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Drivers, Barriers and Sustainability Outcomes of Green Innovation Adoption in Municipal Solid Waste Management in Southeast Asia: A Structured Integrative Review

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Abstract

Southeast Asian cities are generating rapidly increasing volumes of municipal solid waste (MSW). Yet the green innovations that could divert waste from landfills have diffused slowly, and evidence on why they are adopted remains fragmented. This study conducts a structured integrative review of empirical research on the adoption of green innovation in MSW management in Southeast Asia. Twenty-six structured queries across a web search engine, scholarly platforms, and institutional repositories returned 242 records; 30 were assessed in detail, and 16 empirical journal articles published between 2015 and 2026 met the eligibility criteria. The studies were appraised using the Mixed Methods Appraisal Tool and synthesized using the Technology–Organisation–Environment (TOE) framework, informed by diffusion of innovations and circular economy theory. Seven groups of green innovation were identified: source separation and household recycling; community waste banks; composting and biodigesters; smart and digital systems; municipal systems and materials recovery facilities; waste-to-energy; and producer responsibility. Environmental context factors were the most frequently reported, appearing in 14 of the 16 studies: regulation, enforcement, incentives, information, and social norms acted as drivers when strong and as barriers when weak. Organizational factors, notably financial support, partnerships, and local leadership, determined whether schemes could be sustained, while technological factors, chiefly infrastructure and cost, shaped implementation. Social and economic benefits were reported, but no study measured landfill diversion or emission reductions over time, and most studies lacked an explicit theory. The review proposes a sequential TOE-based framework, expressed as four propositions, that links institutional conditions, organizational capacity, and infrastructure to sustained adoption. It sets out a research agenda for green innovation adoption in emerging economies.

Keywords: Green Innovation, Municipal Solid Waste Management, Technology–Organisation–Environment (Toe) Framework, Circular Economy; Sustainability, Integrative Review, Southeast Asia

Introduction

Municipal solid waste (MSW) is one of the fastest-growing environmental burdens of urbanisation. Global MSW generation was estimated at 2.01 billion tonnes in 2016 and is projected to reach 3.40 billion tonnes by 2050, with the steepest growth expected in low- and middle-income economies (Kaza et al., 2018). The United Nations Environment Programme warns that, without urgent action, the economic and environmental costs of waste will continue to rise sharply (UNEP, 2024). Southeast Asia sits at the centre of this challenge: rapid urban growth, rising consumption and limited treatment capacity have left many cities dependent on landfills and open dumps.

Malaysia illustrates the problem clearly. The country generates about 39,078 tonnes of solid waste per day, or roughly 1.17 kg per person per day, with food waste accounting for about 30.6% of domestic waste (The Star, 2024). Annual solid waste generation rose from 13.89 million tonnes in 2019 to 15.2 million tonnes in 2024 and is projected to reach 17.03 million tonnes by 2035 (The Star, 2025). Although the national recycling rate improved to 37.9% in 2024 (The Star, 2025), most residual waste is still landfilled, and long-standing problems of landfill capacity, leachate, and methane emissions persist (Agamuthu & Fauziah, 2011; Moh & Abd Manaf, 2014). In response, the Government launched the *Circular Economy Blueprint for Solid Waste in Malaysia 2025–2035* in 2024 (Ministry of Local Government Development [KPKT], 2024).

Green innovation, defined as new or improved technologies, processes and organisational practices that reduce environmental harm (Rennings, 2000), is widely regarded as essential to this transition. MSW management includes waste-to-energy (WTE), composting and anaerobic digestion, materials recovery facilities, smart and digital collection systems, and circular business models such as extended producer responsibility (Ghisellini et al., 2016; Kirchherr et al., 2017). Yet adoption across the region remains uneven: many initiatives are still at the pilot stage, and scaling them up has proved difficult (Ghazali et al., 2025).

Prior research has documented these challenges mainly through country-level narrative and conceptual reviews (e.g., Ghazali et al., 2025; Moh & Abd Manaf, 2014). At the global level, reviews of waste management in developing countries have catalogued the technical, financial, institutional and social factors that shape MSW systems (Ferronato & Torretta, 2019; Guerrero et al., 2013), and circular economy reviews have mapped the principles and policy instruments of the transition (Ghisellini et al., 2016; Kirchherr et al., 2017). Such reviews are valuable for describing the problem, but they do not systematically identify, appraise, and synthesise the empirical evidence, and they rarely explain why some green innovations are adopted while others stall. They also differ from the present study in scope and in purpose. They are either national or global, so none synthesises empirical adoption studies across Southeast Asia, a region whose cities share rapid urbanisation, fragmented waste governance and constrained municipal finance.

More importantly, they treat green innovation as a set of technologies or policy instruments rather than as an adoption decision taken by identifiable actors, such as local authorities, concessionaires and households. As a result, they identify factors that matter without explaining how those factors combine to produce or prevent sustained adoption. Three gaps follow. First, there is no transparent, reproducible synthesis of empirical studies on the adoption of green innovation in Southeast Asian MSW management. Second, drivers and barriers are usually listed rather than organised within an adoption theory, which limits the accumulation of knowledge. Third, the environmental, economic and social outcomes of green innovations are seldom compared across innovations and countries and are rarely linked to the conditions under which adoption occurs.

This study addresses these gaps through a structured integrative review, with search and selection steps reported in accordance with the PRISMA 2020 statement (Page et al., 2021). Its novelty lies less in the scope of the evidence than in the way that evidence is theorised. It uses the Technology–Organisation–Environment (TOE) framework (Tornatzky & Fleischer, 1990), complemented by diffusion of innovations theory (Rogers, 2003) and circular economy thinking (Geissdoerfer et al., 2017), as an organising lens, and each perspective plays a distinct role. The TOE framework locates adoption conditions in the innovation itself, its infrastructure, the adopting organisation, or its institutional environment, and therefore shows which actor can act on each condition. Diffusion of innovations theory explains how attributes of the innovation itself, such as relative advantage, compatibility and complexity, shape how readily it spreads once those conditions are in place. Circular economy thinking defines what successful adoption should achieve, namely keeping materials in use and moving waste up the waste hierarchy, and so supplies the outcome criteria against which adoption is judged.

The TOE framework and diffusion of innovations theory have been combined in firm-level studies of technology adoption (Oliveira & Martins, 2011), but they have rarely been applied together to public-service waste systems, where adopters are local authorities, concessionaires and households rather than private firms, and they have seldom been connected to circular economy outcomes. Combining the three lenses, therefore, allows the review to ask not only which factors drive or hinder adoption, but also at which level they operate, how they interact, and what the consequences are for sustainability.

The review advances understanding beyond the identification of drivers and barriers in three ways. First, it shows that the same institutional conditions act as drivers where they are strong and as barriers where they are weak; drivers and barriers are therefore better understood as two states of a single set of conditions than as separate lists. Second, it organises these conditions into a sequential framework, expressed as four testable propositions, in which institutional conditions enable organisational capacity, organisational capacity delivers infrastructure, and infrastructure allows favourable household attitudes to become sustained participation. Third, it links adoption to its reported environmental, economic, and social outcomes and shows where outcome evidence is missing, particularly for landfill diversion and emission reduction. In doing so, it extends earlier narrative work on Malaysia (Ghazali et al., 2025) into a structured, regional and theory-informed synthesis that can guide both future empirical testing and municipal policy.

Aim and research questions

This review aims to identify, appraise and synthesise empirical research on the adoption of green innovation in MSW management in Southeast Asia. Five research questions (RQs) guided the review:

RQ1: What types of green innovation in MSW management have been studied in Southeast Asia, and how has this research developed over time and across countries?

RQ2: What technological, organisational and environmental factors drive the adoption of these green innovations?

RQ3: What technological, organisational and environmental factors hinder their adoption?

RQ4: What environmental, economic and social outcomes of green innovation adoption have been reported?

RQ5: Which theories and research methods have been used in this body of research, and what gaps remain for future study?

Theoretical backgrounds

Green innovation in municipal solid waste management

Eco-innovation research distinguishes technological innovations, such as new treatment and recovery technologies, from organisational and institutional innovations, such as new collection schemes, partnerships and regulatory instruments (Rennings, 2000). Both types are relevant to MSW management: a WTE plant or an anaerobic digester is a technological innovation, whereas source-separation schemes, pay-as-you-throw charging and extended producer responsibility are organisational or institutional innovations. In this review, green innovation in MSW management encompasses all of these, provided they aim to reduce waste generation, increase recovery, or reduce the environmental impact of disposal.

Theoretical lens

The TOE framework explains innovation adoption as the outcome of three interacting contexts: the technological context (the characteristics of the innovation and of existing technology), the organisational context (the resources, structure, skills and management support of the adopting organisation) and the environmental context (regulation, markets, industry structure and external support) (Tornatzky & Fleischer, 1990). The framework has been widely used at the organisational level and is flexible enough to incorporate context-specific factors (Oliveira & Martins, 2011). It suits MSW management because adoption decisions are made by local authorities, concessionaires and waste operators, all of which are embedded in national policy and community settings.

Diffusion of innovations theory complements the technological context by explaining how perceived relative advantage, compatibility, complexity, trialability and observability shape the rate of adoption (Rogers, 2003). Circular economy theory frames the purpose of adoption: moving from linear take–make–dispose systems towards systems that keep materials in use (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Together, these perspectives form the coding framework for the review (Fig. 1). Within this framework, the TOE contexts organise the drivers and barriers (RQ2 and RQ3), the attributes identified in diffusion of innovations theory inform the coding of technological factors, and circular economy principles structure the coding of outcomes (RQ4).

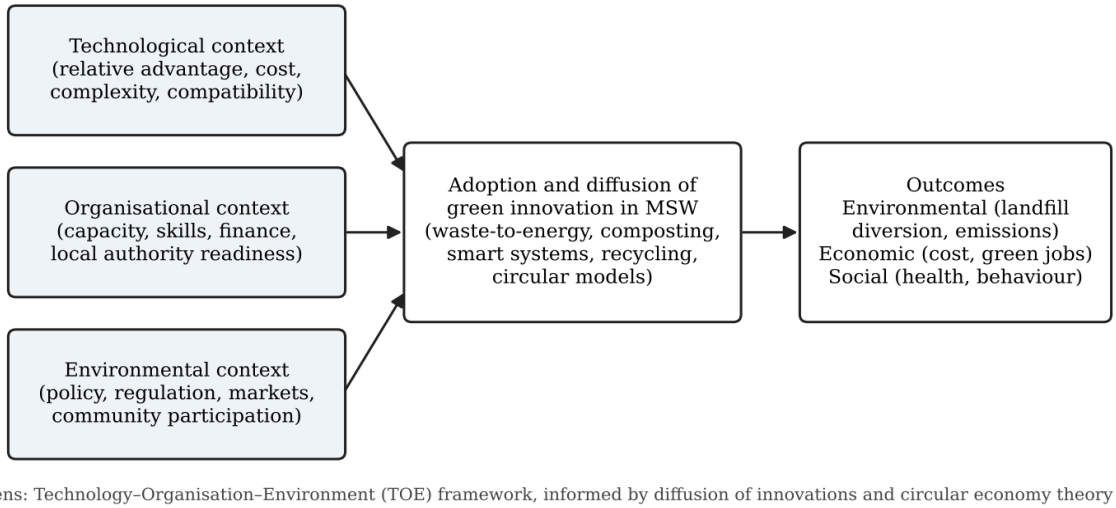


Figure 1. Review framework: TOE contexts, green innovation adoption and outcomes in MSW management

The Malaysian and Southeast Asian context

Under the Solid Waste and Public Cleansing Management Act 2007 (Act 672), MSW management was federalised in the states that adopted the Act, where the Solid Waste and Public Cleansing Management Corporation (SWCorp) regulates collection and disposal; the remaining states retain local authority control. This mixed governance arrangement, combined with continued reliance on landfilling, has contributed to the slow diffusion of recycling and treatment innovations (Moh & Abd Manaf, 2014). Similar combinations of rapid urbanisation, fragmented governance and constrained municipal finance are found across Southeast Asia, which makes a regional synthesis useful for identifying both shared and context-specific conditions for adoption.

Methods

Design

This study is a structured integrative review. Integrative reviews combine evidence from studies with diverse designs to build a comprehensive, theory-informed understanding of a phenomenon (Snyder, 2019; Whittemore & Knafl, 2005). This design suits the present topic because the empirical evidence on green innovation in Southeast Asian MSW management spans surveys, choice experiments, qualitative case studies, and policy evaluations. To make the process transparent and replicable, the search, screening, and selection steps are reported according to the structure of the PRISMA 2020 statement (Page et al., 2021), and the review follows the principles for evidence-informed management reviews set out by Tranfield et al. (2003).

Information sources and search strategy

Searches were conducted on 18 October 2026 using a general web search engine together with open scholarly platforms and publisher sites, including MDPI, SpringerLink, Elsevier (ScienceDirect) abstract pages, RePEc/IDEAS, national journal portals, and institutional repositories in Malaysia, Indonesia, Thailand, Vietnam and Japan. Twenty-six structured queries were run. Each query combined four elements: (1) a green innovation term (e.g.,

source separation, waste bank, composting, anaerobic digestion, biodigester, waste-to-energy, smart or Internet of Things (IoT)-based waste management, materials recovery facility, extended producer responsibility or circular economy); (2) an MSW term (municipal solid waste, household waste or solid waste management); (3) the name of a Southeast Asian country or of the region; and (4) an adoption term (e.g., implementation, barriers, drivers, participation, acceptance or success factors). Table 1 summarises the query themes.

Table 1
Search query themes

Theme	Example Query Terms
Source separation and recycling	"Waste separation at source" OR "source separation" OR recycling AND household AND Malaysia / Vietnam / Singapore
Community-based schemes	"Waste bank" OR "bank sampah" OR "community-based" AND Indonesia / Thailand
Biological treatment	composting OR "anaerobic digestion" OR biodigester AND "food waste" AND Malaysia
Waste-to-energy	"waste-to-energy" OR incinerator AND acceptance OR barriers AND Malaysia / Indonesia
Smart and digital systems	"smart waste" OR IoT OR "smart solid waste management" AND Malaysia / Indonesia / Thailand
Policy and municipal systems	"materials recovery facility" OR "RA 9003" OR "policy implementation" AND Philippines / Vietnam / Thailand
Producer responsibility	"Extended producer responsibility" OR "producer contribution" AND packaging AND Indonesia

Eligibility criteria
Studies were selected against predefined inclusion and exclusion criteria (Table 2).

Table 2
Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Topic	Adoption, implementation, acceptance or performance of a green innovation in MSW management	Industrial, hazardous, medical, construction or e-waste only; purely technical process studies without an adoption dimension
Context	At least one Southeast Asian country	Studies outside Southeast Asia
Evidence	Empirical studies (quantitative, qualitative or mixed methods)	Conceptual papers, editorials and literature reviews
Publication type	Peer-reviewed journal articles with a complete bibliographic record	Conference papers, theses, reports and records without complete bibliographic details
Period	Published 2015 to October 2026	Published before 2015
Language	English	Other languages
Accessibility	Abstract and methods information accessible for appraisal	Records whose abstract or methods could not be accessed

Study selection

All 242 records returned by the 26 queries were screened by title and source. At this stage, 212 records were excluded: duplicates, news articles, reports and presentation slides, as well as records that were off-topic or set outside Southeast Asia. The remaining 30 records were assessed in detail by reading the abstract and, where accessible, the full text, and 16 studies met all the eligibility criteria. Screening was performed by a single reviewer; this is acknowledged as a limitation in Section 6.2.

Quality appraisal

The methodological quality of each included study was appraised against the criteria of the Mixed Methods Appraisal Tool (MMAT), version 2018 (Hong et al., 2018), using information reported in each article. Because the MMAT developers discourage calculating an overall numerical score, a three-level rating was used to summarise the appraisal. Studies were rated as high quality when the design, sampling and analysis were clearly reported and appropriate; as moderate quality when one element (typically the sampling or the description of the sample) was weak; and as low quality when the sample was very small, the data sources were unclear or the method was not reported. The ratings were used to weigh the evidence during synthesis rather than to exclude studies.

Data extraction and synthesis

A standrdised extraction form was used to record the bibliographic details, country, type of green innovation, adopting actor, theory used, research design and sample, drivers, barriers and outcomes of each study. The synthesis proceeded in two stages. First, a descriptive analysis summarised the studies by year, country, innovation type, adopting actor, design, theory and quality (RQ1 and RQ5). Second, a thematic analysis (Braun & Clarke, 2006) was conducted: drivers and barriers were coded inductively and then organised deductively into the technological, organisational and environmental contexts of the TOE framework (RQ2 and RQ3), and outcomes were coded as environmental, economic or social (RQ4).

Because the included studies examined adoption by different actors (households, community groups and local authorities), the TOE contexts were interpreted at the level of the adopting actor. For household-level studies, characteristics of the innovation and of the collection infrastructure were coded as technological; the resources and arrangements of the implementing scheme as organisational; and regulation, incentives, information and social norms as environmental. This multi-level application extends the TOE framework beyond its original firm-level focus and is acknowledged as an interpretive choice.

Results

Search results

The 26 search queries returned 242 records. After 212 records were excluded at the title-and-source stage, 30 records were assessed in detail. Fourteen were excluded: seven because the abstract or methods could not be accessed, two because they were theses, and one each because it was a review article, a conference paper, contained no empirical data, was set outside Southeast Asia or lacked a complete bibliographic record. Sixteen studies were included in the review (Fig. 2).

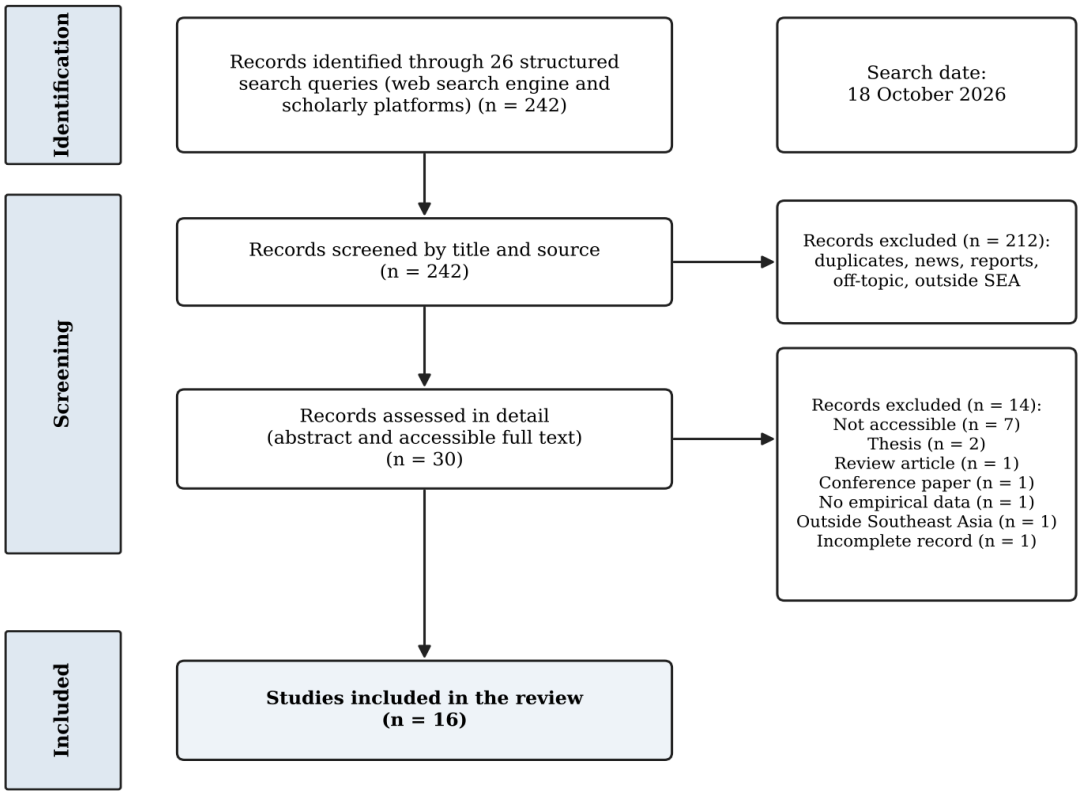


Figure 2. Flow diagram of study identification, screening and inclusion (adapted from PRISMA 2020)

Profile of included studies (RQ1, RQ5)

Table 3 summarises the characteristics of the 16 included studies, and Table 4 presents their profile. Malaysia accounted for seven studies, followed by Indonesia (four), Thailand (two), and Vietnam, the Philippines and Singapore (one each). Research activity increased after 2020: 11 of the 16 studies were published from 2021 onwards, with a peak of four in 2022. Quantitative designs, mainly surveys, were dominant (nine studies), followed by qualitative and case study designs (five studies) and other designs (two studies). Half of the studies focused on households as the adopting actor, five on local authorities or public agencies, and three on community-based groups such as waste banks and villages. Only five studies used an explicit theory, most commonly the Theory of Planned Behaviour (TPB), which was used in three studies. Five studies were rated as high quality, seven as moderate quality and four as low quality.

Table 3

Characteristics of included studies

Study	Country	Green innovation	Design and sample	Key findings
Dhokhikah et al. (2015)	Indonesia	Household waste reduction (sorting, recycling, composting, waste banks)	Waste sampling and survey; 300 households, stratified random (Surabaya)	Supporting factors (training, information, cadres, waste banks) influenced sorting, recycling and composting more than socio-economic characteristics
Yukalang et al. (2017)	Thailand	Municipal collection and source separation system	Qualitative: 28 interviews, 3 focus groups, observation (Maha Sarakham)	Technical, organisational, social-cultural, financial and legal-political barriers; policy not translated into strategy
Singhirunnusorn et al. (2017)	Thailand	Community waste bank	Comparison of two communities (Mahasarakham)	Knowledge and attitudes, not socio-economic factors, shaped participation; planning lacked participation and education resources
Ong et al. (2019)	Singapore	Household recycling and waste minimisation	National survey; 303 households; regression	Knowing what is recyclable, convenience, environmental identity and social-structural factors predicted waste minimisation
Razali et al. (2020)	Malaysia	Source separation	Survey; 900 high-rise households (Kuala Lumpur); PLS-SEM; TPB	Attitude, subjective norm, perceived control and moral norm all significant; moral norm strongest
Trinh et al. (2021)	Vietnam	MSW policy instruments (source separation)	Online questionnaire to local environmental managers; qualitative analysis	Policies unevenly implemented; unrealistic, hard-to-implement policies and lack of resources were core barriers
Ngah et al. (2022)	Malaysia	Source separation	Online survey; 361 residents (Selangor); PLS-SEM; TPB	Attitude strongest predictor of separation behaviour; intrinsic motivation should complement incentives
Razi et al. (2022)	Malaysia	Separation at Source Initiative (SSI)	Qualitative interviews; 5 residents (Klang Valley)	Weak enforcement, insufficient bins and facilities, low awareness and lack of incentives hindered participation
Salleh et al. (2022)	Malaysia	Community composting	Survey of rural villages (Kedah); 32 of 125 villages responded	Information delivery strongest success factor; facilities, finance, technical skills, policy and markets weakest; knowledge and awareness main barriers

Study	Country	Green innovation	Design and sample	Key findings
Fatmawati et al. (2022)	Indonesia	Waste bank policy (collaborative approach)	Qualitative comparative case study (Makassar, Bantaeng)	Regulation, partnerships, CSR and incentives enabled schemes; weak stakeholder communication and socialisation limited them
Bazrbachi et al. (2023)	Malaysia	Smart waste management scheme with source separation	Survey; 432 households, multi-stage random (Shah Alam); EFA/CFA; TPB	Validated TPB-based measurement model of separation intention under a proposed smart scheme
Sulami et al. (2023)	Indonesia	Extended producer contribution via waste banks	Questionnaire survey of members of two waste banks (Bandung)	Producer consideration, knowledge, collection and awareness can strengthen producer contribution to packaging waste
Tehupeiory et al. (2023)	Indonesia	Waste-to-energy	Choice experiment (Jakarta residents)	Strong preference for socialisation of new technology, electricity generation and emission monitoring
Mohd Razlan et al. (2024)	Malaysia	Food waste biodigesters	Multiple case study (3 local authorities, Klang Valley) and interviews	Feedstock supply was the main implementation factor; system cost RM 200,000–450,000
Yazawa et al. (2025)	Philippines	Barangay materials recovery facilities (RA 9003)	Qualitative field study; 5 barangays, 12 MRFs, interviews	Unsegregated waste at MRFs, access gaps, budget-dependent incentives and uneven enforcement; strict local leaders improved compliance
Ahmad et al. (2026)	Malaysia	Smart solid waste management	Survey; 293 stakeholders (SWCorp, city council, concessionaire), Melaka	Financial support, stakeholder acceptance and awareness, and adequate facilities and technology were critical success factors

Table 4
Profile of included studies (n = 16)

Dimension	Category	n	%
Country	Malaysia	7	43.8
	Indonesia	4	25.0
	Thailand	2	12.5
	Vietnam/Philippines/Singapore	1 each	6.3 each
Research design	Quantitative (survey, choice experiment)	9	56.3
	Qualitative/case study	5	31.3
	Other (comparative, questionnaire with qualitative analysis)	2	12.5

Dimension	Category	n	%
Adopting actor	Households and residents	8	50.0
	Local authorities and public agencies	5	31.3
	Community groups (waste banks, villages)	3	18.8
Theory used	Theory of Planned Behaviour	3	18.8
	Other explicit theory (multi-theory, collaborative governance)	2	12.5
	No explicit theory	11	68.8
MMAT quality	High/moderate/low	5 / 7 / 4	31.3 / 43.8 / 25.0

Types of green innovation studied (RQ1)

Seven groups of green innovation were identified. Source separation and household recycling formed the most studied group (five studies), reflecting the policy emphasis on separating and recycling household waste in Malaysia, Vietnam and Singapore (Ngah et al., 2022; Ong et al., 2019; Razali et al., 2020; Razi et al., 2022; Trinh et al., 2021). Community-based waste banks and waste reduction schemes formed the second-largest group (three studies) and were concentrated in Indonesia and Thailand (Dhokhikah et al., 2015; Fatmawati et al., 2022; Singhirunnusorn et al., 2017).

Three groups were each examined in two studies: biological treatment through composting and biodigesters (Mohd Razlan et al., 2024; Salleh et al., 2022); smart and digital waste management (Ahmad et al., 2026; Bazrbachi et al., 2023); and municipal systems and materials recovery facilities (Yazawa et al., 2025; Yukalang et al., 2017). Waste-to-energy (Tehupeiory et al., 2023) and producer responsibility (Sulami et al., 2023) were examined in separate studies. There are signs of a shift over time from household behaviour and community schemes towards smart systems, biodigesters and waste-to-energy, which have appeared mainly since 2023.

Drivers of adoption (RQ2)

Technological context. Perceived benefits of the innovation encouraged adoption. Jakarta residents favoured waste-to-energy options that generated electricity and included emission monitoring (Tehupeiory et al., 2023). Convenience and knowing what is recyclable predicted household waste minimisation in Singapore (Ong et al., 2019), and the availability of adequate facilities and technology was a critical success factor for smart solid waste management in Melaka (Ahmad et al., 2026). For biodigesters, a reliable feedstock supply was the key technical condition (Mohd Razlan et al., 2024).

Organisational context. Financial support was the highest-rated success factor among Malaysian waste agencies, concessionaires and councils (Ahmad et al., 2026). Partnerships with companies, corporate social responsibility funds and NGO support sustained Indonesian waste banks (Fatmawati et al., 2022), and strong local leaders who enforced ordinances achieved better compliance in Philippine barangays (Yazawa et al., 2025). Supporting activities such as training, environmental cadres and waste banks drove household waste reduction in Surabaya (Dhokhikah et al., 2015).

Environmental context. Social and psychological factors were the most consistently reported drivers at household level. Attitude, subjective norm and perceived behavioural control predicted source separation in Malaysia, with moral norm the strongest predictor in Kuala Lumpur (Razali et al., 2020) and attitude the strongest in Selangor (Ngah et al., 2022); the TPB was also validated for separation intention under a proposed smart scheme (Bazrbachi et al., 2023). Environmental identity, knowledge and attitudes encouraged participation in Singapore and Thailand (Ong et al., 2019; Singhirunnusorn et al., 2017). Regulation, award schemes and material incentives encouraged Indonesian waste banks (Fatmawati et al., 2022), information delivery was the strongest success factor for rural composting (Salleh et al., 2022), and stakeholder acceptance and awareness supported smart systems (Ahmad et al., 2026). Producer contribution through extended producer responsibility emerged as a further enabler of community recycling (Sulami et al., 2023).

Barriers to adoption (RQ3)

Technological context. Inadequate infrastructure was the most frequently reported technological barrier: too few separation bins and distant recycling centres in the Klang Valley (Razi et al., 2022), inadequate bins, trucks and collection points in Thailand (Yukalang et al., 2017), trucks unable to reach remote barangays and materials recovery facilities filling with unsegregated waste in the Philippines (Yazawa et al., 2025), and a lack of composting facilities and technical skills in rural Malaysia (Salleh et al., 2022). High capital costs were a barrier to the adoption of biodigesters (Mohd Razlan et al., 2024).

Organisational context. Weak organisational capacity constrained local authorities: limited planning, too few staff and poor record-keeping in Thailand (Yukalang et al., 2017), a lack of resources in Vietnamese localities (Trinh et al., 2021), and weak communication and unclear responsibilities among waste bank stakeholders in Indonesia (Fatmawati et al., 2022). Projects that depended on short-term budgets, such as an exchange incentive that ended when funding did, saw participation decline (Yazawa et al., 2025), and community projects often lacked participatory planning and educational resources (Singhirunnusorn et al., 2017).

Environmental context. Weak and inconsistent enforcement was the most widespread institutional barrier, reported in Malaysia, Thailand and the Philippines (Razi et al., 2022; Yazawa et al., 2025; Yukalang et al., 2017). Vietnamese managers described national policies as unrealistic and difficult to implement (Trinh et al., 2021), and Malaysian residents noted that rules differed between states (Razi et al., 2022). Low public awareness and knowledge (Razi et al., 2022; Salleh et al., 2022), low participation and negative attitudes (Yukalang et al., 2017), insufficient socialisation (Fatmawati et al., 2022), and the absence of a market for compost (Salleh et al., 2022) further slowed adoption. Population growth from unregistered residents strained budgets planned for registered populations (Yukalang et al., 2017).

Table 5

Drivers and barriers of green innovation adoption by TOE context

TOE context	Drivers (studies)	Barriers (studies)	n
Technological	Perceived benefits such as energy generation and monitoring (Tehupeiory et al., 2023); convenience and knowledge of recyclables (Ong et al., 2019); adequate facilities and technology (Ahmad et al., 2026); reliable feedstock (Mohd Razlan et al., 2024)	Insufficient bins, trucks, collection points and facilities (Razi et al., 2022; Salleh et al., 2022; Yazawa et al., 2025; Yukalang et al., 2017); high capital cost (Mohd Razlan et al., 2024)	8
Organisational	Financial support (Ahmad et al., 2026); partnerships, CSR and NGO support (Fatmawati et al., 2022); strong local leadership (Yazawa et al., 2025); training and cadres (Dhokhikah et al., 2015)	Weak planning, staffing and data (Yukalang et al., 2017); lack of resources (Trinh et al., 2021); poor stakeholder communication (Fatmawati et al., 2022); budget-dependent incentives (Yazawa et al., 2025); non-participatory planning (Singhirunnusorn et al., 2017)	7
Environmental	Attitudes, norms and moral norms (Bazrbachi et al., 2023; Ngah et al., 2022; Razali et al., 2020); environmental identity and knowledge (Ong et al., 2019; Singhirunnusorn et al., 2017); regulation, awards and incentives (Fatmawati et al., 2022); information delivery (Salleh et al., 2022); producer contribution (Sulami et al., 2023)	Weak, inconsistent enforcement (Razi et al., 2022; Yazawa et al., 2025; Yukalang et al., 2017); unrealistic policies (Trinh et al., 2021); low awareness and participation (Razi et al., 2022; Salleh et al., 2022; Yukalang et al., 2017); weak socialisation (Fatmawati et al., 2022); no compost market (Salleh et al., 2022)	14

n = number of included studies reporting at least one driver or barrier in that context; a study can appear in more than one context.

Outcomes of adoption (RQ4)

Evidence on outcomes was limited and mostly indirect. Social outcomes were the most frequently reported: waste banks were associated with stronger social interaction and cleaner surroundings (Fatmawati et al., 2022), and community schemes increased awareness and participation (Dhokhikah et al., 2015; Singhirunnusorn et al., 2017). Economic outcomes included additional household income from waste banks (Fatmawati et al., 2022) and the potential side income from selling compost (Salleh et al., 2022), while Mohd Razlan et al. (2024) documented the investment cost of biodigesters. Environmental outcomes were rarely measured directly; Fatmawati et al. (2022) reported improved environmental health, and Dhokhikah et al. (2015) quantified the waste stream (0.33 kg per capita per day, 64.19% food waste) that reduction schemes target. Negative outcomes were also observed: in the Philippines, poorly managed materials recovery facilities accumulated unsegregated waste, and some residents buried plastic waste (Yazawa et al., 2025). No included study measured landfill diversion or greenhouse gas reductions resulting from the adoption of an innovation over time.

Theories, methods and gaps (RQ5)

Theoretical development was weak. Eleven of the 16 studies used no explicit theory, and those that did focused mainly on household intention through the TPB (Bazrbachi et al., 2023; Ngah et al., 2022; Razali et al., 2020). Only Ong et al. (2019) compared several theories, and none of the studies applied an organisational adoption framework such as TOE or diffusion of innovations. Methodologically, the evidence relies heavily on cross-sectional surveys and small qualitative samples; several studies used convenience samples, very small samples (Razi et al., 2022) or low response rates (Salleh et al., 2022), and none used longitudinal or experimental designs. These patterns point to two types of gaps. Strategy gaps concern how the topic is studied: the lack of longitudinal, multi-actor and outcome-measuring designs. Knowledge gaps concern what is known: the organisational and institutional conditions of adoption by local authorities, the scaling of pilot projects, the role of producers and the private sector, and the measured environmental and economic outcomes of green innovations.

Discussion

An integrative framework of green innovation adoption in MSW management

A central finding of this review is that environmental-context factors were the most frequently reported conditions for green innovation adoption. This suggests that, in municipal waste management, external institutional pressures, namely regulatory enforcement, stakeholder expectations and public awareness, may matter more than technological readiness. This contrasts with the firm-level settings in which the TOE framework was developed, where technological and organisational factors have typically received more attention (Oliveira & Martins, 2011). Municipal waste systems operate in highly regulated and socially visible environments in which governance mechanisms play a decisive role.

This review moves beyond descriptive accounts of waste management problems by explaining the conditions under which green innovations are adopted. Organising the evidence through the TOE framework allows drivers and barriers, which are usually reported as separate lists, to be related to one another and to the actors who make adoption decisions. Three insights emerge. First, the environmental context was the most frequently reported, appearing in 14 of the 16 studies, and it appears to be the most decisive: the same institutional conditions, namely enforcement, policy realism and public awareness, act as drivers where they are strong and as barriers where they are weak. Second, the three contexts appear to interact in sequence. Household attitudes and norms were found to be favourable in the Malaysian studies (Ngah et al., 2022; Razali et al., 2020), but the evidence suggests that they translate into practice mainly when the technological context provides convenient infrastructure (Ong et al., 2019; Razi et al., 2022) and the organisational context provides the finance, staff and communication needed to run the system (Ahmad et al., 2026; Fatmawati et al., 2022; Yukalang et al., 2017). Third, adoption can be fragile: schemes that depend on short-term budgets or on individual committed leaders risk losing momentum when that support is withdrawn (Yazawa et al., 2025). Fig. 1 can therefore be refined into a sequential model in which institutional conditions enable organisational capacity, organisational capacity delivers infrastructure, and infrastructure allows favourable household attitudes to become sustained behaviour.

The refined framework can be expressed as four propositions for future testing (Fig. 3). P1: The stronger and more consistent the institutional conditions (enforcement, policy realism and public awareness), the greater the organisational capacity of local authorities to adopt green innovations. P2: Organisational capacity (finance, staff, partnerships and leadership) is positively related to the availability and reliability of waste infrastructure. P3: Infrastructure availability strengthens the relationship between favourable household attitudes and sustained participation in green innovations. P4: Adoption that is sustained through these conditions is positively related to environmental outcomes such as landfill diversion and emission reduction, a relationship that the reviewed studies have not yet tested.

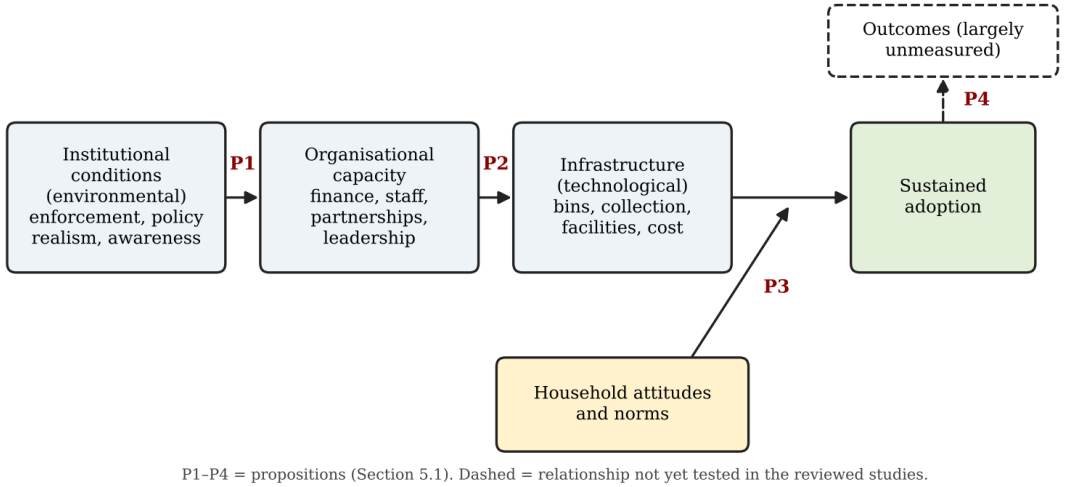


Figure 3. Refined sequential framework of green innovation adoption in MSW management,

Theoretical implications

The review contributes to innovation adoption theory by applying the TOE framework to a public-service setting, where adopters are typically local authorities and their concessionaires rather than private firms. In such settings, the environmental context, including national policy, intergovernmental coordination and community participation, may weigh more heavily than in the firm-level studies in which the TOE framework was developed (Oliveira & Martins, 2011). The findings are consistent with this proposition: the most frequently reported conditions were institutional, and the strongest organisational success factor was financial support rather than internal technological competence (Ahmad et al., 2026). The review further shows that the household-level TPB studies, the most common theoretical approach in the field, explain intention well but do not explain why favourable intentions fail to produce sustained separation when infrastructure and enforcement are weak (Razi et al., 2022). Combining the TOE framework with behavioural theories would therefore help to link the household and organisational levels of adoption. Finally, the review connects adoption research with circular economy thinking by mapping where the reviewed innovations sit on the waste hierarchy, from waste reduction and recycling to energy recovery, although their actual effects on waste flows have yet to be measured.

Practical and policy implications

For Malaysia, the findings provide evidence to inform the implementation of the *Circular Economy Blueprint for Solid Waste in Malaysia 2025–2035* (KPKT, 2024). Four sets of recommendations follow. First, federal and state policymakers should harmonise separation-at-source rules across states and pair them with consistent enforcement, because

inconsistent rules and weak enforcement were among the most frequently reported barriers (Razi et al., 2022; Yazawa et al., 2025; Yukalang et al., 2017). Second, SWCorp and local authorities should treat infrastructure as a precondition for adoption by providing sufficient separation bins in high-rise housing, accessible recycling points and reliable collection. They should also secure multi-year funding for biodigesters and smart systems rather than relying on short-term pilot budgets (Ahmad et al., 2026; Mohd Razlan et al., 2024). Third, waste operators and producers should be brought into partnerships, including extended producer responsibility arrangements that support community collection schemes (Fatmawati et al., 2022; Sulami et al., 2023). Fourth, campaigns aimed at communities and households should appeal to moral norms and environmental identity, not only to incentives, and should explain clearly what can be recycled (Ong et al., 2019; Razali et al., 2020).

Research agenda, limitations and future directions

Research agenda

Building on the gaps identified in Section 4.7, Table 6 sets out a research agenda organised by theory, context, methodology and outcomes.

Table 6

Research agenda for green innovation adoption in Southeast Asian MSW management

Area	Gap identified	Suggested research direction
Theory	Most studies lack an explicit theory; TPB dominates; no organisational adoption framework applied	Apply TOE and diffusion of innovations to local authorities and operators; integrate TOE with TPB in multi-level models
Context	Evidence concentrated in Malaysia and Indonesia; little in Vietnam, the Philippines, Thailand, Cambodia, Laos and Myanmar	Comparative studies across countries and governance arrangements (federalised vs local authority control)
Innovation	Smart systems, biodigesters, waste-to-energy and producer responsibility rarely studied	Studies on the adoption and scaling of emerging technologies and of EPR schemes
Methodology	Cross-sectional surveys, convenience samples and very small qualitative samples; no longitudinal designs	Longitudinal, multi-actor and mixed methods designs; probability sampling; field experiments on interventions
Outcomes	Environmental outcomes rarely measured; intention used as a proxy for adoption	Measure actual separation rates, landfill diversion, emissions and costs over time

Limitations of the Review

This review has several limitations. First, the search used a web search engine, open scholarly platforms and institutional repositories rather than subscription databases such as Scopus and the Web of Science, so relevant studies indexed only in those databases may have been missed. Second, seven potentially relevant records could not be assessed because their abstracts or methods were not accessible, and the quality appraisal relied on the methodological information reported in each article. Third, screening and data extraction were performed by a single reviewer, increasing the risk of selection bias and data-extraction errors. Fourth, only English-language peer-reviewed journal articles were included, so evidence published in Malay, Indonesian, Thai and Vietnamese, as well as government and industry reports, was excluded. Fifth, the small number of included studies and the

heterogeneity of their designs prevented meta-analysis, so the synthesis is qualitative. Finally, publication bias may have favoured studies reporting successful schemes, because successful initiatives are more likely to be published than unsuccessful or discontinued ones; the positive effects of adoption may therefore be overrepresented.

Future directions

Future empirical research could build on this review by conducting comparative case studies of successful and failed adoption under different governance arrangements, by using longitudinal designs to track whether and how pilot projects scale up, and by quantifying the environmental and economic outcomes of green innovations using standardised indicators. Future reviews should replicate this synthesis in Scopus and the Web of Science with dual independent screening, and should extend it to national-language sources and grey literature, such as evaluations of pilot projects by governments and development agencies.

Conclusion

This structured integrative review synthesised 16 empirical studies, published between 2015 and 2026, on the adoption of green innovation in MSW management in Southeast Asia. Using the TOE framework, it identified the technological, organisational, and environmental conditions that drive and hinder adoption, and it mapped the reported outcomes. The evidence suggests that successful adoption depends not only on technological availability but also on organisational preparedness and supportive environmental conditions. Environmental-context factors, namely consistent enforcement, realistic policy, stakeholder engagement, and public awareness, were the most frequently reported, and their effect appears to depend on the organisational capacity of local authorities to finance and operate infrastructure. Favourable household attitudes were reported in several studies but appear insufficient without these conditions, and the environmental outcomes of green innovations remain largely unmeasured. By moving from country-level narrative accounts to a transparent, theory-informed synthesis, the review extends innovation adoption theory to a public-service setting and provides a foundation for evidence-informed policy. As Southeast Asian countries pursue circular economy transitions, coordinated efforts among policymakers, municipal authorities, industry, and local communities will be essential to achieve sustainable and resilient waste management systems.

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