

CHAPTER-4

RESEARCH DESIGN AND METHOD

Introduction

Waste management, particularly municipal solid waste management (MSWM), is a global and local challenge, with significant implications for public health and environmental sustainability. In India, research indicates that about 90% of municipal solid waste is disposed of unscientifically, posing health and environmental risks, while globally, waste generation is projected to rise from 2.1 billion tonnes in 2023 to 3.8 billion by 2050 . Behavioral science theories, such as the Theory of Planned Behavior, have been widely applied to promote recycling, but there is a need for context-specific, in-depth studies to design effective interventions. The COM-B model, part of the Behaviour Change Wheel (BCW), offers a structured framework to analyze behavior by considering capability, opportunity, and motivation, making it suitable for waste management research. This research employs a mixed-methods design that brings the COM-B model (Capability, Opportunity, and Motivation – Behaviour) together with Theoretical Domains Framework (TDF) to investigate household waste segregation behavior in urban India. The COM-B model, developed by Michie et al. (2011), posits that behavior (B) results from the interaction of capability (C), opportunity (O), and motivation (M). This framework guides the research design by structuring the assessment of factors influencing waste segregation, enabling the identification of targeted interventions for municipal solid waste (MSW) management. By combining the two frameworks, the research goes beyond establishing what behaviors take place to knowing why they occur. The COM-B model provides an overarching framework

for considering the conditions for behaviour change, while the TDF gives greater insight into the precise psychological, social, and environmental determinants underpinning these behaviours. Combined, they facilitate a more pragmatic and theory-driven exploration of the enablers and barriers to effective waste segregation and inform more focused and context-specific interventions. Such a dual approach is especially applicable in the Indian scenario, where behavioural tendencies are influenced by an intricate set of cultural values, infrastructure deficiencies, and varied socio-economic conditions, necessitating the employment of conceptual frameworks able to account for both individual and structural influences.

4.1 Research Design

The research employs a sequential explanatory mixed-methods design, combining quantitative and qualitative strategies to establish an in-depth understanding of residential waste segregation behaviors in urban India. A systematic quantitative survey is administered in the formative stage to determine the extent of segregation activities and to make statistical connections between behavioral outcomes and prominent variables corresponding to the COM-B model i.e. Capability, Opportunity, and Motivation. This stage offers a general overview of behaviour patterns and assists in the identification of important predictors and trends in various socio-demographic populations. These results are used as a foundation for the second stage, which consists of semi-structured qualitative interviews. These enable an extended investigation of the facilitators and barriers to underlying behaviours. To further enhance this stage, the Theoretical Domains Framework (TDF) is used as a structured framework to deconstruct the psychological, social, and environmental determinants in greater detail to allow for fine understanding of every COM-B component via its 14 theory-informed

domains. By taking the form of a mixed-methods case study, this design allows contextualized analysis within actual real-life context such as a specific community or urban locale where both observable behavioural consequences (such as segregation frequency or rate of recycling) and their less observable drivers (such as beliefs, habits, perceived norms, or infrastructural limitations) are possible to explore systematically. This multi-layered strategy is most appropriate for the Indian context, where individual household behaviors tend to be influenced by intricate interactions among cultural norms, knowledge deficits, system constraints, and resource availability. Embedding COM-B and TDF within a sequential mixed-methods paradigm guarantees that both the measurable patterns and the qualitative richness of influences on behavior are elicited, thus providing a robust evidence base for the planning of theory-based, context-specific interventions for sustainable waste disposal.

4.2 Data Collection

To gain a multi-faceted and context-sensitive perspective of household waste segregation behaviors in urban India, the research used a sequential explanatory mixed-methods data collection procedure, using both primary and secondary sources of data. The multi-modal design facilitated triangulation of results and added layers of analytical richness by capturing quantitative trends as well as qualitative subtleties in the determinants of behavior. Surveys were conducted in two strategically chosen urban locations, Indore and Varanasi, each representing unique municipal waste management systems and varying levels of citizen participation, thus providing comparative lessons on the socio-behavioral aspects of solid waste management in India.

4.2.1. Primary Data Collection

The two primary components of primary data collection were structured surveys and systematic observation in the field, both intended to investigate behavioral influences as per the COM-B model and further developed using the Theoretical Domains Framework (TDF).

(a) Quantitative Surveys

The structured surveys were the first part of the research, intended to pick up overall trends in public awareness, attitudes, and practices pertaining to segregation of household wastes. Survey questionnaire was designed on the basis of a behaviorally guided diagnosis using the COM-B model targeting constructs of Capability (such as knowledge of separation rules and capacity to distinguish between waste streams), Opportunity (such as availability of bins and frequency of collection), and Motivation (such as intrinsic concern for the environment and perceived social norms). To augment depth, constructs of the TDF were linked to survey questions to investigate domain-specific influences including social influences, reinforcement, emotions, beliefs concerning capabilities, and environmental context and resources.

The survey was given to a stratified sample of respondents who consisted of:

- Households (both formal and informal settlements)
- Small business owners (for example, shopkeepers, vendors)
- Municipal waste workers (including contractual and permanent personnel)

The sample was chosen to provide representation across socio-economic strata, housing types, and distance from formal waste management structures. In each city, 451 respondents were surveyed, collecting data both on paper-based questionnaires and via

digital platforms (Google forms) for enhanced data accuracy and real-time validation. Enumerators received training in ethical data collection, and informed consent was provided by all respondents.

(b) Qualitative Observations

Non-participant on-site observations were made in the second phase to obtain empirical data regarding the segregation of waste and its management in practice. Sites were chosen purposefully to cover the entire lifecycle of waste management, such as:

- Door-to-door points of collection
- Municipal transfer stations
- Composting units and Material Recovery Facilities (MRFs)
- Urban landfills
- Informal recycling centers and scrap markets

The purpose of these observations was to find operational bottlenecks, assess behavioral compliance with segregation practice, judge the state and use of infrastructure (e.g., color-coded bins and signs), and interact with the informal sector in recovering resources. Field notes were diligently noted using an observation protocol checklist, consistent with appropriate COM-B and TDF categories (e.g., physical opportunity, reinforcement, feelings, and environment context). These qualitative data were critical to validating the survey responses and locating areas of discrepancy between self-reported and actual behaviors.

4.2.2 Collection of Secondary Data

Secondary data collection was conducted to place primary results in context, track policy development, and evaluate institutional frameworks over MSWM in both cities.

(a). Policy and Government Reports

A systematic scan of national, state, and municipal-level policy reports was done, including:

- Swachh Bharat Mission (SBM-Urban) guidelines
- Solid Waste Management Rules, 2016
- Policy Guidelines: Encouraging Behaviour Change for Building Waste Segregation at Source (MoHUA, November 2021)
- City sanitation plans, ward-level implementation reports, and yearly performance reviews of Varanasi Municipal Corporation and Indore Municipal Corporation

These reports were reviewed to determine the institutional expectations of citizens' behaviour, planned interventions, and key performance indicators (KPIs) applicable to segregation at source.

(b). Regulatory and Organizational Reports

Datasets and reports of regulatory agencies and organisations engaged in MSWM were studied, including:

- Central Pollution Control Board (CPCB) annual reports.
- State Pollution Control Boards (SPCBs) annual reports.
- NITI Aayog urban development reports.
- Smart Cities Mission implementation and monitoring data from portals.
- Urban local bodies (ULB) waste audits and performance dashboards.

This secondary data yielded useful insights into past trends in performance, segregation rates of compliance, and the impact of behaviour change communication (BCC) approaches.

(c) . Academic Literature and NGO Reports.

- For additional insights and inclusion of civil society views, the research also consulted:
- Peer-reviewed scholarly research on behavioural aspects of waste management in India
- Case studies and field reports from NGOs like Chintan, Saahas Zero Waste, and Waste Warriors that have been engaged in waste segregation drives, informal worker inclusion, and BCC initiatives.

This second layer of data informed the theoretical framework and provided on-ground examples of program success and failure, especially in settings like those in the study locations.

4.3 Sampling Methods

In order to make the study results both statistically representative and socially meaningful, a multi-stage sampling method was utilized with a combination of stratified random sampling and random selection over municipal wards. The sampling strategy was most appropriate in encompassing the variety of household waste segregation practices over different socio-economic and spatial segments in the two chosen cities viz. Varanasi and Indore.

4.3.1 Stratified Random Sampling

For the quantitative survey portion, stratified random sampling was used to systematically control for main population heterogeneity. The urban population in each city was stratified by:

Socio-economic status (e.g., low-, middle-, and high-income groups), Household head gender, and Geographic location (residing in various municipal wards, which represent core urban, peri-urban, and slum areas).

In every stratum, there was random sampling to assure proportional representation. The approach allowed the study to gain insights into a wide range of behaviours, attitudes, and levels of access to municipal solid waste management (MSWM) services, which tend to vary significantly across residential zones and income brackets in Indian urban settings.

Stratification further aided in curbing sampling bias and enhancing the external validity of the survey results.

4.3.2 Sample Size Determination

The household survey sample size was calculated using the Yamane formula (Yamane, 1967), which is a simplified and general accepted equation to calculate sample sizes for finite populations. The formula is written as:

$$n = N / (1 + N * e^2)$$

Where:

- n = required sample size
- N = total number of households in the selected population

- e = desired level of precision (margin of error), commonly set at 0.05 for a 95% confidence level

For this research, the population size of the households (N) was taken from the latest available municipal records and Census information from both cities. Given the formula and a standard 5% margin of error, a minimum representative sample size was determined, which served as a guide for the field enumeration plan. The final number of household respondents gathered from both cities was 451, with roughly similar representation from Varanasi and Indore in order to permit comparative analysis.

4.3.3 Ward-Level Sampling

In order to increase further the spatial representativeness of the samples, a random selection of municipal wards was carried out within each city. From all the administrative wards, a subset was chosen based on a random number generator. In these chosen wards, enumerators conducted household listing and subsequent systematic respondent selection based on interval-based methods. This randomization at the ward level guaranteed that discrepancies in waste management infrastructure, provision of services, and public participation were well reflected between diverse urban areas.

To guarantee that study results were both statistically representative and socially pertinent, multi-stage sampling design was used, incorporating stratified random sampling with random selection over municipal wards. This method was well-adapted for capturing the heterogeneity of household waste segregation practices across various socio-economic and spatial segments in the two target cities, Varanasi and Indore.

The integration of stratified random sampling and ward-level randomization with a statistically robust sample size estimation based on the Yamane formula constituted a sound methodological basis for the quantitative stage of the study. Not only did this sampling plan guarantee representativeness both socio-economically and geographically, but also greater nuanced analysis of behavioural patterns and impediments to segregation of waste in varying urban contexts. Such methodological consistency is particularly vital in the Indian urban context, wherein gaps in infrastructural access and awareness levels can have considerable impacts on environmental behaviors.

4.4 Data Analysis

For comprehensive consideration of the research questions and guarantees of sound interpretation of results, the research utilized a mixed-methods analytical approach using quantitative and qualitative methods. Guiding the analysis was the application of the COM-B model (Capability, Opportunity, Motivation – Behaviour) and the Theoretical Domains Framework (TDF) that offered theoretical underpinnings for coding, interpretation, and triangulation of determinants of neighbourhood households' waste segregation.

4.4.1 Quantitative Data Analysis

The quantitative data, gathered with systematic household surveys, were statistically processed Microsoft Excel 2013 & SPSS 26 (Statistical Package for the Social Sciences). The analytical procedure employed a multi-stage strategy:

(a) Descriptive Statistics

Preliminary analyses entailed calculating descriptive statistics to provide a summary of important behavioural measures throughout the sample. These encompassed:

- Proportion of households adopting source-level segregation,
- Frequency of waste collection (daily, alternate days, irregular),
- Access to segregation infrastructure (availability of bins, colour-coded systems),
- Public satisfaction rates with urban solid waste management service,
- Knowledge of segregation rules and advantages of segregation, and
- Exposure to behaviour change communication (BCC) programme.

These indicators were also broken down by socio-demographic factors (e.g., income level, type of ward, household size, respondent's gender) in order to determine patterns within groups.

4.4.2 Qualitative Data Analysis

The qualitative element of the research incorporated non-participant field observation and inferences drawn from open-ended survey feedback and researcher field notes, with a thematic analysis strategy being used to interpret this data, meaning coding categories being developed deductively across the 14 domains of the TDF, and then further refined inductively as patterns were revealed in the field.

- Field observations were coded with reference to a template of structured coding matched against key COM-B and TDF constructs, including:
- Knowledge and Skills (Capability): Understanding segregation procedures; behaviour observable at source.

- Environmental Context and Resources (Opportunity): Condition and accessibility of bins; visible signs; availability of collection services.
- Social Influences (Opportunity): Influence of community leaders, peer, and informal worker social interaction.
- Motivations from Beliefs regarding Consequences, Reinforcement, and Emotion: Expressed concerns from residents regarding disease, cleanliness, civic pride, or punishment.

4.4.3 Comparative Case Analysis

A comparative analysis of Indore and Varanasi was conducted to bring out contextual similarities and differences in waste management behaviour and systemic facilitators.

The comparison was for:

- Institutional mechanisms (e.g., enforcement, door-to-door collection systems),
- Technological infrastructure (e.g., Material Recovery Facilities, landfill management),
- Cultural and social dynamics (e.g., local perception of cleanliness, caste-based occupation roles),

4.4.4 Implementation of behavioural policies and IEC campaigns.

These qualitative findings were utilized to place quantitative trends in context, cross-validate statistical results, and gain a more profound understanding of how the components of COM-B interact within particular urban contexts.

4.4.5 Qualitative and Quantitative Findings Integration

Both sets of findings were triangulated to further ensure the validity and richness of the analysis. For instance, if quantitative data revealed low segregation of waste in some

wards, qualitative field notes were referred to analyse whether this was associated with infrastructural shortages or negative social norms. This syncretic analysis enabled an integrative behavioural diagnosis, consistent with the rationale of the COM-B model and TDF, and supported the generation of evidence-based, contextually sensitive recommendations for interventions.

The process of data analysis used in this research facilitated a theory-driven, multi-dimensional analysis of waste segregation behaviours in Indian cities. Operationalizing COM-B model and TDF in both quantitative and qualitative data, the study not only established what was happening in terms of behaviours, but also deconstructed why it was happening and under what circumstances. This two-layered analytical framework provides a solid basis for planning future behaviour change interventions and municipal policies that are both empirically grounded and realistic in terms of constraints and incentives.

4.5 Study Area: Indore and Varanasi

The research was undertaken in two key Indian city centres are chosen as Indore in Madhya Pradesh and Varanasi in Uttar Pradesh with same wards size but for their differing municipal solid waste management (MSWM) performances, governance structures, and community involvement practices. The choice of these cities was deliberate and purposive, to enable comparative behavioural analysis under the COM-B (Capability, Opportunity, Motivation – Behaviour) model and the Behaviour Change Wheel (BCW) framework.

4.5.1 Justification for City Selection

Indore has remained the top city in the Government of India's Swachh Survekshan cleanliness ranking for several years. It is widely known to be a model city for effective application of segregation-at-source, door-to-door collection, and community-led waste management practices. The city's institutionalised strategy for behavioural change communication, engaged citizenry, and efficient decentralised waste processing systems made it a suitable case for studying enabling conditions and motivational drivers of pro-environmental behaviours.

In contrast, Varanasi, a city with huge religious and cultural relevance, offers a different urban ecosystem with varied MSWM outcomes. Although it has shown improvement in waste collection under Smart Cities Mission and Swachh Bharat Abhiyan, it still struggles with source segregation, infrastructure constraints, and public awareness. Its inclusion enables consideration of the obstacles and situational limitations that prevent successful behavioural change in urban sanitation systems.

Through the exploration of these two urban environments, the study aimed to not only learn about the behavioural outcomes (e.g., segregation rates and recycling effectiveness), but also the institutional, social, and infrastructural drivers or determinants of change.

4.5.2 Comparative Evaluation Framework

The cities were compared based on a behavioural systems approach rooted in the COM-B model and the larger Behaviour Change Wheel framework. The principal indicators measured were:

- Household waste segregation rates
- Recycling efficiency and waste recovery levels
- Public satisfaction with MSWM services
- Level and nature of community participation
- Exposure to and recall of behaviour change campaigns
- Operational presence of supportive infrastructure (e.g., dual-bin systems, MRFs)

This comparative analysis enabled the identification of both successful behavioural practices and areas requiring targeted intervention. It also highlighted how environmental context (Opportunity), individual knowledge and ability (Capability), and motivational processes interact differently across high- and low-performing systems.

4.5.3 Questionnaire

To capture a comprehensive picture of behavioural drivers in the waste management environment, the research identified and accessed three main groups of stakeholders:

- Urban Households – as the direct drivers of waste segregation and generation behaviour.
- Waste Management Workers – comprising municipal workers, private sector contractors, and informal sector operators directly responsible for waste collection and segregation.
- Local Administrators and Policy Implementers – including ward officers, sanitation inspectors, and urban local body (ULB) functionaries tasked with the planning and implementation of MSWM policies and IEC campaigns.

Being able to tap insights from these stakeholder groups enabled multi-layered analysis of behavioural trends, institutional procedures, and challenges in implementation, strengthening the study findings and increasing the policy usefulness of its recommendations.

4.5.4 Stakeholder Identification

Questionnaire Development for Household Data Collection. The questionnaire was meticulously designed to collect data on waste management practices from households in Varanasi, aligning with the study's aim to identify factors influencing waste segregation behaviors. It was informed by the COM-B model, which guided the inclusion of questions on capability, opportunity, and motivation. Questions were developed by adapting existing scales and creating context-specific items, with a pilot test of 30 households used to refine clarity and relevance. The questionnaire comprised seven sections: demographic information, physical and psychological capability, physical and social opportunity, and automatic and reflective motivation. Response formats included multiple-choice questions, Likert scales, and open-ended prompts to capture both quantitative and qualitative data. Cronbach's alpha is a measure of internal consistency, indicating the relation of a set of 30 constructs. It is found to be 0.83, which refers to strong reliability of a questionnaire or scale. The households were selected via stratified random sampling and surveyed through in-person interviews. Ethical approval was secured, and confidentiality was maintained through anonymization. Data quality was ensured through interviewer training and entry verification, though limitations such as potential response bias were noted. This development process underpins the research design by providing a robust, theory-driven tool for data collection.

The questionnaire was organized into the following sections: (Questionnaire is added to appendix-I).

- Demographic Information: To profile respondents (e.g., age, income, household size).
- Physical Capability: Availability of tools or infrastructure for waste management (e.g., bins, pickup services).
- Psychological Capability: Knowledge and skills related to waste segregation.
- Physical Opportunity: External factors like waste collection frequency.
- Social Opportunity: Influence of neighbours or social norms.
- Automatic Motivation: Habits and routine behaviours.
- Reflective Motivation: Attitudes and personal incentives for managing waste.

These sections were designed to systematically explore all dimensions of the COM-B model, ensuring a thorough investigation of waste management behaviours.