertaken, attitude, action, and behaviour toward different aspects of solid waste management along with behavioural and psychological factors are important factors affecting household recycling activities. Studies have also analysed the relationship between demographic variables and recycling involvement. Gender, age, education, household composition, size, income and ownership are the most commonly studied. Though the findings appear to be inconsistent. The next section discusses our empirical model considering literature suggested and other factors as determinants of waste segregation awareness as well as practice of waste segregation.

3. DATA AND METHODOLOGY OF THE STUDY

Relatively little research has been done on building effective waste management systems in India in general and Delhi in particular. Two market failures regarding solid waste management are critical in addressing the issue. Firstly, waste segregation and disposal generate negative externalities. Secondly, there is a wedge between private and external costs of waste production and disposal leading to generation and disposal of waste greater than that is socially optimal.

The objective of the present study is to assess and examine the determinants of waste segregation awareness and practice at the household level. The study aims to contribute valuable insights and recommendations for enhancing waste management systems in Delhi, with a focus on promoting effective waste segregation practices and minimizing negative externalities associated with waste disposal.

The data collection involved 708 households and utilised questionnaires and interactive sessions. Random and convenient samples were selected from different residential societies in Rohini.

The survey encompassed a total of 64 societies in Rohini (located in Sectors 9, 13, and 14) and 5 blocks (A to E) of Prashant Vihar. Notably, Prashant Vihar differed from the societies, as residents had constructed houses on their individual plots of varying sizes. From each society/block, 10-12 houses were randomly selected for data collection. In total, 708 respondents participated, with 75 households from different blocks of Prashant Vihar and the remaining 633 households from various societies.

The choice of Rohini and Prashant Vihar as the survey's focal areas was deliberate, as the Municipal Corporation of Delhi (MCD) had designated these areas as Model Wards. Consequently, households in these regions were anticipated to be more attuned to the issues and consequences associated with waste segregation and disposal.

4. DATA ANALYSIS AND RESULTS

Rohini is a sub-city in the North West district of the Union Territory of Delhi. It was established more than 40 years ago as the first sub-city project of Delhi Development Authority (DDA). The sub-city is divided into more than 50 sectors. Rohini has only Cooperative Group Housing Societies (CGHS) and block-wise plotted developments. Further, the North Delhi Municipal Corporation in 2019, decided to declare the area as a "Model Area" to serve as an example of efficient waste management.

Table 1 gives an outline of the demographic profile of our 708 household respondents. Most of the households comprised of nuclear families with up to 4 member households constituting 61 per cent of the sample. Only about 2 per cent of the households surveyed had more than 9 members. Predominantly the primary occupation of the households surveyed was Business. Around 39 per cent of the households had Service as their primary occupation. About 15 per cent of the households reported to be households with no active primary occupation or were households that listed that they had retired from active work. About 68 per cent of the households sampled had monthly family income of between ₹1 and ₹5 lakh rupees, while 20 and 12 per cent of the households had incomes of less than ₹50, 000 per month and more than ₹5 lakh per month respectively. Since the locality of Rohini chosen has primarily housing societies, households residing in flats constitute more than 90 per cent of our sample.

Table 1: Profile of Respondents based on Select Demographic Parameters (% of total Sample)

Variable	Households
Household Size	
Up to 4 Members	61.08
Between 5 & 9 Members	37.07
More than 9 Members	1.85
Primary Occupation of the Household	
Business	46.41
Service	38.75
Retired	14.84
Monthly Family Income of the Household	
Less than ₹50,000	20
Between ₹50,000 to ₹1 Lakh	33.26
Between ₹1 Lakh to ₹5 Lakhs	34.74
Above ₹5 Lakhs	12
Kind of Residence	
Flat	91.11
Independent House	8.89

Source: Authors' calculations based on survey data collected via the Household Primary Survey

Questionnaire used for the survey is designed in parts. The first part is related to demographic questions of households surveyed, such as number and composition of family members, educational level, average family income, and the kind of profession they are engaged in-service or business. The second part collected information on source separation behaviour of households, their intention, attitude towards separation and disposal of waste, awareness about of different categories of wastes and uses of composting of organic (wet) waste, society's initiative to create facility for processing wet waste. Most of the questions in this part are in terms of binary responses.

The third part of the questionnaire relates to awareness of households regarding adverse impact of inappropriate disposing off waste on factors such as, land, water and climate, realisation that mixing hazardous waste with other wastes could lead to toxic substance leakage causing harm to the environment and thus impacting the general health of public. Further, there are questions to find views regarding role of households, resident welfare associations (RWAs), the municipality (MCD) and Government in spreading information on waste segregation and difficulties faced by Households in waste segregation. The responses in this section were collected on a five-point Likert Scale. The *study employed a range of statistical and econometric tools* to analyse the collected data, including t-tests and ANOVA and Logistic Regressions.

4.1 Logistic Regression

The primary objective of logistic regression is to understand and quantify the association between the set of independent variables and the probability of an observation belonging to a specific category. In the logit model, the log odds of a particular outcome are modelled as a linear combination of the predictor variables. This allows for a systematic examination of how changes in the independent variables influence the odds of the binary outcome, facilitating a deeper understanding of the relationships within the dataset. The logit model assumes that the probability distribution of μ_i follows the logistic probability distribution.

Given that $Z_i = \alpha + \beta X_i + \mu_i$, $P_i = \frac{1}{1+e^{-Z_i}}$ ------ (1)

To estimate (1), a transformation is used.

In other words, we have $\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i}$ ------- (2)

Correspondingly, $L_i = ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \alpha + \beta X_i + \mu_i$
   is to be estimated.

Y, the dependent variable in our analysis takes three forms-

- Waste segregation Awareness
- Waste Segregation Practice

Our dependent variable thus has following two categories:

➢ y=1, if the household is aware about/practices waste segregation, and

➢ y=0, if the household is not aware about/does not practice waste segregation,

Our independent variables include the following:

- Household Size
- Education of the Head of the Household
- Proportion of Working Members in the Household
- Proportion of Children in the Household
- Kind of Residence
- Household Occupation
- Reporting Availability of Different Coloured Dustbins
- Waste Disposal Method

In models involving waste segregation practice additional variables of knowledge and awareness about waste segregation were also included.

4.2 Empirical Analysis: Understanding Factors Influencing Household Waste Segregation Behaviour

This section analyses the crosstabs-based relation between three self-reported behavioural waste segregation tendencies- Awareness about Waste Segregation and Practicing Waste Segregation on the one hand and several other household characteristics on the other. More specifically variables with which cross-tabulations are undertaken are:
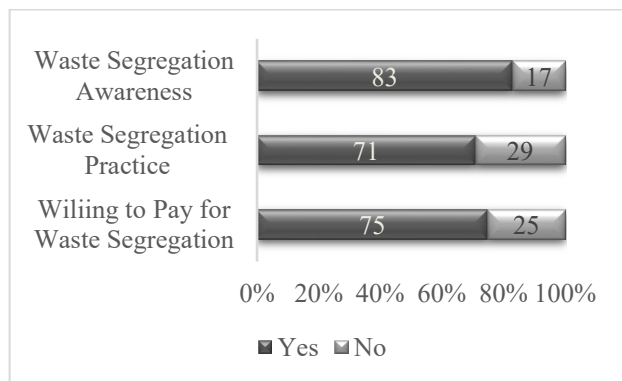
i. Household Size

ii. Primary Occupation of the Household- Business, Service, Retired

iii. Monthly Family Income

iv. Education Level of the Household

v. Kind of Residence

Figures 3 through 5 and Tables 2 through 4 present cross-tabs for the sample based on select questionnaire parameters.

Awareness about Waste Segregation, Practicing Waste Segregation and Willing to Pay for Waste Segregation

Our respondent households were asked about their respective awareness about waste segregation as well as whether they follow waste segregation practices. Figure 3 shows the results pertaining to the self-reported

behaviour of households regarding these aspects.

Source: Authors' calculations based on survey data collected via the Household Primary Survey

Figure 3: Households Self-Reporting Awareness about Waste Segregation and Practicing Waste Segregation

There is a difference in the number of households being aware of waste segregation and those practicing waste segregation. It was observed that about 17 per cent of the total households surveyed are not aware about waste segregation whereas around 29 per cent of the households surveyed do not practice waste segregation. This shows that many households are aware of waste segregation, however, they fail to adapt waste segregation practices. This is a critical concern and reflects that either the municipal authorities or Resident Welfare Associations (RWA's) need to propagate and in fact enforce waste segregation practices.

Awareness about Waste Segregation and Practicing Waste Segregation and Household Size Categories

The relationship between different categories of household sizes and responses received pertaining to awareness about waste segregation and practicing waste segregation is shown in Figure 4. As is apparent from the figure for all categories of households the percentage of households who self-reported that they are aware about waste segregation is more than 80 per cent.
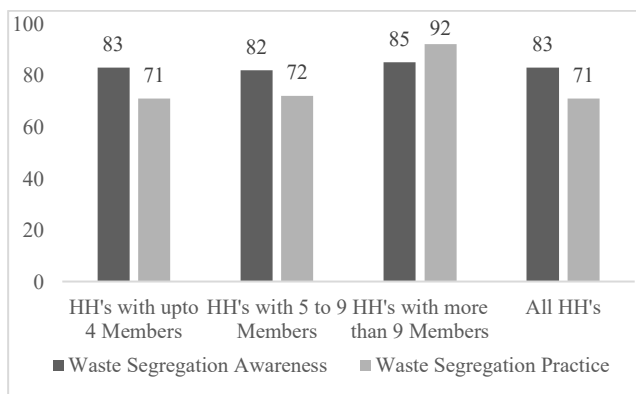
Figure 4: Awareness about Waste Segregation and Practicing Waste Segregation and Household Size Categories

Regarding, practicing waste segregation 71, per cent of households having upto four members reported that they practice waste segregation while 72 and 92 per cent of the larger households having upto 9 and more than 9 members reported that they practice waste segregation. 71 per cent of all households reported that they practice waste segregation.

Awareness about Waste Segregation and Practising Waste Segregation and Household Primary Occupation

The relationship between different categories of household primary occupations- business, service and retired, and responses received pertaining to awareness about waste segregation and practising waste segregation are given in Table 2.

Table 2: Awareness about Waste Segregation and Practicing Waste Segregation and Household Primary Occupation

Household Primary Occupation	Waste Segregation Awareness	Waste Segregation Practice
Business	77.32	63.19
Service	87.50	75.31
Retired	82.11	76.6
Chi²(Measure of Association)	9.2168**	11.54***

Source: Calculations based on data collected via the Household Primary Survey
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Waste segregation awareness reveals 77.32 and 87.5 and 82.11 households respectively from business, service and retired categories of household primary occupation reported that they are aware about waste segregation. The proportion of households stating that they practice waste segregation from these categories was lower at 63.19, 75.31 and 76.6 per cent respectively for business, service and retired categories.

The Chi² Statistic was also calculated to measure the association between household primary occupation and awareness about waste segregation and practicing waste segregation with the results being reported in the last row of Table 2. As is evident there is significant and positive association between the household primary occupation and the attitude towards waste segregation.

Awareness about Waste Segregation and Practicing Waste Segregation and Monthly Family Income

The relationship between different levels of monthly family income and responses received pertaining to awareness about waste segregation and practicing waste segregation is shown in Table 3. Out of the households with monthly income less than ₹50000, 85 and 75 per cent reported that they are aware about waste segregation and practice waste segregation respectively. The

category of households with monthly income between ₹50000 and ₹100,000 had the lowest number of households testifying about their awareness and practice waste segregation. Households in the highest monthly income category also have the largest proportion of households who claim that they practice waste segregation.

Table 3: Awareness about Waste Segregation and Practicing Waste Segregation and Monthly Family Income

Monthly Family Income	Waste Segregation Awareness	Waste Segregation Practice
Monthly Family Income Less than ₹50000	85.11	74.74
Monthly Family Income ₹50000 to ₹100,000	82.17	67.52
Monthly Family Income ₹100,000 to ₹500,000	88.68	76.25
Monthly Family Income above ₹500,000	85.71	78.57

Source: Calculations based on data collected via the Household Primary Survey

Awareness about Waste Segregation, Practicing Waste Segregation and Willingness to Pay for Waste Segregation and Education of the Head of the Household

The relationship between education of the head of the household and responses received pertaining to awareness about waste segregation and practicing waste segregation are given in Table 4.

Table 4: Awareness about Waste Segregation and Practicing Waste Segregation Education of Head of the Household

Education of the Head of the Household	Waste Segregation Awareness	Waste Segregation Practice
Completed Schooling	61.36	56.82
Graduation	79.72	68.52
Post-Graduation/Professional Education	91.18	79.41
Chi²(Measure of Association)	20.82***	9.86***

Source: Calculations based on data collected via the Household Primary Survey

Note: $^{*} p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$

Education of the head of the household seems to have a significant bearing on the attitude towards waste segregation. Higher education levels of the head of the household seem to be associated with not only more awareness about waste segregation but also with a greater inclination towards adoption of waste segregation practices.

Out of the households whose heads reported to be just school pass outs, 61.36 and 56.82 per cent reported that they were respectively aware about waste segregation and practiced waste segregation. Further, for households whose heads reported to be graduates, about 80 and 69 per cent of the households respectively conveyed that they were aware about waste segregation and practiced waste segregation. The households whose heads had the highest levels of education also reported highest levels of awareness as well as adoption of waste segregation practices.

More interestingly while exploring the relationship between household adaptation of waste segregation practices and their educational qualification, it was observed that out of the 262 Households with qualification higher than graduation, 21 per cent did not practice of waste segregation.

The Chi² Statistic was also calculated to measure the association between education levels of the head of the household and awareness about waste segregation and practicing waste segregation. There is significant and positive association between the education levels of the head of the household and awareness about waste segregation and practicing waste segregation.

Awareness about Waste Segregation, Practicing Waste Segregation and Willingness to Pay and Different Kinds of Residence

The relationship between kinds of residence-flats or independent houses and responses received pertaining to awareness about waste segregation, practicing waste segregation and willingness to pay for waste segregation is shown in Figure 5.
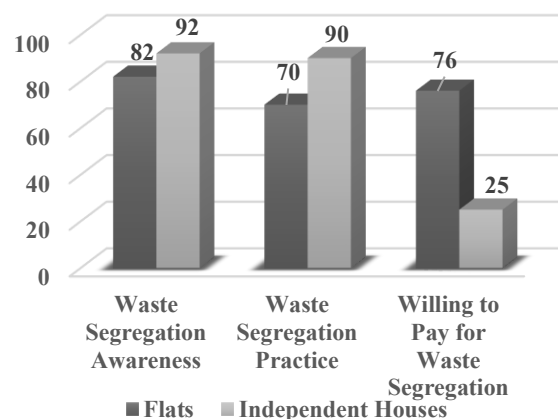
Source: Based on data collected via the Household Primary Survey

Figure 5: Awareness about Waste Segregation and Practising Waste Segregation and Kind of Residence

82 per cent of the respondents in flats vis a vis a higher percentage of 92 per cent in independent houses reported that they are ware about waste segregation. Also, a higher

proportion of 90 per cent of independent house respondents reported that they practice waste segregation vis a vis 70 per cent of the respondents in flats.

Empirical Analysis based on Logit Models

To find the factors that have a significant impact on self-reported-(i) awareness about waste segregation and (ii) adoption of practice of waste segregation Logit Model has been employed. In this section, we present and analyse the results of the econometric exercise.

The log-odds of our Logit Model for factors impacting awareness about waste segregation are given in Table 5.

Table 5: Determinants of Awareness about Waste Segregation (Logit Model-Log-Odds)

	(1)	(2)	(3)	(4)
Household Size: *Base Category- up to 4 Members*				
Household Size (5 to 9 Members)	0.254 (0.401)	0.345 (0.298)	-0.171 (0.373)	-0.130 (0.364)
Household Size (More than 9 Members)	-1.431 (1.274)	0.164 (0.903)	-0.766 (0.902)	-0.778 (1.004)
Education of the Head of the Household: *Base Category: Completed Schooling*				
Graduation	1.233** (0.506)	0.862** (0.379)	0.763 (0.479)	0.833* (0.449)
Post-Graduation/ Professional Education	1.922*** (0.602)	1.700*** (0.455)	1.372** (0.589)	1.364** (0.541)
Monthly Family Income: *Base Category: Less than ₹50,000*				
Monthly Family Income ₹50,000 to ₹100,000	-0.309 (0.465)			
Monthly Family Income more than ₹100,000 to up to ₹500,000	0.314 (0.496)			
Monthly Family Income more than ₹500,000	0.714 (0.847)			
Proportion of Senior Citizens in the Household		1.209** (0.550)	0.943 (0.750)	0.965 (0.711)
Proportion of Working Members in the Household		1.063* (0.607)	1.555** (0.718)	1.269* (0.704)
Proportion of Children in the Household		-0.213 (0.876)	0.464 (1.133)	
Kind of Residence: *Base Category: Flat*				
Independent House			0.795 (1.321)	0.932 (1.305)
Household Occupation: *Base Category-Business*				
Service			-0.216 (0.419)	
Retired			-0.521 (0.512)	
Availability of Different Colored Dustbins			0.227 (0.345)	0.577* (0.349)
Waste Disposal Method: *Base Category- Self in Society Bin/Area Bin*				
Collected by authorized area/society waste picker				0.389 (0.455)
Constant	0.301	-0.233	-0.160	-0.537
Chi²	15.560	21.569	13.265	17.771
P	0.029	0.003	0.276	0.038
Pseudo R²	0.077	0.063	0.056	0.066
N	235	376	238	257

Source: Regression estimates based on survey data collected. Robust standard errors in parentheses.

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- *Household Size:* Compared to the base category of households with up to 4 members, the largest household sizes seem to be less aware about waste segregation as shown by their lower (but non-significant) log odds in all the models. Middle size households appear to have a non-homogeneous impact on awareness about waste segregation. In models (1) and (2) households with number of members between 5 and 8 have larger log-odds compared to the base category while in models (3) and (4), with the kind of residence being considered in the estimation, the middle-sized household have lower but non-significant log odds, reflecting their lower awareness about waste segregation.

- *Education of the Head of the Household*: The education of the head of the household has a significant impact on awareness about waste segregation. In fact, the log-odds of the head of the household being a graduate vis a vis having simply completed schooling (the reference category) are higher and significant in all models (except (3)). Interestingly, the log odds for the even higher education category of the head of the household has larger and significant log odds in all models reflecting that higher education levels of heads of households have a significant impact on creating awareness about waste segregation amongst households.

- *Monthly Family Income:* The reference category for this variable is family income less than ₹50,000. Households having incomes between ₹50,000 and ₹100,000 seem to be less aware about waste segregation, while households in even higher monthly income groups of income between ₹100,000 and ₹500,000 as well as the highest income group of monthly income more than ₹500,000 appear to be more aware about waste segregation. The largest monthly income group having the largest log-odds. However, in general the impact of family income on waste segregation awareness is non-significant.

- *Proportion of Senior Citizens in the Household*: Having a larger proportion of senior citizens in the households leads to great awareness about waste segregation as is evidenced from the positive log odds ratio in models (2), (3) and (4). In fact, the impact of

having more senior citizens in households on awareness about waste segregation is also significant (model (2)).

- *Proportion of Working Members in the Household*: A larger proportion of working members in the households also leads to a significantly larger awareness about waste segregation as is evidenced from the positive as well as significant log odds in models (2), (3) and (4).

- *Proportion of Children in the Household*: The proportion of children in the household appears to have a heterogenous impact on awareness about waste segregation. A larger proportion of children leads to greater awareness about waste segregation if factors such as household residence kind and household occupation are considered, though the impact is non-significant. Without the latter two factors, the log odds ratio of the proportion of children is negative reflecting that a higher proportion of children imply lower awareness about waste segregation (again the impact is non-significant, model (2)).

- *Kind of Residence*: Compared to the base category of flats, households residing in independent houses reported being more aware about waste segregation.

- *Household Occupation*: The households with the primary occupation of business appear to be more aware about waste segregation vis a vis retired households or households with service as the primary occupation as service. Further, the differential impact reflected by the log odds is larger for retired households.

- *Availability of Different Colored Dustbins*: Compared to the respondents who reported the non-availability of different colored dustbins, the ones who observed the availability of different colored dustbins appear to be more aware about waste segregation. In fact, availability of different colored dustbins appears to be a significant factor (model 6) and the respondents who reported their availability have a higher log odds of 0.577 compared to the reference category of the respondents who did not report the availability of different colored dustbins.

- *Waste Disposal Method*: Waste Disposal Method: The reference group for this categorical variable is waste disposal by the household on its own in society bin/area bin. As per our empirical estimates the log odds for households where waste is collected by authorized area/society waste picker are larger reflecting that these households are more aware about waste segregation. Though the differential impact is non-significant.

Table 6 gives the log-odds of estimations from the logit regression undertaken for factors impacting adoption of practice of waste segregation.

Table 6: Determinants of Practising Waste Segregation (Logit Model-Log-Odds)

	(1)	(2)	(3)	(4)	(5)	(6)
Household Size: *Base Category- up to 4 Members*						
Household Size (5 to 9 Members)	0.335 (0.305)	0.336 (0.385)	0.294 (0.286)	0.104 (0.322)	-0.094 (0.307)	-0.018 (0.354)
Household Size (More than 9 Members)	-0.626 (1.504)	0.485 (1.013)	**1.726** (0.869)**	0.806 (0.986)	0.821 (1.025)	**2.076* (1.079)**
Education of the Head of the Household: *Base Category: Completed Schooling*						
Graduation	0.580 (0.485)	-0.365 (0.696)	0.528 (0.414)	0.583 (0.459)	**0.895** (0.429)**	0.668 (0.523)
Post-Graduation/ Professional Education	**0.901* (0.510)**	-0.298 (0.700)	**0.975** (0.445)**	0.732 (0.504)	**0.914** (0.461)**	0.432 (0.543)
Monthly Family Income: *Base Category: Less than ₹50,000*						
Monthly Family Income ₹50,000 to ₹100,000	0.651 (0.400)	-0.840 (0.543)				
Monthly Family Income more than ₹100,000 to upto ₹500,000	0.509 (0.410)	**-1.007* (0.555)**				
Monthly Family Income more than ₹500,000	0.172 (0.657)	-0.249 (0.795)				
Waste Segregation Awareness (Self Reporting)		**4.16*** (0.693)**				**3.07*** (0.452)**
Proportion of Senior Citizens in the Household			**1.45*** (0.515)**	0.798 (0.652)	**1.385** (0.669)**	**1.276* (0.763)**
Proportion of Working Members in the Household			0.482 (0.602)	0.367 (0.678)	1.039 (0.662)	0.548 (0.795)
Proportion of Children in the Household			1.194 (0.856)	0.996 (0.950)		
Score on Knowledge about Waste Segregation			**0.34*** (0.066)**			
Kind of Residence: *Base Category: Flat*						
Independent House				1.281 (1.098)	1.312 (1.224)	**1.342* (0.749)**
Household Occupation: *Base Category-Business*						
Service				0.123 (0.350)		
Retired				0.378 (0.501)		
Availability of Different Colored Dustbins				0.340 (0.299)	**0.516* (0.297)**	0.386 (0.361)
Waste Disposal Method: *Base Category- Self in Society Bin/Area Bin*						
Collected by authorized area/society waste picker					0.454 (0.410)	0.347 (0.480)
Constant	0.504	-1.753	-3.95	-0.501	-1.113	-2.93
Chi²	9.659	40.612	41.314	10.622	13.518	59.094
P	0.209	0.000	0.000	0.475	0.141	0.000
Pseudo R²	0.030	0.299	0.120	0.033	0.055	0.260
N	234	234	352	238	257	256

Source: Regression estimates based on survey data collected. Robust standard errors in parentheses.

Note: $^*\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

- *Household Size:* In contrast to results evidenced for awareness about waste segregation, compared to the base category of households with up to 4 members, the largest household sizes seem to be practicing greater amount of waste segregation as shown by their positive differential log odds ratios in all models (except model (1)). In fact, the differential impact for the largest household sizes is also significant for models (3) and (6).

  As in the case of awareness about waste segregation, middle size households appear to have a non-homogeneous impact on practicing waste segregation. In all models except (5) and (6) households with number of members between 5 and 8 have larger differential log-odds ratio compared to the base category.

- *Education of the Head of the Household*: Higher education of the head of the household has a positive impact on practicing waste segregation wherever significant. In fact, the differential log-odds of the head of the household being a graduate vis a vis having simply completed schooling (the reference category) are higher in all models (except (2)). The differential log odds ratio for the even higher education category of the head of the household being professionally qualified or a post graduate are larger in all models (compared to the differential log-odds of the head of the household being a graduate) and are significant in models (1), (3) and (5). Hence, higher education levels of heads of households again seem to have a significant impact on adaption of the practice of waste segregation.

  Importantly, in model (2) where the differential log-odds ratio of the head of the household being a graduate vis a vis a graduate or the higher category of being a post-graduate/professionally qualified are negative, has an important variable in terms of awareness about waste segregation which has a positive as well as significant impact on practicing waste segregation.

- *Monthly Family Income:* Essentially, higher monthly family incomes seem to have an adverse (though largely non-significant) impact on the adoption of the practice of waste segregation. Compared to the reference category for this variable-family income less than ₹50,000, families with monthly family income between ₹100,000 and ₹500,000 have log-odds that are significantly smaller by 1.007.

- *Waste Segregation Awareness:* Awareness about waste segregation significantly and positively impacts practicing waste segregation as reflected by the positive and significant log-odds ratio for this variable.

- *Proportion of Senior Citizens in the Household*: As in the case of awareness about waste segregation, having a larger proportion of senior citizens in the households leads to greater adoption of the practice of waste segregation. This impact is also significant.

- *Proportion of Working Members in the Household*: A larger proportion of working members in the households also leads to a greater adaption of waste segregation practices but the impact is non-significant.

- *Proportion of Children in the Household*: A larger proportion of children also has a positive but non-significant impact on adoption of the practice of waste segregation.

- *Score on Knowledge about Waste Segregation:* Our questionnaire collected responses on knowledge about waste segregation. Specifically, responses were collected on the following statements "MCD has helped spread information on waste segregation"; "Media (Newspapers, TV, Radio) has helped spread information on waste segregation" and "Our RWA has helped spread information on waste segregation" as a part of the survey. The respondents were asked whether they "Strongly agree", "Agree", are "Neutral" about, "Disagree", or "Strongly disagree" with these statements. The respective responses were given numerical values of 5, 4, 3, 2 and 1. The scores were added, with higher scores reflecting greater knowledge about waste segregation. These scores were then taken as an independent variable as a determinant in the practice of waste segregation.

  As is apparent from the results reported in Table 6, Score on Knowledge about Waste Segregation has a positive and significant impact on households in adoption of practice of waste segregation.

- *Kind of Residence*: Compared to the base category of flats, households residing in independent houses appear to be practicing greater waste segregation as is evidenced from their positive differential log-odds. The impact is also significant in model (6).

- *Household Occupation*: The households with the primary occupation of service or even retired households are more likely to practice waste segregation vis a vis business households. Further, the differential impact reflected by the log odds is larger for retired households. Though in general the impact is non-significant.

- *Availability of Different Colored Dustbins*: Compared to the respondents who reported the non-availability of different colored dustbins, the ones who observed the availability of different colored dustbins practice greater waste segregation. The impact is also significant in model (5).

- *Waste Disposal Method*: The reference group for this categorical variable is waste disposal by the household on its own in society bin/area bin. As per our empirical estimates the differential log odds for households where waste is collected by authorized area/society waste picker are larger reflecting that these households are practice greater waste segregation. Though again, as in the case of awareness about waste segregation, the differential impact is non-significant.

5. CONCLUSION AND POLICY IMPLICATIONS

The comprehensive analysis undertaken, utilising a combination of cross tabulations and Logit, models, provides a nuanced understanding of the multifaceted factors influencing awareness, and adoption of waste segregation practices among households. These findings contribute valuable insights for the formulation of effective policies and strategies aimed at fostering sustainable waste management practices.

The investigation into awareness about waste segregation revealed that household size, education of the head of the household, and the presence of senior citizens and working members play crucial roles. Larger households and higher education levels exhibit positive trends in awareness, indicating the potential impact of these demographic factors. Additionally, the availability of different colored dustbins and waste disposal methods significantly influences awareness, emphasizing the importance of infrastructure and communication channels in shaping public consciousness.

The analysis of waste segregation practices further highlighted the complexity of factors influencing adoption. While larger households show a positive inclination toward waste segregation, the impact of education is limited and inconsistent. Notably, self-reported awareness, the proportion of senior citizens, and knowledge scores positively affect the likelihood of practicing waste segregation. However, the proportion of working members displays a limited and nonsignificant impact, emphasizing the need for targeted interventions.

5.1 Policy Implications

Effective waste separation and collection programs are a critical component of an integrated solid waste management system. There is a strong need to make waste generators understand their moral duty and thereby bring a habitual change in the way they *waste resources*. In this regard it is important to encourage recycling as well as reusing behaviour. Segregated waste subsequently collected, categorised and recycled, can help generate revenues. It is also important to manage organic waste and develop composting facilities within each society/block covering 100 to 150 households. Having listed the essential components that can help realise effective and efficient waste management systems, we lay down specific policy implications emerging from our study.

- To address the waste disposal and management problem, it is suggested that the Resident Welfare Association's (RWA's) along with the Municipal Corporations should undertake conduct awareness programme, seminars, display posters, and distribute pamphlets.

- It is not only important to create awareness about waste segregation but it is also important to educate people as to how to undertake the task of waste segregation and the address the myths surrounding it.

- To propogate waste segregation, retired persons can be tapped as an important source. They appear to be more aware and practise waste segregation, it is suggested that RWAs should use the services of these retired people to make households aware and persuade them to adopt practising segregating of waste.

- In this regard it is also important to educate the young in schools and colleges about the practice of waste segregation.

- Instead of holding households responsible, collective responsibility should be fixed with the residential societies. Hefty fines should be imposed on the housing society if its residents do not segregate waste.

- Waste collectors should also be educated about waste segregation and made aware of the ill effects of mixing the waste. They should also be provided adequate equipment to ensure that they are able to collect segregated waste.

Lastly, it is strongly suggested that the state governments instead of popularising adoption of waste segregation through print or social media using services of celebrities, should collaborate with Higher Educational Institutes (HEIs). Acknowledging that the New Education Policy (NEP) emphasises on community engagement programmes, students and teachers from different HEIs can play key roles in enabling people understand that solid waste is an economic resource in the real sense. They should visit the areas in the near vicinity to promote awareness and persuade people to segregate their waste in the interest of the whole country. This should be carried out continuously for at least two years to make households understand and adopt these practices habitually. A collaborative and continuous approach needs to be followed by each state government.

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