

Behavioral Pathways Toward Sustainable Consumption and Municipal Solid Waste Management in Bangladesh's Secondary Cities: An Holistic VBN–TPB Framework

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Abstract

The management of municipal solid waste has become a critical sustainability issue in Bangladesh's secondary cities as a result of rapid urbanisation, increasing waste generation, weak source segregation, limited recycling, irregular collection, and continued dependence on uncontrolled disposal. Although previous studies have examined municipal solid waste management from technical, infrastructural, institutional, and governance perspectives, limited attention has been given to the behavioural pathways that shape household participation in sustainable waste management practices. This gap is particularly important in secondary cities, where municipal capacity and policy implementation are often weaker than in major metropolitan areas.

*This study seeks to examine the behavioural pathways that shape household participation in sustainable municipal solid waste management in Bangladesh's secondary cities by integrating the **Value–Belief–Norm (VBN) Theory** and the **Theory of Planned Behaviour (TPB)**. The proposed conceptual framework explains sustainable waste management behaviour through two complementary theoretical pathways. The VBN pathway explores how environmental values, ecological beliefs, awareness of environmental consequences, ascription of responsibility, and personal norms influence household waste management practices. The TPB pathway investigates the roles of attitude, subjective norms, perceived behavioural control, and behavioural intention in shaping behaviours such as waste segregation, recycling, reuse, composting, proper storage, and responsible disposal. In addition, socioeconomic characteristics, along with perceptions of government environmental policies and incentive mechanisms, are incorporated as contextual moderating factors that may influence the relationships between these determinants and sustainable waste management behaviour.*

The study will adopt a quantitative cross-sectional survey design and analyse household-level data using reliability testing, validity assessment, and Partial Least Squares Structural Equation Modelling. The expected contribution of this study is both theoretical and practical. Theoretically, it develops an integrated VBN–TPB framework for explaining household sustainable waste behaviour in secondary-city contexts. Practically, it will provide evidence for municipalities and policymakers to design behaviourally informed interventions, including awareness programmes, source-segregation campaigns, incentive mechanisms, community-based monitoring, and improved service support. The findings are expected to support more effective and locally appropriate strategies for sustainable municipal solid waste management in Bangladesh's secondary cities.

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Introduction

1.1 Background of the Study

Rapid urbanisation in low- and middle-income countries has placed significant strain on municipal solid waste management systems, particularly in urban areas where waste collection, source segregation, recycling, treatment, and final disposal infrastructures remain inadequate. Bangladesh exemplifies these challenges, as rapid population growth, urban expansion, evolving consumption patterns, and limited municipal capacity have substantially increased both waste generation and the demand for effective waste management services. While major metropolitan centres such as Dhaka and Chattogram have received considerable policy and scholarly attention, secondary cities have emerged as critical areas of concern due to their accelerated growth and comparatively weaker institutional, financial, and technical capacities. Consequently, these cities face mounting difficulties in developing and sustaining efficient and environmentally sound municipal solid waste management systems. (Tanner et al., 2009; Listiningrum et al., 2023)

Sustainable municipal solid waste management depends not only on municipal infrastructure, policy, and technology, but also on household-level behavior. Waste is first generated, stored, separated, reused, recycled, or discarded at the household level. Therefore, household participation in source segregation, recycling, reuse, composting, and responsible disposal is central to improving sustainable MSWM outcomes. However, the

behavioural pathways that influence household participation remain insufficiently understood in Bangladesh's secondary cities. This study addresses this issue by applying an integrated Value–Belief–Norm and Theory of Planned Behaviour framework to explain sustainable household waste management behaviour. (Tanner et al., 2009; Lassa & Nugraha, 2014).

1.2 Problem statement

While a substantial body of research has examined municipal solid waste (MSW) management from technical, infrastructural, and institutional perspectives, comparatively limited attention has been given to the behavioural mechanisms that influence the adoption of sustainable waste management practices at the household level, particularly in Bangladesh's secondary cities (Tanner et al., 2009; Nugraha & Lassa, 2018). Existing studies have predominantly focused on major metropolitan areas such as Dhaka and Chattogram, leaving the dynamics of waste management in secondary cities relatively underexplored. This gap is especially concerning given that secondary cities often face greater waste management challenges due to limited institutional, financial, and administrative capacities (Tanner et al., 2009; Listiningrum et al., 2023). Consequently, empirical evidence remains insufficient regarding the factors that motivate households to engage in sustainable waste management behaviours. In particular, there is a limited understanding of how environmental values, ecological beliefs, personal norms, attitudes, subjective norms, perceived behavioural control, and policy-related incentives shape household decisions concerning waste segregation, recycling, reuse, composting, and responsible disposal practices. To address this gap, the present study integrates the **Value–Belief–Norm (VBN) Theory** and the **Theory of Planned Behaviour (TPB)** to develop a comprehensive conceptual framework for examining the behavioural pathways that influence sustainable municipal solid waste management in Bangladesh's secondary cities.

i. Sustainable Waste Management Challenges in Developing Countries

The institutional dimension is a critical determinant of waste management performance. Drawing on the Wastaware Benchmark Indicators Framework, Wilson et al. (2015) argue that the effectiveness of municipal solid waste management extends beyond the provision of technical infrastructure and services; it is fundamentally shaped by the quality of governance, financial sustainability, stakeholder engagement, and institutional capacity. Through a comparative analysis of waste management systems across diverse urban contexts, the authors demonstrate that technical interventions alone are insufficient to achieve sustainable outcomes in the absence of enabling governance arrangements, effective regulatory mechanisms, and robust institutional structures. Their findings underscore the importance of strengthening institutional frameworks as a prerequisite for improving the overall performance and sustainability of municipal solid waste management systems

These trends are very evident in Bangladesh. The urban population has risen to almost 40% of the country's total population in 2022 from about 8% in 1974, and is expected to exceed 60% of the country's population by 2050. This demographic transformation, coupled with rapid industrialisation and evolving consumption patterns, has significantly increased the generation of municipal solid waste (MSW). It is estimated that urban areas in Bangladesh produce more than 33,000 tons of waste per day, a figure projected to increase substantially by 2041. These growing pressures present considerable challenges for a country with constrained financial, technical, and institutional capacities, highlighting the need for strategic and integrated waste management approaches that extend beyond conventional engineering- and infrastructure-focused solutions (Nugraha & Lassa, 2018; Mavlutova et al., 2023).

The informal waste sector constitutes a vital component of waste management systems in many developing countries and is often responsible for a substantial proportion of material recovery and recycling activities. Gutberlet (2021) argues that informal waste pickers frequently achieve higher recycling rates than formal waste management systems, particularly for recyclable materials with established market value. Evidence from successful integration models implemented across Latin America and Asia suggests that sustainable waste management strategies should move beyond a narrow emphasis on mechanization and instead foster economic opportunities, social inclusion, and system-wide improvements. Such approaches enhance overall waste recovery performance while avoiding the marginalization and displacement of informal waste actors (Aparcana, 2017). These experiences underscore the importance of recognizing existing social structures, behavioral dynamics, and community participation when designing and implementing effective waste management interventions.

Table 1.1: Municipal Solid Waste Composition by Source in Bangladesh

Waste Category	Residential (%)	Commercial (%)	Street/Industrial (%)
Food / Organic Waste	60–80	70–85	40–60
Plastics	3–8	5–10	6–10
Paper / Polyethylene Bags	3–10	5–10	2–6
Metals and Glass	2–5	3–8	5–10
Textiles / Cloth	2–4	1–3	1–2
Others (rubber, e-waste, medical)	<2–3	Minor	Relatively higher

Source: Adapted from Waste Concern (2021) and BBS (2022).

National urban waste baseline

The total average waste generated in the urban Bangladesh during 1 day was found to be 33,574.30 tons/day which is equivalent to 0.52 kg/capita/day (Waste Concern, 2021). In the same dataset, the largest proportion of waste generated in 2021 was food waste (79.5% overall), with food waste shares recorded as 79.9% in cities and 80.74% in pourashavas (Waste Concern, 2021).

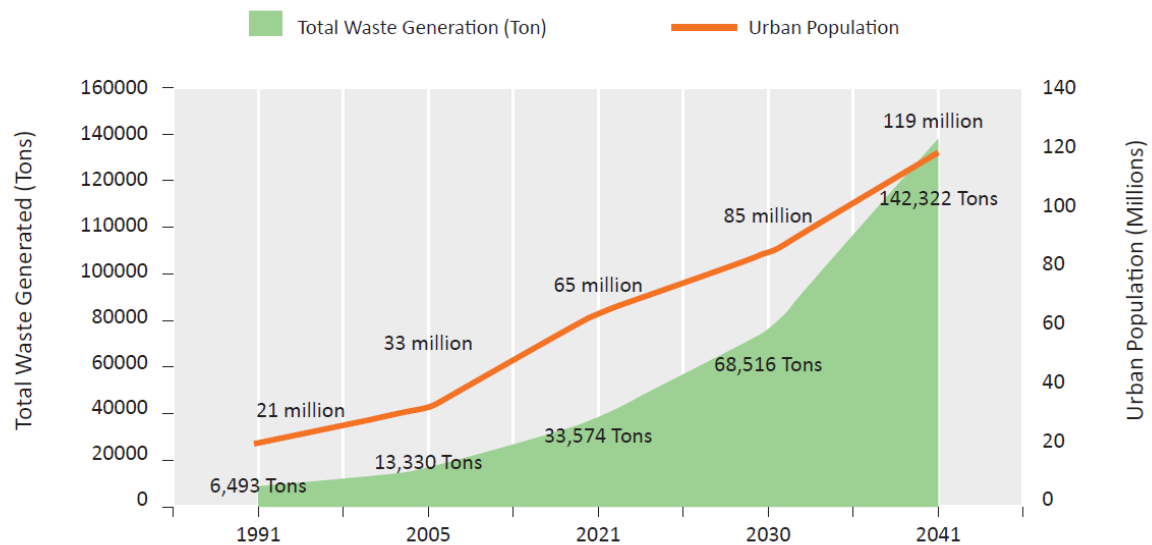


Figure 1 : Total Waste Generation vs. Urban Population

Source: Waste Concern, 2021.

Major city corporations (location-wise MSW generation and per-capita rates)

A widely cited comparative analysis of six major cities reported substantial variations in municipal solid waste (MSW) generation, including both total daily waste volumes and per-capita generation rates (Abedin & Jahiruddin, 2015).

Location (City Corporation)	MSW generated (tons/day)	Population (million)	Per-capita MSW (kg/capita/day)
Dhaka (DCC)	5,340	11.00	0.485
Chattogram/Chittagong (CCC)	1,315	3.65	0.360
Khulna (KCC)	520	1.50	0.347
Rajshahi (RCC)	170	0.45	0.378
Barishal/Barisal (BCC)	130	0.40	0.325
Sylhet (SCC)	215	0.50	0.430

Planning implication: Dhaka is the major node with high volume, but other secondary large cities, particularly Chattogram and Khulna have significant export tonnage and should be targeted for upgrading of the system including coverage of collection, transfer, treatment and controlled disposal (Abedin & Jahiruddin, 2015). The technical relevance of interventions targeting organics (segregation at source, decentralized

composting/biowaste treatment, and marketable compost pathways) While these approaches exhibit consistent applicability at the national level, their operational feasibility and effectiveness may vary considerably across municipalities owing to differences in institutional capacity, resource constraints, and access to established market channels.

(Waste Concern, 2021).

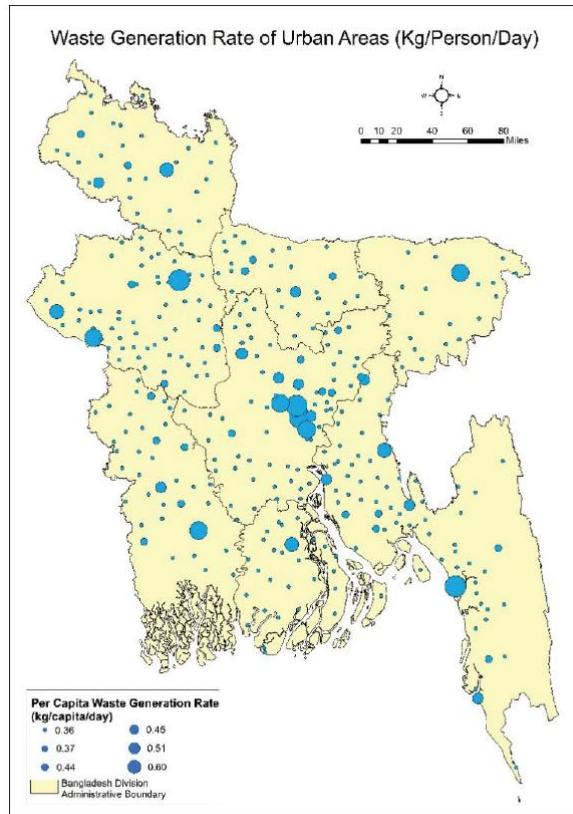


Image 3: Map of total waste generated (2021)

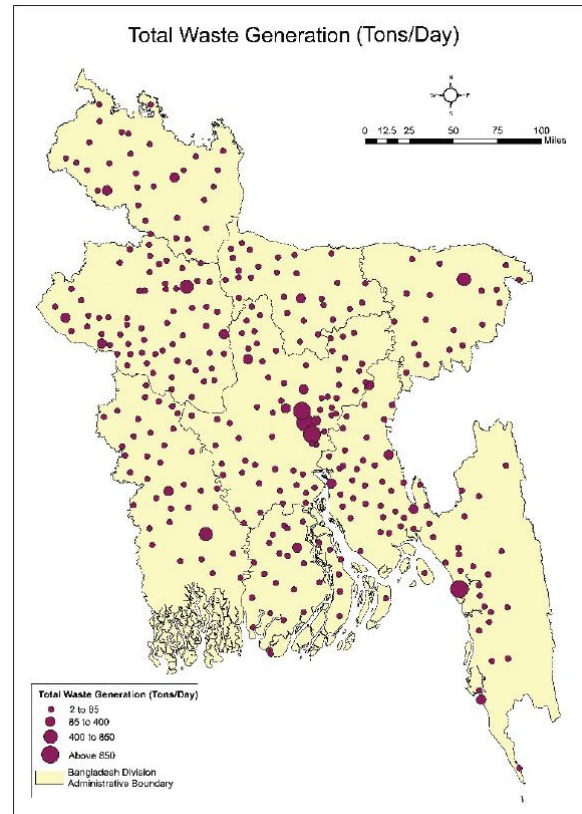


Image 4: Map of per capita waste generation rate (2021)

Source: Waste Concern, 2021.

ii. The State of Municipal Solid Waste Management in Bangladesh

Waste management in Bangladesh demonstrates some general characteristics of developing countries and also has a few characteristics that are unique to Bangladesh which will pose challenges and opportunities for waste management improvements. The system is embedded in a complex institutional landscape with responsibilities for service delivery delegated to local government entities but lacking in capacity building and financial resources.

The Bangladesh Bureau of Statistics (BBS, 2022) reported that around 20,274 metric tons of MSW was generated in the city corporations and municipalities on a daily basis with 79 percent collection efficiency during 2020-2021. Nevertheless, this overall figure hides major differences between urban typologies and areas. Ahmed et al. (2025) describe a waste management system that is marked by low waste collection efficiency in secondary cities (55-60%), low level of waste treatment (less than 5% of waste is treated), and high level of waste disposal in uncontrolled open dumps and poorly managed landfills.

The waste management context in Bangladesh differs from that of many other South Asian countries due to several distinctive characteristics. Foremost among these is the predominantly organic composition of the municipal waste stream. (around 79.5% food waste) and this presents significant anaerobic decomposition problems and large composting opportunities that are largely unused. Secondly, the country is affected by severe climate vulnerabilities like frequent flooding, cyclones and seasonal fluctuations, which affect waste systems and generate surge needs thereby putting waste systems beyond reach of the response capability of the municipalities. Third, Bangladesh's informal economy is also characterised with a widespread informal waste recovery sector that processes an estimated 90% of plastic recycling activities (Uddin & Begum, 2023), but with inadequate formal integration, coordination and sector protection.

The waste management in Bangladesh is multi-level, from the national level (Ministries) to the divisional level (Divisional administration) to the district level (District administration) to the local government level (Local government institutions). Policy guidance is issued by the Ministry of Local Government, Rural Development and Co-operatives under various policy documents such as the National 3R Strategy for Waste Management (2010), Solid Waste Management Rules (2021) and service delivery is delegated to the city corporations and pourashavas. This institutional structure, however, poses challenges to implementation, such as weak fiscal transfers, low technical capacity at the local level, multiple agency coordination and enforcement. The problems are especially severe in secondary cities where the presence of political attention, technical knowledge and resources are not as available as in large cities or metros (Tanner et al. 2009; Lassa & Nugraha 2014).

These data show that Bangladesh's MSWM challenge is not only a technical issue of waste volume and collection capacity. The high organic fraction of waste, low source segregation, weak treatment systems, and reliance on uncontrolled disposal indicate that household-level practices are central to sustainable waste management. Without household participation in segregation, proper storage, recycling, and organic waste recovery, municipal infrastructure and circular economy initiatives are unlikely to function effectively.

1.3 Research gap

Municipal solid waste management in Bangladesh has commonly been examined from technical, infrastructural, institutional, and governance perspectives. (Tanner et al., 2009; Nugraha & Lassa, 2018). However, limited attention has been given to the behavioural mechanisms that shape household participation in sustainable waste management practices, particularly in secondary cities. Existing studies are often concentrated on major metropolitan areas such as Dhaka and Chattogram, while secondary cities remain under-examined despite their growing waste burden, weaker municipal capacity, and lower levels of formal waste service provision.

Consequently, a critical gap remains in the evidence base. Municipal authorities and policymakers have limited access to contextually grounded empirical insights into the behavioural determinants of sustainable household waste management. Specifically, insufficient attention has been given to understanding how environmental values, ecological beliefs, awareness of consequences, ascription of responsibility, personal norms, attitudes, subjective norms, perceived behavioural control, socioeconomic conditions, and perceived government policy incentives collectively shape household decisions regarding waste segregation, recycling, reuse, composting, and environmentally responsible disposal practices.

The problem is therefore not only that secondary cities face weak MSWM systems, but that the behavioural pathways through which households participate in sustainable MSWM remain insufficiently explained. This study addresses this problem by developing and testing an integrated Value–Belief–Norm and Theory of Planned Behaviour framework for sustainable household waste management behaviour in Bangladesh's secondary cities.

1.4 Research Gap

Table: Summary of Research Gaps and Study Contributions

Gap Category	Nature of the Gap	Representative Evidence	Study Contribution
Secondary-City Evidence Gap	MSWM research is metro-centric; secondary cities behavioural and governance realities are underexplored.	Tanner et al. (2009); Hossain & Shams (2020); Waste Concern (2021)	First systematic multi-city comparative assessment of secondary cities across Bangladesh ecologically diverse urban system.
Behavioural Pathway Gap	The sequential chain from environmental values → awareness → attitude → behaviour → practices is untested in Bangladesh secondary cities.	Stern (2000); Ajzen (1991); Klöckner (2013)	Empirically tests and models the full behavioural pathway using household survey data and SEM/PLS-SEM.
Theory Integration Gap	VBN and TPB are rarely integrated systematically in waste management studies; most studies apply one theory alone.	Ali et al. (2025); Awino & Apitz (2024)	Constructs an integrated VBN-TPB framework explaining both moral-normative and rational-intentional pathways.
Policy-Behaviour Interface Gap	Studies rarely examine how perceived government policy and incentives moderate behavioural pathways.	Yao & Zhou (2023); Islam et al. (2023)	Tests perceived government environmental policy and incentives as a moderator of attitude-behaviour and behaviour-practice links.

Framework Validation Gap	No validated behavioural framework exists for secondary-city MSWM in Bangladesh; existing frameworks from developed countries may not transfer directly.	Wilson et al. (2015); Subedi et al. (2023)	Validates an integrated behavioural-institutional framework under diverse ecological and climate-risk conditions.
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Source: Developed from reviewed literature.

Although there are some existing studies that can offer useful information on household waste behaviour, there are three gaps. First, a lot of studies focus on one factor, namely on normative or rational choice factors, separately instead of by using VBN and TPB. Second, despite a relatively small number of cities, the evidence base is predominantly focused on the major cities of Bangladesh and only a small amount of attention is paid to secondary cities. Thirdly, the moderating effect of socioeconomic characteristics and perceived government environmental policies is yet to be explored. This study aims to fill these gaps by developing and testing an integrated VBN–TPB framework for the implementation of sustainable MSWM behaviour in the secondary cities of Bangladesh.

1.4 Research aim

This study aims to examine the behavioural mechanisms that influence household engagement in sustainable municipal solid waste (MSW) management in the secondary cities of Bangladesh by integrating the Value–Belief–Norm (VBN) Theory and the Theory of Planned Behaviour (TPB).

1.5 Research objectives

Keep these aligned with the conceptual framework:

1. To assess the effects of environmental values, ecological beliefs, awareness of environmental consequences, ascription of responsibility, and personal norms on household adoption of sustainable municipal solid waste management behaviours.
2. To investigate the influence of attitude, subjective norms, perceived behavioural control, and behavioural intention on household adoption of sustainable municipal solid waste management practices, including waste segregation, recycling, and responsible disposal.
3. To test an integrated VBN–TPB conceptual framework explaining sustainable MSWM behaviour in Bangladesh’s secondary cities

1.6 Research questions

Use questions that mirror the objectives:

1. How do VBN-related factors influence household sustainable waste management behaviour in Bangladesh’s secondary cities?
2. How do TPB-related factors influence household behavioural intention and actual waste management practices?
3. How effectively does an integrated VBN–TPB framework explain sustainable MSWM behaviour?

1.7 Significance of the study:

This study is significant because achieving sustainable municipal solid waste management (MSWM) in Bangladesh’s secondary cities requires not only effective infrastructure and policy interventions but also active household participation (Tanner et al., 2009; Listiningrum et al., 2023). Household behaviours, including waste segregation, recycling, reuse, composting, and responsible disposal, are essential to the success of sustainable waste management systems.

From a theoretical perspective, the study contributes to the literature by integrating the **Value–Belief–Norm (VBN) Theory** and the **Theory of Planned Behaviour (TPB)** into a unified framework. This integrated approach enables a more comprehensive understanding of both the moral-normative and rational-intentional determinants of household sustainable waste management behaviour.

From a practical perspective, the study provides empirical evidence on the behavioural factors that influence household participation in sustainable waste management. The findings can assist municipalities and policymakers

in designing targeted interventions, including awareness campaigns, community engagement initiatives, improved service provision, and incentive-based policy measures.

Contextually, the study addresses an important research gap by focusing on Bangladesh's secondary cities, which remain underrepresented in the MSWM literature despite experiencing rapid urban growth, increasing waste generation, and relatively limited municipal capacity. The findings are expected to support the development of context-specific and scalable strategies for sustainable waste governance in these urban areas.

1.8 Significance and Contributions of the Study:

This study contributes to the advancement of research and practice in sustainable municipal solid waste management (MSWM) in four important ways.

First, the study develops and empirically validates an integrated conceptual framework that combines the **Value–Belief–Norm (VBN) Theory** and the **Theory of Planned Behaviour (TPB)** to explain household engagement in sustainable waste management practices in Bangladesh's secondary cities. By incorporating environmental values, ecological beliefs, awareness of consequences, ascription of responsibility, personal norms, attitudes, subjective norms, perceived behavioural control, behavioural intentions, and actual behaviour, the framework provides a comprehensive explanation of the psychological and social mechanisms that shape household participation in sustainable MSWM.

Second, the study generates practical insights for municipalities and local authorities by identifying the key behavioural determinants of household waste segregation, recycling, reuse, composting, and responsible disposal. Understanding the relative influence of these factors can support the design of targeted and evidence-based interventions. For example, if perceived behavioural control emerges as a significant predictor, policy efforts may focus on improving access to waste bins, collection services, segregation facilities, and recycling infrastructure. Similarly, if subjective norms are found to be influential, community leaders, educational institutions, religious organisations, and neighbourhood networks may be engaged to strengthen social support for sustainable waste management practices.

Third, the study extends the existing literature by examining the role of perceived government environmental policies and incentive mechanisms in influencing household waste management behaviour. This perspective enables a deeper understanding of how households respond to policy instruments such as regulatory measures, awareness campaigns, enforcement mechanisms, financial incentives, and waste-related communication initiatives. The findings are expected to inform the development of more effective policy interventions, including source-segregation programmes, incentive-based schemes, user-fee reforms, and community-based monitoring systems.

Fourth, the study provides context-specific evidence from Bangladesh's secondary cities, a setting that remains underrepresented in the MSWM literature. Existing research has largely focused on major metropolitan areas, despite the fact that secondary cities face distinct challenges associated with rapid urban growth, increasing waste generation, and comparatively limited institutional capacity. By addressing this gap, the study contributes valuable empirical evidence that can support the formulation of locally relevant, scalable, and sustainable waste management strategies in emerging urban centres.

Overall, the study advances theoretical understanding, enriches the empirical evidence base, and provides practical guidance for policymakers and municipal authorities seeking to promote sustainable municipal solid waste management in Bangladesh's secondary cities.

II. Literature Review

2.1 Introduction

This chapter reviews previous theoretical and empirical studies relevant to household sustainable MSWM behaviour. The review focuses on behavioural studies, VBN theory, TPB, integrated VBN–TPB models, socioeconomic influences, perceived government policy and incentives, and empirical evidence from Bangladesh and comparable developing-country contexts. The purpose is to identify the theoretical and empirical gaps that justify the proposed conceptual framework.

Waste Types in Secondary Cities

One of the key drivers to give secondary urban areas a policy agenda is that their waste issue is not exclusively about “general MSW”. Rather, it is a collection of interrelated waste types, which interact with poor urban systems.

2.2 Previous Studies on Household MSWM Behavior :

Previous studies show that household participation is central to sustainable MSWM because waste separation, storage, reuse, recycling, and disposal decisions begin at the household level. However, many studies report an awareness–behaviour gap: residents may recognise the environmental and health impacts of poor waste management but fail to practise source segregation or recycling due to weak service systems, lack of facilities,

inconvenience, limited incentives, and low enforcement. This suggests that household waste behaviour cannot be explained by awareness alone; rather, it requires a broader behavioural framework that incorporates values, norms, attitudes, perceived control, and institutional support.

2.3 Secondary Cities and Urban Governance

Although the concept of secondary cities as key locations for sustainable development has been increasingly embraced in the literature on urban governance, the study of waste management has mostly neglected these contexts, preferring to focus on either big metropolitan areas or rural areas. The governance issues experienced by secondary cities can be different from those of large metros and smaller towns, as they are subject to rapid growth and existing infrastructure becomes stretched, have more complex waste streams due to diverse economic activities, but lack institutional capacity and political attention given to major cities as found by Satterthwaite (2016). The secondary cities have certain specific features which have adverse impacts on the waste management performance and potential for sustainability in Bangladesh. These urban centres also tend to have relatively smaller economical bases, less technical skills, and investment in infrastructure compared to larger metropolitan areas, and they are also subjected to different types of waste generated by agricultural markets, small industries, administrative activities, and increased commercial activity (Nugraha & Lassa, 2018; Iqbal et al., 2023). Secondary cities vary in their nature, adding to the complexity of waste management planning. The problems related to salinity, storm surge, sea-level rise, and flood in haor region differ from those in peri-urban areas, coastal regions, and northern regions affected by floods and heat stress (Chowdhury et al., 2025; Li et al., 2023; Allarane et al., 2023). Some governance issues in secondary cities directly impact the performance of waste management, such as limited budgets for waste management (which is often less than 2% of total municipal budget); limited technical staff, which is often fewer than five persons dedicated to waste management per municipality; lack of equipment (limited collection vehicles, no specialized treatment infrastructure); weak regulatory enforcement capacity (fewer human and financial resources for regulatory enforcement), and weak coordination between municipal departments, NGOs, informal actors and higher-level government bodies (Mavlutova et al., 2023; Nugraha & Lassa, 2018). These pressures are exacerbated by fast urban population growth, which frequently puts pressures on investment in infrastructure and institutional capacity. A view of the governance could also explain why service inequality is still present. Many cities provide a spatially-selective collection and street cleaning service, with a higher frequency of service for areas that are politically visible or commercially central, compared with areas in the periphery. This disparity arises from administrative prioritisation in the context of fiscal and political pressures, and contributes to citizens' attitudes and practices, diminishing trust in the services, reducing segregation and normalising informal dumping. If household members feel that the city does not enforce compliance, awareness campaigns fail because non-compliance makes sense when they can't rely on the city's performance (Tanner et al. 2009; Magotra et al. 2023).

2.4 Theory of Waste and Relevant Waste Management Theories

TPB explains behaviour through the formation of behavioural intention, which is shaped by attitude, subjective norms, and perceived behavioural control. In household waste management, attitude reflects whether individuals view waste segregation, recycling, or composting as useful and worthwhile. Subjective norms capture social pressure from family, neighbours, community leaders, or local institutions. Perceived behavioural control reflects whether households believe they have the necessary facilities, knowledge, time, and municipal support to perform sustainable waste practices. This makes TPB especially relevant to secondary cities where behavioural intention may be constrained by irregular collection, lack of separate bins, poor recycling access, and weak enforcement.(Tanner et al., 2009; Nugraha & Lassa, 2018).

2.5 Five Waste Management Models: A Global Review

The literature analysed shows that there is no one best model for sustainable governance of MSW. Five main models have emerged as the predominant ones in international waste management studies with their own advantages and disadvantages in the context of secondary cities in a developing country such as Bangladesh. The following table provides an international, empirical, and comprehensive overview and comparison of these models.

Integrated Sustainable Waste Management (ISWM) model integrates technical service delivery, institutional coordination, stakeholder engagement, environmental sustainability and financial feasibility. ISWM's major analytical strength is to connect domains that are typically disconnected in policy practice: engineering decisions and governance arrangements; and service performance and social inclusion and financial sustainability. Initial contributions put ISWM on a multi-dimensional platform, allowing to examine waste systems in the perspective of stakeholders, system elements and sustainability aspects (Ignatuschtschenko, 2017; Wilson et al., 2015).

The Circular Economy model redefines waste as a valuable resource, focusing on material cycles, value keeping and moving away from linear waste disposal systems towards a regenerative flow of resources. In China, Indonesia, Nepal, Mongolia and Rwanda lessons learned have led to the integration of ISWM with CE strategies, creating a new and prominent sustainability pathway from waste governance to production systems and consumption behaviour (Nugroho & Bik, 2025; Subedi et al., 2023).

Pay-As-You-Throw (PAYT) model is an economic incentive approach to behaviour change that ties waste disposal costs to waste volumes generated. Germany, Italy, Ireland, Estonia and Portugal have shown that, with pricing mechanisms, monitoring, enforcement and public acceptance, waste separation and waste reduction can be achieved and municipal efficiency improved (Morlok et al., 2017; Buccioli et al., 2011). In developing nations, the effectiveness of PAYT relies on the capability of institutions, residents' willingness to pay and the availability of waste measurement systems.

The Decentralised Community Based Waste Management model focuses on neighbourhood level recovery, composting, informal recycling, and encourages the participation and shared responsibility of the local community. Indonesia, Ghana, Zimbabwe and Bangladesh, among others, have community-based models that have proven to enhance local ownership, lower landfill pressure, and facilitate resource recovery in a circular way when integrated with municipal planning and market linkages (Yedla, 2012; Khair et al., 2019; Halimah & Machdum, 2023).

The Waste-to-Energy (WtE) model is a technology driven line of business which emphasizes on recovering energy from residual waste streams. The composition of the waste, the technological capacity, environmental protection, emission control, financing and regulation are all crucial factors to consider in implementing WtE. WtE may not be immediately applicable for LMICs with high levels of organic waste and poor levels of segregation unless there is strong pre-treatment, institutional capacity, and environmental compliance mechanisms in place (Hodgkinson et al., 2021; Tsui & Wong, 2019).

Table 2.1: Comprehensive Review of Waste Management Models Worldwide

SL	Author / Year	Country Context	Research Type	Theory Framework	Waste Management Model	Key Relevance for This Study
I. INTEGRATED SUSTAINABLE WASTE MANAGEMENT (ISWM) MODEL						
1	Ignatuschtschenko (2017)	China; Japan; Vietnam	Comparative analysis	ISWM (stakeholders, system elements, sustainability aspects)	ISWM	Demonstrates multi-dimensional ISWM applicability in Asia; foundational for systems-based assessment of secondary cities.
2	Wilson et al. (2015)	Multi-country	Framework/indicator development	ISWM benchmarking (Wasteaware)	ISWM	Provides diagnostic template for assessing governance quality alongside physical waste-chain performance.
3	Yukalang et al. (2017)	Thailand	Qualitative (interviews, focus groups)	Barriers to MSWM/ISWM	ISWM	Identifies institutional and behavioral barriers to ISWM in an LMIC context analogous to Bangladesh.
4	Wilson & Scheinberg (2010)	Multi-country	Good-practice framework	ISWM framing	ISWM	Establishes ISWM as a governance and stakeholder framework, not merely a technical service model.
5	Subedi et al. (2023)	Nepal	Review perspective	ISWM + CE principles	ISWM	Demonstrates ISWM–CE integration in a South Asian secondary-city setting; directly relevant to Nepal.
II. CIRCULAR ECONOMY / ZERO WASTE MODEL						
6	Nugroho & Bik (2025)	China; Indonesia	Comparative policy/case analysis	Circular economy vs community-based approach	Circular Economy / Zero Waste	Shows CE strategy implementation and community-based integration in developing Asia.

7	Tao et al. (2024)	China; UK	Comparative policy analysis	Industrial symbiosis policy instruments	Circular Economy / Zero Waste	Illustrates how policy instruments drive circularity; applicable to Bangladesh regulatory design.
8	Ogotu et al. (2023)	Rwanda	Qualitative/policy impact study	Circular economy (10-R alignment)	Circular Economy / Zero Waste	Demonstrates policy-driven circular economy in an African LMIC; useful for regulatory benchmarking.
9	Malinauskaitė et al. (2017)	EU (countries)	Overarching review	CE + energy recycling framing	Circular Economy / Zero Waste	Connects circular economy to integrated European waste systems; high-income reference for CE ambition.
10	Akmal et al. (2023)	Pakistan	Quantitative (SEM)	Behavioural/SEM framework	Circular Economy / Zero Waste	Applies SEM to household segregation and CE relevance; methodologically closest study to this research.
III. PAY-AS-YOU-THROW (PAYT) MODEL						
11	Morlok et al. (2017)	Germany	Case study / impact evaluation	PAYT ("polluter pays")	PAYT	Empirical evidence of PAYT impact on waste reduction and sorting behavior; benchmark for incentive design.
12	Buccioli et al. (2011)	Italy	Panel analysis	Incentives and sorting behavior	PAYT	Demonstrates how unit pricing incentivizes recycling; relevant for fee-based behavioral change in Bangladesh.
13	Yao & Zhou (2023)	China	Quantitative (acceptance modeling)	Policy acceptance modeling	PAYT	Examines urban residents acceptance of waste policy instruments; directly relevant to RQ3.
14	Murad et al. (2007)	Malaysia	Contingent valuation regression +	Willingness-to-pay framing	PAYT	Assesses WTP for waste services in a developing-country context; informs secondary-city fee acceptance.
15	Dunne et al. (2008)	Ireland	Policy/acceptability study	Public acceptability framing	PAYT	Highlights public acceptability as a prerequisite for PAYT success; aligns with perceived policy incentives construct.
IV. DECENTRALIZED COMMUNITY-BASED WASTE MANAGEMENT MODEL						
16	Yedla (2012)	Bangladesh (Dhaka)	Case study / replication	Decentralised composting	Decentralized Community-Based Management	Dhaka composting model demonstrates decentralised organic recovery in Bangladesh; directly applicable.
17	Khair et al. (2019)	Indonesia (Medan)	Environmental + economic assessment	3Rs / waste bank operations	Decentralized Community-Based Management	Waste bank model shows community-based recovery aligned with circular economy in LMIC Asia.
18	Halimah & Machdum (2023)	Indonesia (Bandung)	Qualitative/participation analysis	Participatory development	Decentralized Community-Based Management	Demonstrates participatory waste management in secondary Indonesian cities; replicable in Bangladesh.
19	Kyere et al. (2019)	Ghana	Governance/policy analysis	Decentralization governance	Decentralized Community-Based Management	Governance analysis of decentralised waste management; informs institutional design for secondary cities.
20	Sinthumule & Mkumbuzi (2019)	Zimbabwe (Bulawayo)	Case study	Community-based waste management	Decentralized Community-Based Management	Community-based approach in an African secondary city; relevant to equity and informal sector integration.

V. WASTE-TO-ENERGY / THERMAL TREATMENT MODEL						
21	Hodgkinson et al. (2021)	Multi-country	Conceptual/positi oning	CE rationale for WtE	WtE / Thermal Treatment	Positions WtE within circular economy logic; relevant for policy conditionality in Bangladesh.
22	Tsui & Wong (2019)	Multi-country	Conceptual overview	Bioeconomy expansion of WtE	WtE / Thermal Treatment	Frames WtE within bioeconomy development; highlights technology-readiness conditions.
23	Saha Naidoo & (2024)	South Africa	Applied technology adoption analysis	Landfill reduction objective	WtE / Thermal Treatment	Examines WtE for landfill diversion in an African LMIC; relevant for Bangladesh disposal transition.

Source: Compiled by the Author from reviewed literature.

Behavioural Pathways to Sustainable Municipal Solid Waste Management in Bangladesh's Secondary Cities: An Integrated VBN-TPB Framework.

2.7 Integrated Sustainable Waste Management, Circular Economy, and Behavioural Pathways

Overall, the literature indicates that there is not a single model that could be considered as the solution for sustainable waste governance in secondary cities in Bangladesh. ISWM serves as the overarching diagnostic and governance framework, Circular Economy provides the direction of sustainability and resource-efficiency, PAYT provides an economic incentive and household accountability, Decentralised Community Based Management provides a way to enhance participation and local implementation, and WtE provides a technology-centric pathway with institutional and infrastructural readiness.

In the context of developing countries like Bangladesh, the most applicable model should be a hybrid, which incorporates the principles of the ISWM, circular economy, decentralised organic waste recovery, community engagement, linking with informal sector, and context-sensitive financing. This is more realistic than using only centralized disposal or capital-intensive technologies especially in areas where municipalities do not have capacity and biodegradable waste is still a major component (Wilson et al., 2015; Yedla, 2012; Subedi et al., 2023; Mavlutova et al., 2023; Magotra et al., 2023).

Linking these waste management models with household behavioural pathways is a crucial link. Households must comply with source separation to effectively implement ISWM, while the idea of stakeholder coordination is emphasized. The success of CE circular transitions is reliant on households actively engaging with recycling, composting and reducing waste. Household willingness to pay and fairness of fee structures are critical to the effectiveness of PAYT. Engagement with the community, and the resulting norms, form the backbone of decentralised community-based management. For WtE, upstream household behaviour, in terms of organic content and segregation quality, are also needed to make WtE work.

The connection is why a purely institutional/infrastructure-focused approach to MSWM is not enough: the success of each of the big waste management models depends on the behavioural engagement of the households. Therefore, it is important to have this insight to provide a theoretical basis for the conceptual design of this study, which places VBN and TPB frameworks at the centre (Tanner et al., 2009; Listiningrum et al., 2023).

2.8 Theoretical Foundation: Value-Belief-Norm Theory and Theory of Planned Behavior

2.8.1 Value-Belief-Norm (VBN) Theory

Value-Belief-Norm (VBN) theory is a comprehensive model for the understanding of pro-environmental behaviour, which connects values, environmental action and ecological worldview through a causal chain: values → ecological worldview → awareness of consequences → ascription of responsibility → personal norms → action (Stern, 2000). The theory has been successfully used in a number of environmental behaviors such as energy saving (Steg et al., 2005), water saving (Corral-Verdugo et al., 2008), and waste reduction (Kirakozian, 2016). In waste management settings, VBN theory helps to understand how people who are aware of the environmental impact of inadequate waste management, feel responsible for it and take actions in relation to it start to create internal moral norms which can motivate sustainable waste management practices like source separation, recycling participation, and collaboration with the municipal services. The moral motivation focus is especially significant in contexts of developing countries where formal incentive systems may be weak or non-existent. The applications of VBN theory to waste management in developing countries during the last years show its cross-cultural validity and the necessity of adaptation to local situations. The literature in South Asian contexts demonstrates that institutional factors like the availability of services, the credibility of policies, and community social capital significantly influence the strength of the values-behaviour pathway (Awino & Apitz, 2024; Magotra et al., 2023).

2.8.2 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) provides a complementary view that believes behaviour is determined by the individual's intention to perform the behaviour through three factors: attitude toward behaviour, subjective norms also known as perceived social expectations, and perceived behavioural control, which is the individual's belief in their ability to perform the behaviour (Ajzen, 1991). Behavioural intention is in turn related to behaviour with the relationship being mediated by actual behavioural control. Meta-analytic evidence shows that TPB works across a wide range of cultures and economics with regard to waste-related behaviours. TPB is found to explain 40–60% of variance in waste management behaviours, such as recycling, composting and waste reduction, as demonstrated by la Barbera and Ajzen (2021).

TPB is especially important in the understanding of waste behaviour in resource constrained environments because it explicitly addresses the perceived behavioural control which is the person's evaluation of their ability to perform the behaviour, taking into account available resources, opportunities and constraints. This component is particularly essential for secondary cities where infrastructure challenges and service gaps are prevalent, influencing behavioral outcomes and shaping effective interventions.

2.8.3 Rationale for Theoretical Integration

There has been a rise in recent environmental behaviour research that recommends using VBN and TPB together to increase the explanatory power and more comprehensive intervention design. The authors of this study, Klöckner et al. (2013) show using a meta-analysis that the integrated models account for a greater amount of the variance in environmental behaviour than single-theory models alone (typically 50-70% of the variance in behaviour is accounted for by integrated models vs. 30-45% for single theory models). Integrated VBN-TPB approaches are useful in waste management applications in terms of capturing the moral-normative pathway (behaviour is motivated by internalized environmental values and personal responsibility) as well as the rational-intentional pathway (behaviour is triggered by cost-benefit considerations, social norms, and capacity evaluations).

By examining these integrated behavioural models in the context of DWMC, Ali et al. (2025) highlight that sustainable waste management practices are influenced by both rational factors (service availability, economic incentives, social support) and normative factors (environmental values, personal responsibility). Their study has found that both pathways are insufficient in predicting waste management behaviour in resource constrained urban context. This study takes this combined effort to the secondary cities of Bangladesh, and introduces moderating effects of socioeconomic features and government perceived environmental policy and incentives.

2.9 Conceptual Framework

The conceptual framework translates the integrated VBN-TPB logic in the context of governance and service delivery in secondary cities in Bangladesh. The framework highlights sustainable MSWM as a behavioural-institutional pathway where the values and knowledge about the environment as independent variable, influence the waste management practices of the household through a sequential chain of awareness, attitude, and behavioral intention and behavior.

Environmental values (VBN) is the most upstream independent variable and includes biospheric, altruistic and egoistic value orientations (Stern et al., 1999). The second independent variable is Environmental Knowledge (TPB/VBN) which is the cognitive knowledge of environmental issues, environmental risks associated with waste and environmental actions to take for waste. The first mediating construct between Environmental Values and Environmental Knowledge is Environmental Awareness which denotes an individual's awareness of environmental issues related to waste and their implications, and an awareness of personal relevance to the issues. Environmental Awareness is then found to affect Environmental Attitude, another mediating variable which represents an individual's appraisal and value-based orientation towards sustainable waste management. Attitude influences Behaviour (Intention), which includes subjective norms, perceived behavioural control and self-efficacy. As the third mediator, behaviour directly affects the primary outcome measure, Waste Management Practices, which represents observable household activities such as source separation, appropriate storage, timely collection of waste, involvement in recycling and composting, when possible.

There are two moderating variables in the framework that affect the magnitude and direction of the relationships. Socioeconomic Status (SES) is also included in the model as a moderator for various pathways across the model, especially as a moderator for links between knowledge and awareness, as well as attitude and behaviour. According to VBN theory, the attitude-behaviour and behaviour-practice pathways are influenced by perceived Government Environmental Policy and Incentives, which includes regulations, enforcement mechanisms, financial incentives and institutional responsiveness, all of which are determined by structural conditions.

Table 2.3: Framework Domain Operationalization Matrix

Domain	Theoretical Basis	Operational Definition	Illustrative Indicators	Scale	Analytical Role
Environmental Values	VBN (Stern, 2000)	Personal value orientations toward the natural environment and society	Biospheric, altruistic, egoistic value items (Schwartz, 1977; Stern et al., 1999)	5-pt Likert	Primary IV — upstream initiation VBN
Environmental Knowledge	TPB / VBN	Cognitive understanding of waste risks, practices, and institutional responsibilities	Waste-health risk knowledge, segregation rules, 3R/CE principles, municipal roles	5-pt Likert + factual items	IV — activates awareness construct
Awareness	VBN / TPB	Recognition of waste-related environmental consequences and personal relevance	Awareness of drainage risks, disease vectors, segregation norms, actor responsibilities	5-pt Likert	1st mediating construct
Attitude	TPB (Ajzen, 1991)	Evaluative and normative disposition toward sustainable waste practices	Willingness to segregate, cooperate, trust services, accept user charges	5-pt Likert	2nd mediating construct
Behaviour (Intention)	TPB	Expressed intention and enacted conduct toward sustainable practices	Subjective norms, perceived behavioural control, self-efficacy beliefs	5-pt Likert	3rd mediating construct
Waste Management Practices	TPB / VBN	Observable household waste behaviours and service interactions	Source segregation, storage, collection handover, recycling, composting	Frequency + Likert	Primary dependent variable
Socioeconomic Status (SES)	TPB / VBN	Sociodemographic characteristics affecting pathway strength	Education, income, occupation, age, residential tenure, household size	Categorical / ordinal	Moderating variable
Perceived Govt. Policy & Incentives	VBN / TPB	Perceived effectiveness and credibility of waste regulations and incentives	Bylaw awareness, enforcement visibility, policy trust, incentive availability	5-pt Likert	Moderating variable — attitude-to-practice pathway

Source: Developed from Ajzen (1991), Stern (2000), and Stern et al. (1999).

III. Methodology

3.1 Introduction

This chapter builds the hypotheses that implement the integrated VBN-TPB conceptual framework introduced in Chapter Two and defines the evaluation criteria and procedures that are used to assess the integrated VBN-TPB conceptual framework. The chapter is organized as follows: conceptual logic of the framework, direct effect hypotheses, mediation hypotheses, moderation hypotheses, evaluation of conceptual framework, and summary of all the hypotheses. A short theory based on VBN theory, TPB or the combined theory is provided for each of the hypotheses. A framework evaluation section is provided at the end of the chapter, detailing the methods of reliability, validity and structural modelling by which the integrated model will be tested and validated. The logic of analysis shows that the environmental values and environmental knowledge in this framework are considered as independent variables that act as upstream variables, and it is expected that these variables will trigger the process of environmental behaviour change through a chain of variables that occur in between, namely awareness, attitude, and behaviour (Stern, 2000; Ajzen, 1991; Klöckner, 2013). The chain is not supposed to be homogenous; the socio-economic context and perceived government environmental policy and incentives are theorised to be mediators of key relationships within the chain, giving rise to heterogeneity in secondary-city context.

3.2 Conceptual Logic of the Framework:

This study adopts a quantitative cross-sectional survey design to test the hypothesised relationships in the integrated VBN-TPB framework.

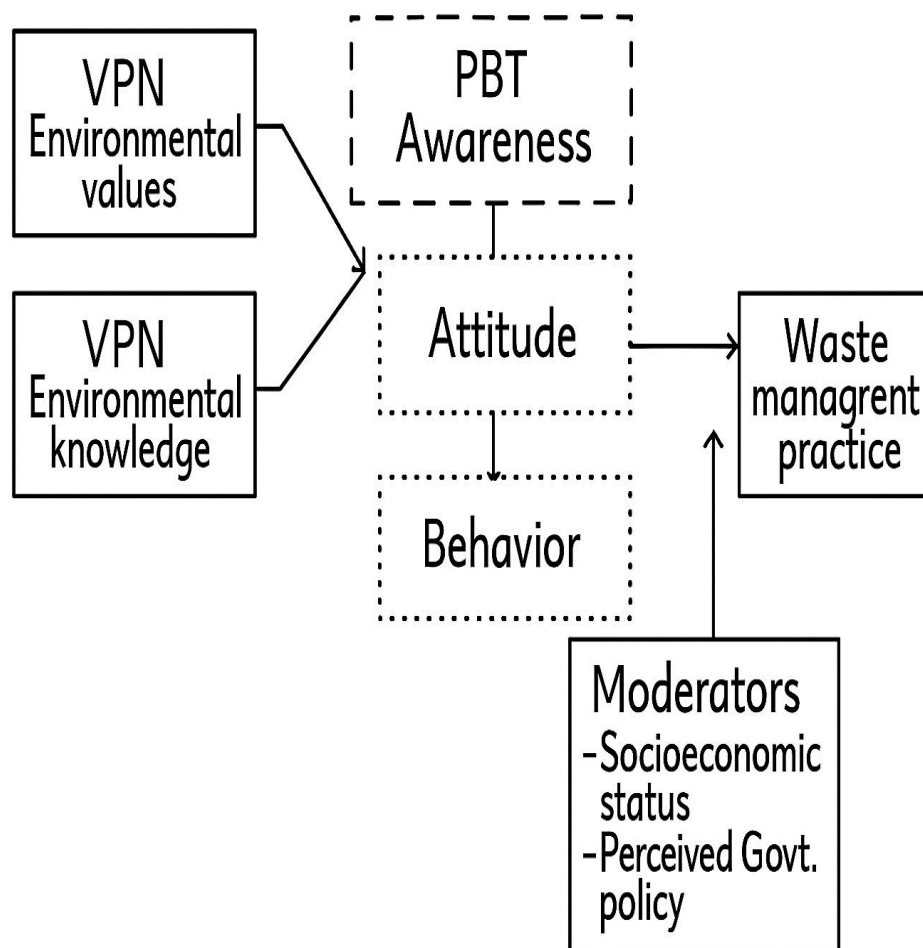


Figure-1 : Conceptual Framework work flow

The integrated VBN-TPB framework is based on two complementary explanatory logics. Based on VBN theory, the moral-normative pathway suggests that people with strong biospheric and altruistic values are more likely to feel a threat to the environment (awareness of consequences), believe that they personally have a responsibility towards the environment (ascription of responsibility), and internalise moral norms that can influence pro-environmental behaviour (Stern, 2000; Stern et al., 1999). In this pathway, behaviours are driven by a sense of moral duty, not by self-interest.

TPB indicates that rational-intentional path would involve attitude towards the behavior, subjective norms (perceived social expectations) and perceived behavioral control (Ajzen, 1991). When perceived control is sufficient, intentions help to predict actual behaviour. In this pathway, behaviour is not only a result of moral obligation but of social influence, capacity assessment and cognitive evaluation as well.

Theoretically important is the integration of these two pathways, as neither one path captures all the factors influencing household waste behaviour in resource constrained secondary cities (Klöckner, 2013; Tanner et al., 2009). Strong environmental values (VBN) can be supported, but if institutional support (TPB) is perceived as low or environmental control (TPB) is not, then the household may not act. On the other hand, households can experience positive attitudes and high perceived control (TPB) but not experience internalized moral norms (VBN) and consequently behave inconsistently. The integrated framework is able to capture these interactions by setting the upstream ones as environmental values and knowledge, and the downstream ones as the sequential mediating chain between upstream values and downstream practices, namely awareness, attitude and behaviour.

The overall strength and direction of relationships in this chain is moderated by the socioeconomic status and perceived government environmental policy and incentives. SES relates to the efficiency of the knowledge-to-awareness (education effect), the viability of sustainable practices (income effect), and the reception of environmental information by occupation and community embeddedness (community and occupation

embeddedness effects). Perceived policy and incentives influences the transformation of positive attitudes to behaviour (enforcement credibility effect) and its persistence as routine practice (incentive continuity effect).

3.3 Direct Effect Hypotheses

The following direct effect hypotheses specify the main hypothesised relationships among the framework's core constructs, consistent with the causal logic of VBN and TPB.

H1: Environmental values have a significant positive effect on environmental awareness.

Justification: The VBN theory suggests that people with biospheric and altruistic values are more likely to be able to develop an ecological worldview and to realize the implications of environmental degradation, which leads to increased awareness (Stern, 2000; Stern et al., 1999).

H2: Environmental knowledge has a significant positive effect on environmental awareness.

Justification: Knowledge is a precondition for awareness; factual understanding of the linkages between waste and health, the rules of segregation and circular economy principles directly inform recognition of environmental consequences (Ajzen, 1991; Stern, 2000).

H3: Environmental awareness has a significant positive effect on attitude toward sustainable waste practices.

Justification: Being aware of the consequences leads to the activation of evaluative orientations: people who are aware of the environmental and public health consequences of poor waste management are more likely to show positive orientations toward sustainable waste management. This is a reflection of the cognitive-evaluative relationship found throughout VBN research (Stern et al., 1999).

H4: Attitude toward sustainable waste practices has a significant positive effect on behavioural intention and behaviour.

Justification: TPB's central pathway: favourable attitudes towards source segregation, recycling, and municipal cooperation increase the likelihood that people develop strong behavioral intentions and actually perform the behavior (Ajzen, 1991).

H5: Behavioural intention and behaviour have a significant positive effect on household waste management practices.

Justification: According to TPB, intention is the immediate determinant of behavior and behavior is directly influencing observable practices, such as source segregation, timely disposal and participation in recycling (Ajzen, 1991).

H6: Environmental values have a significant positive direct and indirect effect on household waste management practices.

Justification: Theory of VBN: morally oriented values will lead to pro-environmental action via two pathways: direct path via norm activation and indirect path via complete mediation chain. Theoretically expected pathways (Stern, 2000) both exist

3.4 Mediation Hypotheses

The framework outlines a sequential mediation process where the role of awareness, attitude and behaviour as intermediate constructs in the transfer of the influence of environmental values and knowledge to waste management practices. This chain is expressed in the following mediation hypotheses.

H7: Awareness mediates the relationship between environmental values and attitude toward sustainable waste practices.

Justification: Environmental values do not directly create attitudinal dispositions; instead, it is by raising awareness of consequences and then triggering positive attitudes toward sustainable practices. This is indicative of the VBN causal chain (Stern et al., 1999).

H8: Awareness mediates the relationship between environmental knowledge and attitude.

Justification: Awareness of waste consequences and responsibilities is informed by knowledge and this in turn influences attitudinal orientations towards sustainable behaviour. The cognitive link between the integrated VBN-TPB pathway is awareness.

H9: Attitude mediates the relationship between awareness and behavioural intention and behaviour.

Justification According to TPB (Ajzen, 1991), awareness does not lead to the behaviour itself, but rather to the evaluative attitudes that filter the awareness before it becomes behavioural intention.

H10: Behavioural intention and behaviour mediate the relationship between attitude and sustainable waste management practices.

Justification: The chain of attitude – intention – enacted behaviour – practice is the key mechanism in the TPB (Ajzen, 1991).

H11: The full sequential pathway (environmental values and knowledge → awareness → attitude → behaviour → waste management practices) constitutes a chain mediation model.

Justification: sustainability of waste practices is predicted by the integrated VBN-TPB model, which assumes that the full causal chain is present in which each construct attempts to influence the others upstream, while also being influenced by the others downstream (Klößner, 2013).

3.5 Moderation Hypotheses

The moderating hypotheses describe the conditions that are likely to influence the strength of each of the relationships in the behavioural pathway chain. Two groups of moderators are explored, socioeconomic status (SES) and perceived government environmental policy and incentives.

H12: Socioeconomic status (particularly education level) moderates the relationship between environmental awareness and attitude, such that the effect is stronger among more highly educated respondents.

Justification: The goal is to raise the capacity to process environmental information and to turn awareness into favourable attitudinal orientations, through higher education. The cognitive-evaluative component in the behavioural pathway is strengthened by education (Stern, 2000).

H13: Socioeconomic status (particularly household income) moderates the relationship between attitude and behavioural intention/behaviour, such that the effect is stronger among higher-income households.

Justification: The more income, the less financial barriers to sustainable practices (e.g. buying separate containers for waste or paying waste collection fees), which increases the chances of converting positive attitudes into behavioural intentions and actions (Ajzen, 1999).

H14: Perceived government environmental policy and incentives moderate the relationship between attitude and behavioural intention/behaviour, such that the effect is stronger when households perceive government policy as credible, visible, and incentivising.

Justification: VBN theory acknowledges that the institutional enablers are part of the perceived behavioural control of TPB and that structural conditions affect the feasibility of norm-driven action. Attitudinal dispositions are reinforced into behavioural intentions by the credible policy and visible incentives (Stern, 2000; Ajzen, 1991).

H15: Perceived government environmental policy and incentives moderate the relationship between behaviour and sustainable waste management practices, such that the effect is stronger when enforcement is consistent and incentives are available.

Justification: Behavioural intentions that are enacted can fail to become regular sustainable behaviours without continuous institutional support. Behavioural engagement is translated into stable household practices when there are consistent enforcement and tangible incentives. (Yao & Zhou, 2023).

3.6 Evaluation of the Conceptual Framework

3.6.1 Reliability Assessment

All multi-item latent constructs will be tested for internal consistency reliability with Cronbach's Alpha and Composite Reliability (CR). For social science research, the acceptable Cronbach's Alpha a value is 0.70 or higher and values exceeding 0.95 will be checked for item redundancy (Hair et al., 2019). A less sensitive measure (the number of scale items) and Composite Reliability will also be reported, with thresholds of 0.70. These reliability tests will be performed in the SPSS and SmartPLS softwares.

3.6.2 Validity Assessment

Content validity will be determined using the expert product review method involving three to five academics and practitioners who are experts in the field of environmental behaviour, MSWM, urban governance, and quantitative research methodology. The experts will assess the relevance, clarity and theoretical fit of the items and the appropriateness for context. An item will be revised or removed if it does not have a Content Validity Index score > 0.80. Construct validity will be analyzed using a two-stage measurement model process. The dimensional structure of latent constructs and the poor loading of items and cross-loading will be examined first by using the Exploratory Factor Analysis (EFA) in SPSS. Finally, Confirmatory Factor Analysis (CFA) will be done to formally evaluate indicator reliability (standardized factor loadings ≥ 0.70 preferred), convergent validity (Average Variance Extracted ≥ 0.50), and discriminant validity (Fornell-Larcker criterion and Heterotrait-Monotrait (HTMT) ratio (HTMT < 0.85/0.90)). The common method bias will be evaluated by means of procedural controls (anonymous administration, temporal separation) and statistical diagnostics (Harman's single factor test, full collinearity VIF).

3.6.3 Mediation Analysis

Bootstrapping with at least 5,000 resamples will be used for mediation analysis, to obtain bias-corrected confidence intervals for the indirect effects. Confidence intervals for indirect effects will be calculated and the significance of mediation will be determined by whether the intervals contain the null value. Specific indirect effects (e.g., values $\rightarrow$ awareness $\rightarrow$ attitude) as well as the total indirect effect of environmental values on waste

management practices via the entire chain will be estimated. The type of mediation (full vs partial) will be compared by looking at the significance of direct and indirect effects in the structural model.

3.6.4 Moderation Analysis

Whether the product indicator approach or orthogonalisation method would be used for modelling the interaction terms of moderation would depend on the distributional characteristics of the moderating variables and would be examined in SmartPLS. Interaction effects will be graphed to show the direction and form of moderation. Multi-group analysis (MGA) will also be used to compare path coefficients between groups in the categorical moderators (e.g. the SES education level or city strata), and between-group differences will be evaluated using the permutation based testing. City-level and service-coverage group comparisons will also explore whether there is a systematic variation in behavioural pathways in ecological and municipal contexts.

3.6.5 Structural Model Assessment

PLS-SEM is used as the main modelling method in this study, as it aligns with the research aims of predicting the effects, incorporating multiple latent constructs and examining the mediation and moderation effects under different contexts of cities. Model evaluation will involve reporting the path coefficients (β), t-values, p-values, and 95% bootstrap confidence intervals for all hypothesised paths; coefficient of determination (R^2) for endogenous constructs; effect sizes (f^2) for each predictor; predictive relevance (Q^2) through blindfolding; and Standardised Root Mean Square Residual (SRMR) as a model-fit indicator (Hair et al., 2019).

3.7 Summary of Hypotheses

Table 3.1 below gives a detailed description of all 15 hypotheses developed in this chapter organised by type (direct, mediation, and moderation) and with their underlying theories.

Table 3.1: Summary of Hypotheses and Theoretical Justification

H#	Hypothesis Statement	Theoretical Justification	Type
H1	Environmental values have a significant positive effect on environmental awareness.	VBN theory posits that biospheric and altruistic values elevate ecological worldview and awareness of consequences (Stern, 2000).	Direct
H2	Environmental knowledge has a significant positive effect on environmental awareness.	Knowledge acts as an enabling precondition that informs awareness and perceived consequences (Ajzen, 1991; Stern et al., 1999).	Direct
H3	Environmental awareness has a significant positive effect on attitude toward sustainable waste practices.	Awareness of consequences activates evaluative dispositions; cognitive-evaluative link well established in VBN and TPB research.	Direct
H4	Attitude toward sustainable waste practices has a significant positive effect on behavioural intention and behaviour.	Central TPB pathway: favourable attitudes increase behavioural intention and enacted behaviour (Ajzen, 1991).	Direct
H5	Behavioural intention/behaviour has a significant positive effect on household waste management practices.	TPB: intention is the proximal predictor of behaviour; behaviour in turn drives observable practices.	Direct
H6	Environmental values have a significant positive effect on household waste management practices (via the full mediation chain).	VBN: values ultimately manifest in pro-environmental behaviour through moral norm formation.	Direct
H7	Awareness mediates the relationship between environmental values and attitude.	Awareness acts as the cognitive bridge linking moral values to evaluative orientations per VBN causal chain.	Mediation
H8	Awareness mediates the relationship between environmental knowledge and attitude.	Knowledge shapes awareness which in turn conditions attitudinal formation (integrated VBN-TPB pathway).	Mediation
H9	Attitude mediates the relationship between awareness and behavioural intention/behaviour.	Awareness does not directly generate behaviour; attitude functions as the evaluative mediating step per TPB.	Mediation
H10	Behaviour mediates the relationship between attitude and sustainable waste management practices.	Behaviour is the proximal determinant of practices; attitude operates through intention and behaviour per TPB.	Mediation
H11	The sequential pathway (values → awareness → attitude → behaviour → practices) is fully mediated.	The integrated VBN-TPB model predicts a chain mediation from upstream moral constructs to downstream practices.	Mediation

H12	Socioeconomic status (education, income) moderates the awareness–attitude relationship.	Higher education and income strengthen the cognitive-evaluative link; SES conditions capacity to translate awareness into attitudes.	Moderation
H13	Socioeconomic status moderates the attitude–behaviour relationship.	Perceived behavioural control is shaped by SES; income and education affect feasibility of sustainable practices.	Moderation
H14	Perceived government environmental policy and incentives moderate the attitude–behaviour relationship, such that the effect is stronger when policy is credible and incentives are visible.	VBN: structural conditions shape norm-driven action; TPB: perceived behavioural control includes institutional enablers.	Moderation
H15	Perceived government environmental policy and incentives moderate the behaviour–practice relationship.	Credible enforcement and incentives convert positive behavioural intentions into routine waste management practices.	Moderation

Source: Developed from Ajzen (1991), Stern (2000), Stern et al. (1999), and Klöckner (2013).

3.8 The Proposed Mathematical Model :

First test reliability and validity.

Reliability

Cronbach's Alpha

$$\alpha > 0.70$$

Composite Reliability

$$CR > 0.70$$

Convergent Validity

Average Variance Extracted

$$AVE = \frac{\sum \lambda_i^2}{n}$$

Requirement:

$$AVE > 0.50$$

where λ_i is the loading of each indicator.

Example:

Indicator	Loading
PN1	0.82
PN2	0.79
PN3	0.85

Then:

$$AVE = \frac{0.82^2 + 0.79^2 + 0.85^2}{3} = 0.673$$

Valid.

Discriminant Validity

Use:

HTMT

$$HTMT < 0.85$$

or

$$HTMT < 0.90$$

Structural Model Estimation

Estimate path coefficients.

Example output:

Relationship	Beta
V → EB	0.60
EB → AC	0.71
AC → AR	0.64
AR → PN	0.58
PN → BI	0.35
ATT → BI	0.26
SN → BI	0.18
PBC → BI	0.28
BI → SWMB	0.52
PBC → SWMB	0.31

Test significance using bootstrapping:

$$t > 1.96$$

for 95% confidence.

Estimating the Sustainability Waste Management Index (SWMI)

After obtaining latent scores from SEM:

Standardize all variables:

$$Z_i = \frac{x_i - \mu}{\sigma}$$

Create:

$$SWMI = w_1PN + w_2ATT + w_3SN + w_4PBC + w_5BI + w_6SWMB$$

where w_i are SEM loadings or path coefficients.

Example:

$$SWMI = 0.18PN + 0.15ATT + 0.10SN + 0.17PBC + 0.20BI + 0.20SWMB$$

Scale:

$$0 - 100$$

Higher values indicate more sustainable waste management performance.

novel index:

$$SWMPI = \frac{(V \times EB \times PN) \times (ATT + SN + PBC)}{WGR}$$

where:

WGR = Waste Generation Rate (kg/person/day)

Empirical steps:

Step 1

Obtain latent scores from SEM.

Example:

Variable	Score
V	4.2
EB	3.9
PN	4.1
ATT	4.0
SN	3.7
PBC	3.8

Waste Generation Rate:

$$WGR = 0.65 \text{ kg/day}$$

Step 2

Calculate:

$$\begin{aligned} SWMPI &= \frac{(4.2 \times 3.9 \times 4.1) \times (4.0 + 3.7 + 3.8)}{0.65} \\ &= \frac{67.16 \times 11.5}{0.65} \\ &= 1188.2 \end{aligned}$$

Normalize:

$$SWMPI^* = \frac{SWMPI - SWMPI_{min}}{SWMPI_{max} - SWMPI_{min}} \times 100$$

to produce a city sustainability score between 0 and 100.

Stage 1

Confirmatory Factor Analysis (CFA)

Stage 2

PLS-SEM estimation of the integrated VBN–TPB model

Stage 3

Multi-group analysis across secondary cities

Stage 4

Construct a Sustainable Waste Management Index (SWMI)

Stage 5

Link SWMI to actual municipal outcomes:

Recycling rate

Waste diversion rate

Collection efficiency

Waste generation rate

through regression:

$$SWMI = \alpha + \beta_1 RR + \beta_2 CE + \beta_3 WDR + \epsilon$$

This would provide both a strong behavioral theory contribution and a practical sustainability assessment framework for Bangladesh's secondary cities.

For SEM, data collection is the most critical stage because SEM works with latent variables (Values, Beliefs, Personal Norms, Attitude, PBC, etc.) that cannot be measured directly. You collect data through a structured survey questionnaire and then use the responses as indicators of the latent constructs.

Step 1: Define the Unit of Analysis

The most suitable unit of analysis is:

Household heads

Adult household members responsible for waste disposal

Residents living in secondary cities

Not municipal officials (unless doing a separate stakeholder analysis).

Step 2: Develop the Questionnaire

Use a Likert scale:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Values (V)

V1: Protecting the environment is important to me.

V2: I feel responsible for conserving natural resources.

V3: Sustainable living is one of my personal priorities.

Environmental Beliefs (EB)

EB1: Improper waste disposal harms the environment.

EB2: Household waste contributes to pollution.

EB3: Waste segregation can reduce environmental degradation.

Awareness of Consequences (AC)

AC1: Poor waste management causes health problems.
AC2: Open dumping affects community well-being.
AC3: Improper waste disposal can worsen climate change.
Ascription of Responsibility (AR)
AR1: I have a responsibility to reduce waste.
AR2: Households should participate in waste management activities.
AR3: My actions can help improve environmental quality.
Personal Norm (PN)
PN1: I feel morally obliged to manage waste properly.
PN2: I would feel guilty if I littered.
PN3: Proper waste management is my duty.
Attitude (ATT)
ATT1: Recycling is beneficial.
ATT2: Waste segregation is worthwhile.
ATT3: Sustainable waste practices improve city life.
Subjective Norm (SN)
SN1: My family expects me to manage waste responsibly.
SN2: People important to me support recycling.
SN3: My community encourages proper waste management.
Perceived Behavioral Control (PBC)
PBC1: I have access to waste collection services.
PBC2: I can easily separate household waste.
PBC3: I have the ability to recycle if I want.
Behavioral Intention (BI)
BI1: I intend to separate waste regularly.
BI2: I plan to participate in recycling activities.
BI3: I will adopt sustainable waste management practices.

Sustainable Waste Management Behavior (SWMB)
SWMB1: I separate organic and recyclable waste.
SWMB2: I regularly use municipal waste services.
SWMB3: I avoid littering.
SWMB4: I try to reduce household waste generation.

Step 3: Collect Actual Sustainability Data
Besides survey responses, collect objective indicators such as:
Waste generated per household (kg/day)
Frequency of waste collection
Recycling participation
Composting participation
Distance to collection point
Multi-stage sampling
Select cities
Select wards
Select neighborhoods
Select households

Step 5: Determine Sample Size

Method	Recommended Sample
CB-SEM	400–600
PLS-SEM	300–500
Multi-group SEM	500–800

For your study:

$$n = 750$$

is a strong target.

Example:

150 households $\times$ 6 cities = 750 respondents

Step 6: Pilot Study

Before the main survey:

Conduct a pilot with:

30 – 50

respondents.

Check:

Clarity of questions

Reliability

Local language suitability

Calculate:

Cronbach's Alpha > 0.70

Step 7: Field Survey

☐ KoboToolbox

☐ ODK

☐ SurveyCTO

☐ Google Forms

Record:

Demographics

Socioeconomic characteristics

Waste behaviors

VCN and TPB variables

Step 8: Data Preparation

Example:

ID	V1	V2	V3	EB1	EB2	PN1	ATT1	PBC1	BI1	SWMB1
1	5	4	5	4	5	5	4	4	5	4

Then:

Check missing values

Remove outliers

Test normality (for CB-SEM)

Step 9: SEM Estimation

Import data into:

SmartPLS (recommended)

AMOS

LISREL

Mplus

Measurement Model

Assess:

Factor loadings (>0.70)

Composite Reliability (>0.70)

AVE (>0.50)

HTMT (<0.85)

Structural Model

Estimate path coefficients:

$V \rightarrow EB \rightarrow AC \rightarrow AR \rightarrow PN$

$PN, ATT, SN, PBC \rightarrow BI$

$BI, PBC \rightarrow SWMB$

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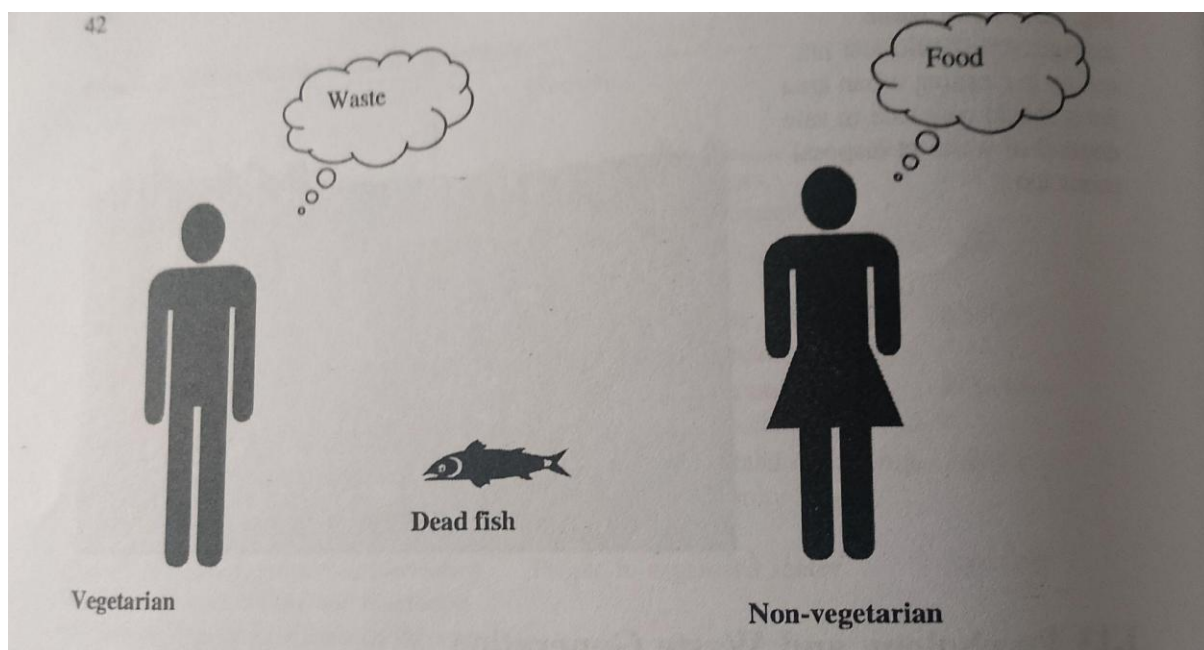
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Time Frame of Reseach Journey

Year 1	2025-26	Status
Literature review	<i>ongoing throughout Year 1</i>	
Research methodology development	3 months	Completed
Area selection and planning	1 months	Completed
6-month review	(22/12/2025)	Completed
Methodology Development	5 months	Completed
Milestone-1, COC	June,2026	Upcoming
Year 2 (Upcoming)	2026-27	Status
Data testing of specific area(Field Survey)	8 months	Upcoming
Data preparation	2 months	Upcoming
Data analysis	2 months	Upcoming
Milestone-2, MCR	June'2027	Upcoming

Year 3 (Final Stage)	2027-28	Status
Data Review	3 months	Upcoming
Data analysis and integration	3 months	Upcoming
Report Writing & Research Article	6 months	Upcoming
Milestone-3, PSS	(07/2028)	Upcoming
Thesis submission	3 months	Upcoming
Review and Finalisation	3 months	Upcoming

Appendix -1: Behaviour pattern



From a waste-management perspective, the image symbolically illustrates how the same object—a dead fish—is perceived differently based on dietary practice, revealing an underlying issue of food and waste valuation. The vegetarian figure associates the dead fish with “waste,” as it lies outside that dietary system and has no consumptive value, whereas the non-vegetarian figure perceives the same fish as “food,” attributing utility and value to it. This contrast highlights that waste is not an inherent property of an object but a socially constructed category shaped by cultural habits, consumption patterns, and ethical choices. In the context of environmental sustainability, the image underscores how misalignment between production and consumption can generate waste: food that is valuable to one group may become discarded by another, leading to inefficiencies and ecological harm. Thus, the image invites a critical reflection on how dietary preferences influence food systems, waste generation, and resource use, emphasizing the need for more inclusive and efficient strategies to reduce avoidable waste and better manage biological resources such as fish stocks.

Appendix -2: World Waste Data 2022 (Reference : World Bank Data)

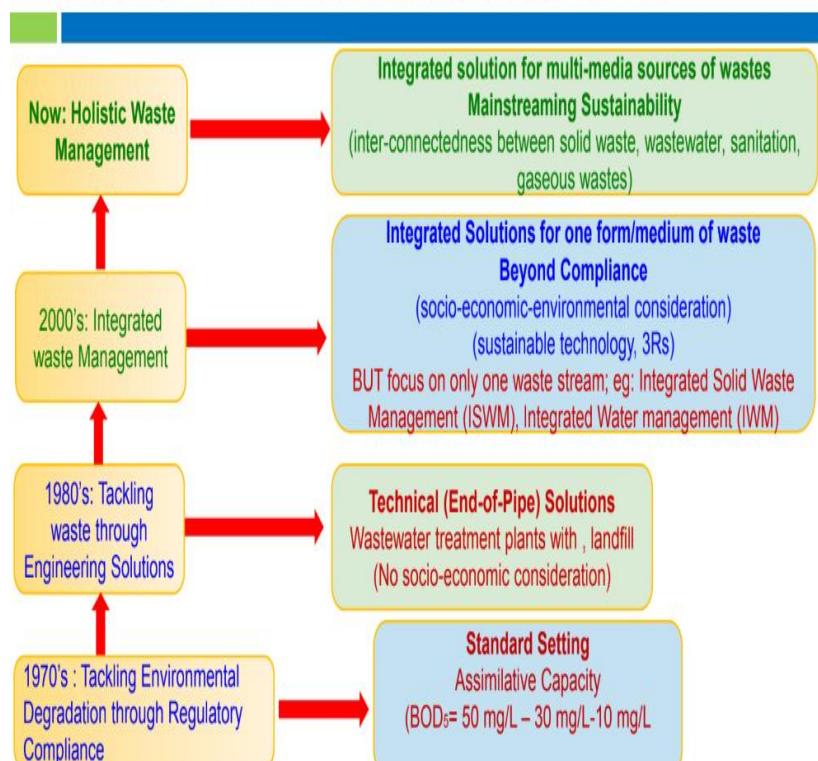
Region / Country	Waste Generated (per capita/day)	% Collected	Total (2022, Mt)	Key Feature
USA / Canada	~2.2 kg	~100%	330+ Mt	Advanced recovery, high energy use
EU avg	1.2–1.5 kg	~99%	~250 Mt	Circular economy policies expanding
Bangladesh	0.52 kg	80.6%	31.6 Mt	High organic + paper share; low recycling
India	0.40 kg	~75%	202 Mt	Large scale + improving collection
Sub-Saharan Africa (avg)	0.46 kg	31%	180 Mt	Fastest growth rate projected
Global avg	0.88 kg	68%	2.6 billion t	50% rise by 2050 if unchecked

GLOBAL SOLID WASTE DATA



Appendix-3 : Evolution of Waste Management

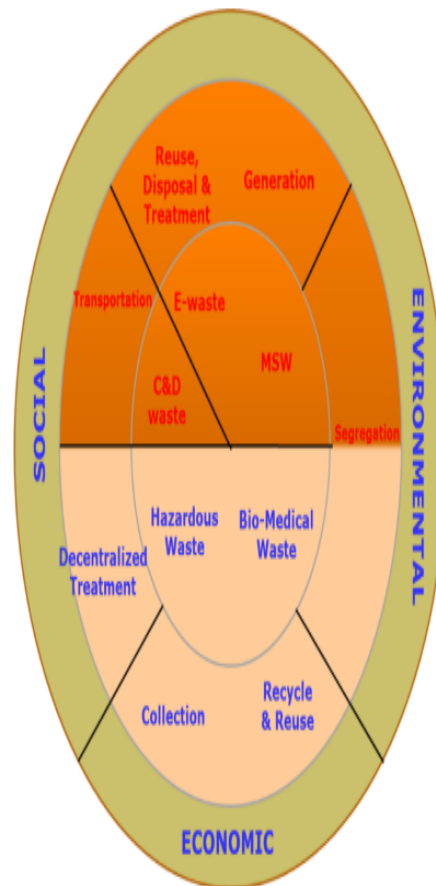
Evolution in Waste Management Approaches



Appendix-4 : Integrated Solid Waste Management in term of ESG

Integrated Solid Waste Management (ISWM)

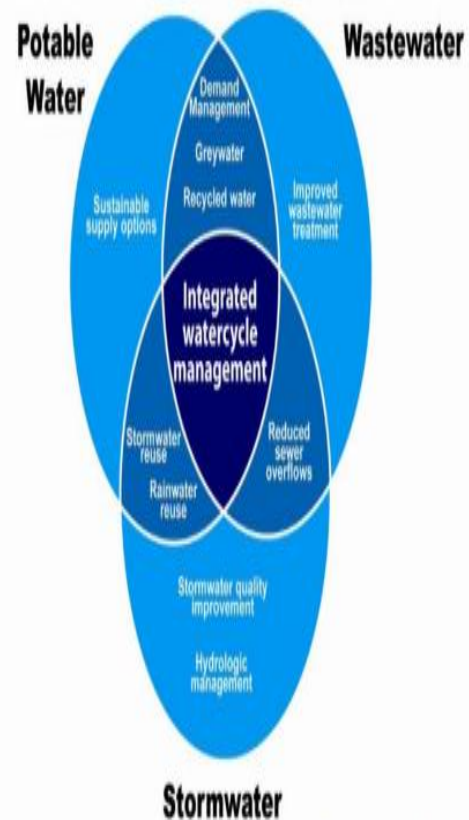
- 'Waste' is replaced by a concept of 'resource', combined with a well-organized and controlled waste stream.
- A modern integrated waste management policy is based on a combination of waste prevention and avoidance, maximized recycling of used goods, waste re-use, sorting and separate waste collection.
- A variety of aspects (technical, environmental/ public health, financial) and various stakeholders, governmental or non-governmental, formal or informal, profit- or non-profit oriented (cooperation, relationships) are included



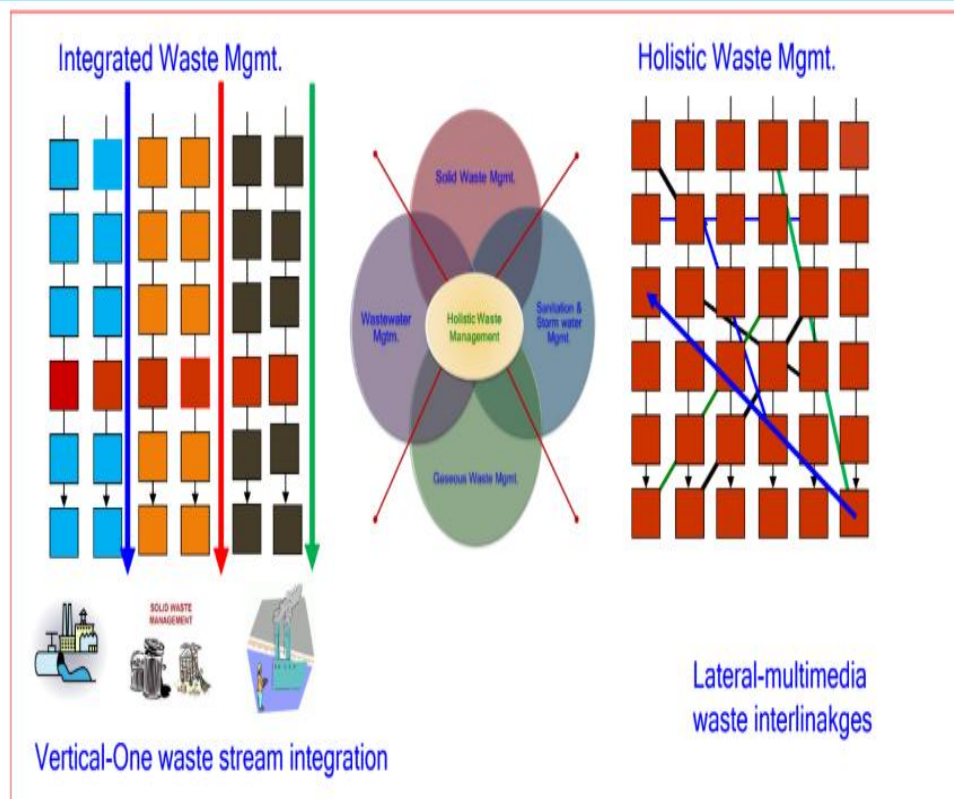
Integrated Water Management (IWM)

- Integrated water management (IWM) is 'a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems'. (GWP-TAC 2000).
- Integrated Water Management (IWM) is a strategy that brings together all facets of the water cycle – water supply, sewage management, water treatment and stormwater management – to achieve strong triple bottom line benefits.

Source: <http://www.watercentre.org/iwm-themes/integrated-water-management/integrated-water-management>
<http://www.sswm.info/category/concept/iwm>



Paradigm Shift: Holistic Systems Approach



Moving from sectoral approach to the holistic approach- treat the root cause than just one of the symptoms