CHAPTER 3

CONCEPTUAL FRAMEWORKS

Introduction

Effective municipal solid waste management is the demand of urban areas/cities, which implies coordination of strong infrastructure facilities and community participation. This can be possible by integrating an integrated municipal solid waste management (IMSWM) framework with the national behaviour change framework (NCBF) and including the COM-B model, behaviour change wheel (BCW) framework and Theoretical Domains Framework (TDF). The following combination can be a powerful approach to ensure effective MSWM in cities. As we know, IMSWM ensures the establishment of necessary waste management systems like collection and recycling for proper waste handling. NCBF will help adapt strategies to the local culture through communication and social norms that foster community engagement. COM-B model and BCW framework offer insight into human behaviour elements, i.e., identifying barriers and enablers in MSWM. It can help design interventions that encourage positive behaviour in MSWM. Thus, an integration approach is essential to foster behaviour that leads to sustainable and effective MSWM.

3.1 Integrated Framework for Municipal Solid Waste Management

Background

Municipal solid waste (MSW) includes discard from residential, commercial, and institutional activities in urban areas food waste, paper, plastics, glass, metal, and other mixed material make up municipal solid waste (MSW). Rising urban populations generate a lot of waste, thus public health, environmental protection, and resource

preservation becomes an issues. Effective waste management is therefore absolutely crucial for sustainable cities since improper waste management might lead to pollution, global warming, and health hazards. To resolve this integrated municipal solid waste management (IMSWM) is the only solution. IMSWM addresses waste from its inception to disposal, unlike typical waste management which may focus on collection, transportation, treatment and disposal of waste. It combines several techniques to cut waste generation, recover as much as feasible, and dispose of trash in a way that is ecologically acceptable. This approach is align with international goals for sustainability that are included in the United Nations' Sustainable Development Goals (UN SDG), especially those for sustainable cities and sustainable consumption.

IMSWM is a structured framework to handling municipal solid waste, using IMSWM techniques sustainable results can be achieved. The hierarchy of waste management; first priority is prevention of waste; followed by reuse, recycling, recovery, and disposal as a last resort. It seeks to minimise waste's impact on environmental, save resources, and enable a circular economy whereby waste is seen as a resource rather than an issue.

3.1.1 Comprehensive waste management is the focus of IMSWM.

- **Generation**: Sources of waste generation are Domestic household, businesses, and institutions.
- **Collection**: the rejected trash is collected from discarded points.
- **Processing**: Organising, recycling, or treating trash to retrieve resources.
- **Disposal:** Disposing of any waste that cannot be reused or recycled. Mostly inert or non-reactive matter.

Through bridging these phases, IMSWM ensures that waste management is affordable, effective, and ecologically sound. Design an integrated system by means of coordination among stakeholders including local governments, private sectors, communities, and individuals.

3.1.2 Key Components of IMSWM

- **Waste Minimisation**

The best approach of waste management is to prevent addition of new waste into the system termed as waste minimisation, which is all about reducing the amount of waste generated at its source.

(A). Source reduction: Source reduction is techniques meant to reduce the generation of waste. Using reusable bags, bottles, or containers instead of single-use plastics can helps to reduce waste generation. Businesses can design goods with less packaging or longer lifetime, for example biodegradable packaging or long-lasting electronics. Governments can introduce bans on plastic bags and developing policies to encourage source reduction. For instance San Francisco has passed plastic bag bans in the city to reduce waste.

(B). Education and Awareness

Awareness-through education is crucial for sustainable & responsible behaviour. Education through school projects, seminars, and campaigns help communities understand the financial and environmental benefits of minimising waste, recycling, and disposal. For instance, public seminars might teach communities how to restore items rather than discard them away, as to fostering a sustainable culture.

- **Waste Segregation at Source and Collection**

(A). Segregation at source:

Households and commercial establishment are involve into separating waste into types organic (food waste), recyclable (paper, plastic, glass, metal), and non-recyclable or hazardous (batteries, chemicals) nature makes processing / treatment easier downstream. For instance, colour-coded bins can help recyclers to sort waste correctly as seen in Tokyo where policy and regulation on garbage sorting have helped to improve recycling rates.

(B). Efficient collection system: proper waste collection systems will routinely gather waste without mixing. This can be possible if they separately drop-off sites for hazardous materials or specialised vehicles for recyclables, organic waste, and non-recyclables. Good collecting reduces transportation cost & contamination which lead to proper recycling and composting of collected waste.

- **Resource Recovery and Recycling**

Recycling and resource recovery turn trash into valuable assets, so lowering the need for raw materials and landfill usage.

(A). Material Recycling: it is the collecting and processing of materials including paper, plastics, glass, and metals to create new products. For instance new bottle can be manufacture by recycled plastic which in turn reduces the demand for raw materials derived from petroleum. To be successful, recycling programs, there must be public willingness as well as facilities such as material recovery facilities (MRFs). Strong infrastructure and public support have driven Copenhagen into a city with high recycling rate (Copenhagen Solutions).

(B). Waste to resource conversion: Food waste and garden clippings can be decomposed to make nutrient-dense soil additions for horticultural and agricultural uses known as compost. The process of systematically degrading to organic matter is called composting. High composting may lead to diversion of major chuck of organic waste that may degrade in landfills where it would break down anaerobically and release methane, a potent greenhouse gas (GHG's). By distribution of prepared compost to nearby farms, community composting programs can cut landfill waste.

- **Waste treatment and disposal**

IMSWM applies treatment and disposal methods with least effect on the environment for wastes that cannot be avoided, reused, or recycled.

(A). Waste-to-Energy: Technologies including anaerobic digestion and burning non-recyclable waste into energy help to anaerobic digestion breaks down organic waste to generate biogas that can be used for energy; incineration burns trash to generate heat or electricity. With very little landfill use, Sweden, for example, uses waste-to- energy plants to heat homes (Swedish EPA).

(B). Disposal management: landfill are meant to be environmentally friendly, only handle disposal. Modern landfills trap methane gas for fuel generation, capture leachate i.e. a hazardous liquid originated from broken-down of organic waste in anaerobic condition and under high pressure. It has potential to contaminating the groundwater, and have detrimental environmental impact. For instance, scientific landfills in Germany, use gas capture technologies to reduce emissions (German Environment Agency).

3.1.3 Advantages of IMSWM

Many Advantage offered by IMSWM lead to sustainable urban growth:

- **Environmental Preservation:** IMSWM lowers pollution and impacts of climate change by reducing landfill use and emissions.
- **Waste to value creation:** Composting and recycling help to preserve utilisation of virgin natural resources like water, minerals, and wood.
- **Economic Benefits:** Revenue from the sale of materials or energy as well as job possibilities for the recycling and waste-to- energy industries come from resource recovery.
- **Public health**: it is greatly reduced by appropriate waste management in terms of diseases resulting from incorrect disposal, such as waterborne disease resulting from contaminated groundwater.
- **Circular economy:** IMSWM advocates a circular economy by means of waste as a resource, so reducing reliance on non-renewable resources.

3.1.4 Challenges / barriers of implementation of IMSWM

IMSWM is effective framework, but its implementation faces difficulties despite of these advantages:

- **Establishment Cost:** advanced landfills, waste-to-energy facilities, or recycling centres needs high investment.
- **Public participation:** It depends on resident's education, willingness & responsible behaviour of properly separating waste and controlled consumption, both of which is individual choice.

- **Infrastructure:** Developing countries lack the infrastructure to enable effective collecting and processing systems.
- **Policies and Enforcement**: Like waste segregation / separation rules, strong policies need to be stringently applied.

3.1.5 Roles of each stakeholders to achieve IMSWM:

- Governments: being a statutory body government frame policies including plastic ban or recycling rules, develop infrastructure and act as funding source.
- Industries: they are liable for implementation of sustainable practices including production, waste reduction or environmentally friendly packaging.
- Communities: Community participation help neighbourhood recycling programs and engage in waste sorting/ segregation initiative s. the major transformation of IMSWM can be achieved active community actions.
- Individuals: People's attitudes and behaviour are two essential components that reflect using reusable goods and properly sorting trash.

The innovative approach to address the growing urban waste issue is integrated municipal solid waste management. IMSWM creates cleaner, healthier, and more sustainable cities through waste minimisation, efficient segregation and collecting, resource recovery, appropriate treatment and safe disposal. Its success depends on collaboration & coordination of multiple stakeholder .i.e. governments, businesses, local communities, and people coming together to embrace sustainable living. IMSWM is a resource-efficient, environmentally friendly waste management tool / framework that ensures a better quality of life for next generations.

3.2 National Behaviour Change Communication Framework for Garbage Free Cities.

"National Behaviour Change Communication Framework for Garbage Free Cities," is a strategic initiative meant to advance sustainable urban sanitation all around India. Initiated to enhance the continuous "Jan Andolan" (people's movement) for garbage-free cities, the framework builds on the successes of the first phase of Swachh Bharat Mission - Urban (SBM-U), started in 2014, and addresses newly arising sanitation issues. Maintaining a scientific and logical approach fit for inclusion in an academic report, this summary covers its goals, methods, and structure.

3.2.1 Basic Goals

The framework seeks to raise general awareness and active citizen participation so transforming urban sanitation. Its main objectives:

- Emphasising sustainable sanitation practices, urban people should be informed about the idea of garbage free cities and their positive effects on quality of living.
- Encouragement of communities to own sanitation projects will help to turn urban cleanliness into a group movement.
- Focussing on new priorities including used water management, reduction of single-use plastics, source segregation of waste, and remedial action of legacy dumpsites helps one to address behavioural challenges.
- Ensuring inclusive participation of stakeholders that are citizens, waste collectors, managers, and decision-makers allows one to institutionalise hygienic practices and prevent regression.

These objectives complement the more general aims of SBM-U 2.0, launched in 2021, to promote sustainable urbanisation and circular economy principles (NBCF, 2022). Principal Techniques Combining the following tactics, the framework takes an evidence-based, multifarious approach to behaviour change communication (BCC):

3.2.2 Stakeholder Engagement and Segmentation:

Waste generators (e.g., households, businesses), waste collectors (e.g., frontline workers), waste managers (e.g., sanitation inspectors), and decision-makers/enablers (e.g., policymakers, media) the framework notes as four stakeholder groups. Communication is catered to their particular responsibilities in order to encourage practices including responsible waste disposal and source separation.

3.2.3 Communication channels and pillars:

Advocacy, Citizen Engagement, and Interpersonal Communication is a three-pillared approach that are applied via several outlets, including:

- Mass media (e.g., radio, TV)
- Mid-media, say street theatre or wall paintings,
- Digital media including social media and the Swachhata App
- Interpersonal communication that is, door to door campaigns

Strategic alliances with governments, NGOs, and commercial companies improve outreach

3.2.4 Campaign Design and Behavioural Nudges:

Rigid research, gap analysis, and need assessments guide campaigns in their design and behavioural nudges, so addressing behavioural factors including Motivation,

Capability, and Opportunity**.** Designed to inspire pride and empathy, culturally appropriate messages such as "Har Din Ke Liye Teen Bin" used in Swachh Survekshan rankings and slogans that help to promote sustainable practices.

3.2.5 Infrastructure Support and Capacity Development

At national, state, and local levels, the framework stresses technical support and training for stakeholders. It emphasises how important functional infrastructure like separate waste collecting systems to maintain behaviour modification.

3.2.6 Monitoring and Evaluation:

By means of input, output, and outcome indicators that is, number of trained personnel, citizen feedback, behavioural changes act as strong framework tracking campaign effectiveness. Third-party assessments and the Swachhatam portal help to assure responsibility and flexibility.

3.2.7 Key insights

Using behavioural science, stakeholder cooperation, and technology tools like the Swachhata App, the framework offers a scientifically based approach to attain sustainable urban sanitation. Its ability to change India's urban scene is highlighted by its focus on localisation, citizen involvement, and cooperative projects. The alignment of the framework with global sustainability goals, such the United Nations Sustainable Development Goals, increases its relevance (Cuervo-Cazurra et al., 2022).Offering states and cities with practical ideas to promote a cleaner, more sustainable urban India, this thorough, evidence-based framework acts as a road map.

3.3 COM-B model integrated with Behaviour Change Wheel (BCW) Framework

"Behaviour change interventions are fundamental to the effective practice of clinical medicine and public health, as indeed they are to many pressing issues facing society."

***Susan Michie**, **Maartje van Stralen**, & **Robert West**, inventors of the COM-B Model*

- **Background**

The BCW consists of three layers: the COM-B model at the hub, nine intervention functions (e.g., education, persuasion, environmental restructuring), and seven policy categories (e.g., legislation, fiscal measures, communication /marketing). The COM-B model posits that behaviour is influenced by psychological and physical capability, social and physical opportunity, and reflective and automatic motivation. This framework has been applied to public health issues like tobacco control and obesity, as noted in Michie et al. (2011) and its adaptability extends to environmental behaviours.

3.3.1 Defining the Target Behaviour

Segregation in MSWM involves actions such as sorting waste into designated bins at home or workplaces, driven by individual decisions and influenced by systemic factors like infrastructure and policy. This behaviour aligns with the BCW's scope, as it requires changes in knowledge, environment, and motivation.

3.3.2 COM-B Analysis for Waste Segregation

To design interventions, we first analyze the COM-B components:

- **Capability**:
    - **Psychological Capability**: Individuals may lack awareness of segregation benefits, methods, or consequences of improper disposal. For example, households might not know how to separate organic from recyclable waste.

- **Physical Capability**: Limited access to bins, space constraints, or physical ability may hinder segregation.
- **Implication**: Interventions should focus on education and training to build knowledge and skills.

- **Opportunity**:
  - **Social Opportunity**: Social norms, peer influence, or community practices may encourage or discourage segregation. For instance, if neighbors segregate waste, individuals are more likely to follow.
  - **Physical Opportunity**: Availability of infrastructure (e.g., separate bins, collection services) and ease of access affect behaviour. Poor bin placement or irregular collection can deter segregation.
  - **Implication**: Interventions should modify the social and physical environment to facilitate segregation.

- **Motivation**:
  - **Reflective Motivation**: Conscious decisions based on environmental values, cost savings, or legal requirements (e.g., fines for non-segregation).
  - **Automatic Motivation**: Habitual behaviours, emotional responses (e.g., convenience), or aversion to effort may influence segregation.
  - **Implication**: Interventions should address both conscious and unconscious motivations through persuasion and incentivization.

This analysis aligns with the BCW's approach, as detailed in the decision Lab, emphasizing understanding these factors to design effective interventions (Pilat & Krastev, 2021).

3.3.3 Selecting Intervention Functions

Based on the COM-B analysis, we select intervention functions from the BCW's nine options:

1. **Education**: Increase knowledge about segregation benefits and methods. Example: Public workshops, school programs, or informational brochures on waste categories.
2. **Persuasion**: Use campaigns to change attitudes, leveraging social norms or authority figures. Example: Media stories showing community leaders segregating waste or highlighting "most people segregate waste."
3. **Incentivization**: Offer rewards for segregation, such as discounts on utility bills or loyalty points. Example: Points systems for households that consistently segregate waste.
4. **Training**: Equip stakeholders (e.g., waste handlers, community leaders) with skills to promote segregation. Example: Training programs for waste management staff on handling segregated waste.
5. **Environmental Restructuring**: Modify environments to make segregation easier, such as providing clearly labeled bins or convenient collection systems. Example: Uniform color codes (green for wet waste, blue for dry waste, black for inert).

6. **Modeling**: Showcase examples of successful segregation practices to inspire others. Example: Case studies of communities with high segregation rates.
7. **Enablement**: Provide resources and support, such as supplying bins or collection services. Example: Distributing free bins to households.
8. **Coercion**: Use legal measures to enforce segregation, though less preferred, such as fines for non-compliance.
9. **Restriction**: Limit behaviours that hinder segregation, such as banning mixed waste disposal in certain areas.

These functions address deficits in capability, opportunity, and motivation, as outlined in the "Behaviour change wheel: a Guide to design intervention", a book by Michie et al. (2014)

3.3.4 Identifying Policy Categories

To support these interventions, we select from the seven policy categories:

Legislation: Enforce laws mandating segregation, such as requiring households to separate waste into specified categories. Example: Fines for non-segregation under municipal bylaws.

1. **Fiscal Measures**: Use financial incentives or disincentives, such as tax breaks for recycling facilities or penalties for improper disposal. Example: Subsidies for households that segregate waste.
2. **Regulation**: Oversee waste management industries to ensure compliance with segregation standards. Example: Regulating waste collection companies to handle segregated waste properly.

3. **Environmental / Social Planning**: Design urban policies for segregation infrastructure, such as centralized waste collection points or community composting sites. Example: Inclusionary zoning for waste management facilities.
4. **Service Provision**: Offer community services supporting segregation, such as regular collection schedules for segregated waste. Example: Separate collection days for recyclables and organic waste.
5. **Communication/Marketing**: Run public campaigns promoting segregation, using multi-lingual, pictorial messages. Example: Awareness campaigns with science-based content on segregation benefits.
6. **Guidelines**: Develop standards for segregation practices, such as guidelines for households on waste categories and for waste organizations on handling. Example: National guidelines on color-coded bins.

These policies enable the delivery of interventions, as seen in applications to health and sustainability.

3.3.5 Detailed Examples and Considerations

To illustrate, consider a scenario where a city aims to increase waste segregation:

- **Intervention Example**: Launch an education campaign informing residents about segregation benefits, addressing capability. This could involve community workshops, as suggested by Tanwi Trushna (2024).
- **Policy Example**: Implement legislation mandating segregation with fines, addressing opportunity, as seen in urban planning discussions.

The NITI Aayog (2021) document Promoting Behaviour Change for Strengthening Waste Segregation at Source: Policy Guidelines provides specific recommendations, such as using nudge interventions (e.g., intuitive bin design) and strengthening IEC messaging, aligning with BCW functions like Environmental Restructuring and Education.

Field studies mentioned in the document, such as China's waste segregation pilot (2000-2015) in 26 cities, increased sorting frequency by 0.243 points, persisting 13 years post-intervention, demonstrating long-term effectiveness. The Netherlands' littering reduction project (2010) showed descriptive social norms reduced littering by 20%, highlighting persuasion's role.

- **Limitation of model**

However, challenges exist. The BCW's complexity, as noted by Neurolaunch (2024), can make implementation time-consuming, and human behaviour's messiness may not fit neatly into categories. Additionally, waste segregation involves systemic factors like infrastructure, which the BCW may not fully address alone, requiring integration with other frameworks.

3.3.6 Comparative Analysis with Related Applications

While direct BCW applications to waste segregation are limited, related uses in reducing littering or promoting recycling provide insights. For instance, applying the BCW to recycling behaviour might involve persuasion campaigns, similar to our approach, as suggested by the framework's versatility across sectors, per Wilson and Marselle (2016). The lack of specific studies highlights the need for further research, but the framework's theoretical grounding supports its application.

Table: 3.1 Summary of Interventions and Policies

Component	Intervention Functions	Policy Categories
Capability	Education, Training	Guidelines, Service Provision
Opportunity	Environmental Restructuring, Restriction	Environmental/Social Planning, Regulation
Motivation	Persuasion, Incentivization, Modeling, Enablement	Legislation, Fiscal Measures, Communication/Marketing

Source: Mitche et al (2011).

This Table 3.1 organizes the interventions and policies by COM-B components, ensuring systematic approach.

3.4 Theoretical Domain Framework (TDF)

"*Theoretical Domain Framework provides a theoretical lens through which to view the cognitive, affective, social and environmental influences on behaviour"*

Atkins et al. (2017)

Theoretical Domains Framework (TDF) is utilised in implementation studies to evaluate and address factors influencing behaviour. Identifying the determinants of a specific behaviour is crucial for any effective intervention designed to modify that behaviour. Evidence indicates that theory-based behaviour change interventions are more effective than those lacking a theoretical foundation. The TDF is a comprehensive theoretical framework integrating 84 constructs derived from 33 most pertinent theories to implementation enquiries. The consensus process employed by this cross-disciplinary group to formulate the framework involved (I) identifying relevant theories and theoretical constructs related to behaviour change, (ii) simplifying these theories and constructs into overarching theoretical domains, (iii) assessing the significance of the theoretical domains; (iv) performing a cross-disciplinary evaluation and synthesis

of the domains and constructs; (v) validating the list of domains; and (vi) piloting a series of interview questions to gather perspectives on the constructs and domains. The domains encompass the physical and social environment; however, most pertain to individual motivation and capability factors.

3.4.1 Theoretical Domains Framework and COM-B

This framework builds on the COM-B model by providing a more detailed lens. It is an extension of COM-B. It identifies 14 domains that influence behaviour, grouped under the COM-B components. These domains allow us to pinpoint specific waste segregation factors and design targeted interventions. Here is how they align:

(a) . Capability

- **Knowledge**: Understanding what items belong in each waste category (e.g., recyclables vs. non-recyclables).
- **Skills**: The practical ability to sort waste correctly.
- **Memory, Attention, and Decision Processes**: Remembering to segregate and making quick decisions about waste disposal.
- **Behavioural regulation:**Self-monitoring or remaining alert while disposing of MSW

(b) . Opportunity

- **Environmental Context and Resources**: Tools (e.g., separate bins) and systems (e.g., waste collection) are available.
- **Social Influences**: The impact of peers, family, or community norms on segregation habits.

(c) . Motivation

- **Beliefs about Capabilities**: Confidence in one's ability to segregate correctly.
- **Beliefs about Consequences**: Awareness of the benefits (e.g., environmental protection) or risks of not segregating.
- **Emotions**: Feelings like responsibility, pride, or guilt tied to waste management.
- **Reinforcement**: Rewards or penalties that encourage or discourage the behaviour.
- **Goals:** Personal reducing MSW can encourage segregation.
- **Intensions:** planning to initiate sorting of recyclables from the next day.
- **Social/professional role/identity:** a person feeling pride for eco-friendly habits (e.g., segregation of waste at source).

The TDF is an extensive framework that enables researchers to discern factors that may affect behaviours and the intended behaviour modifications, including barriers and facilitators. By incorporating social and environmental elements, the TDF extends beyond theories that concentrate solely on individual factors, such as beliefs and motivations (Fig 3.1). It may function as:

- A planning instrument designed to identify determinants and suitable techniques for addressing previously recognised barriers and facilitators to enhance the outcomes of an implementation strategy.
- Researchers use an evaluation instrument to assess how effectively an intervention targets specific behavioural determinants and retrospectively identify factors contributing to its success or failure (Nilsen, 2015).

- Researchers initially designed the TDF to change the behaviours of healthcare professionals, but they have also successfully adapted it in studies of individual behaviour change (Marshman et al., 2016).

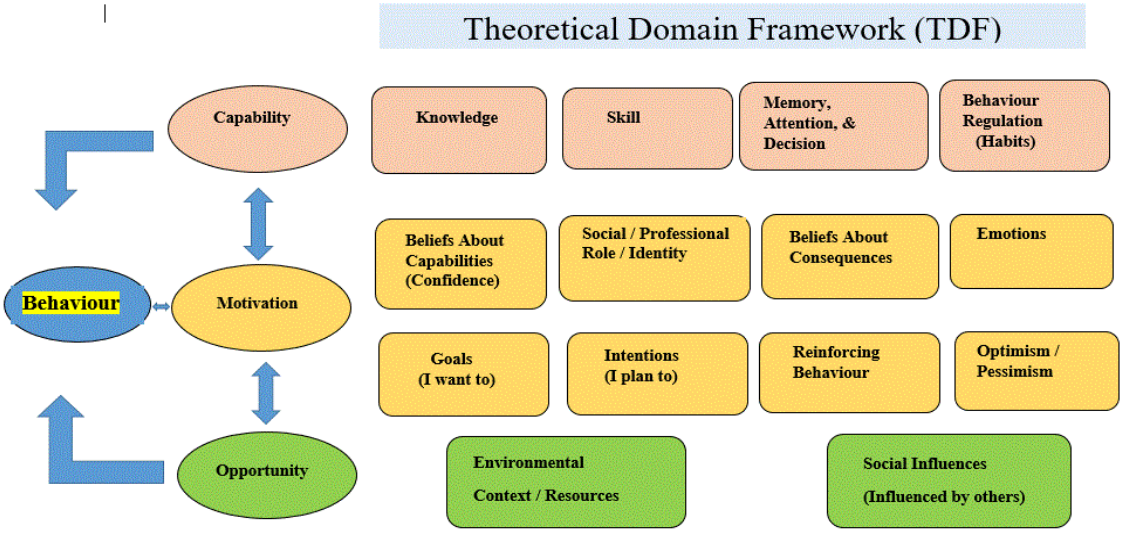

Figure 3.1: TDF along with COM-B.

The BCW and TDF provides a structured method to design interventions and policies for promoting waste segregation in MSWM, focusing on education, persuasion, and environmental changes, supported by legislation and fiscal measures (Fig. 3.1). While direct evidence is limited, the framework's adaptability makes it suitable, though challenges like complexity and systemic factors require careful consideration. This analysis offers a starting point for addressing waste segregation, with potential for further refinement through empirical studies.

3.5 Conclusion

Combining the ISWM, NBCF, BCW and TDF forms a strong framework for exploring and enhancing behaviour towards MSWM. The ISWM model guarantees a sustainable waste management system, NBCF ensures culturally appropriate engagement

mechanisms, and COM-B/BCW provides a scientifically proven approach to behaviour change. The comprehensive strategy is poised to elicit sustainable waste management practices, resulting in cleaner, trash-free cities. But effective realization needs proper