

Effectiveness of Tech enabled Business Models: Consumer Perspectives on Waste Segregation Behaviors and Channel Preferences – A Multi-Theory Conceptual Model and Measurement Development

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Abstract

India's municipal solid-waste governance mandates source-segregation, yet household compliance remains low. Tech-enabled waste collection ventures using mobile apps have also struggled to scale. Two things remain untested: what drives household source-segregation behaviors, and whether households prefer human-mediated over app-only collection. This paper develops a conceptual model to test both. It investigates seven theories: Theory of Planned Behavior, the Norm Activation Model, Value-Belief-Norm theory, Institutional Trust, deterrence theory, the Technology Acceptance model and Service-Dominant Logic. The sample is Mass Affluent/emerging HNI individual residing at urban Indian gated communities. We map seven theory-anchored latent constructs, derive eleven hypotheses. This paper presents a 48-item multi-construct instrument designed for PLS-SEM field testing. Unlike past India-focused TPB studies, our model treats segregation behavior as a measured outcome, not just a proxy for intention. In addition, past research also treats collection step as incidental. We operationalize channel preference as two independent constructs: app-plus-human and app-only. This lets us test directly whether app-only underperformance reflects a structural preference for human-mediated service. This paper is a conceptual and instrument development contribution ahead of fielding, in the spirit of a design or registered-report submission.

Keywords: Solid waste management; Source segregation; Collection channel preference, Business Models for Sustainability.

1. Introduction

India generates approx. 1,70,000 tonnes of municipal solid waste per day in FY 2021-22, of which about 92 percent was collected and 54 percent treated (Khan, Mishra & Singh, 2025). The remainder is handled by an informal sector of waste pickers and scrap dealers, who have historically outperformed formal systems on recovery rates for paper, plastic, and glass (IDR, 2026). Based on Tracxn sector report extract (Mar 2025) about 50million USD was invested on collection based ventures by private sector in the last 5 years supporting app based digital solutions combined with subscription based, reward based business models. Source segregation has been mandated by Solid Waste Management Rules of 2016, however household compliance in most Indian cities remains inconsistent (Kaur & Kaur, 2024; Sahoo et al., 2022), and even the affluent, digitally fluent neighbourhoods show wide variance in sorting practice.

With the institutional support of the policy, a new wave of technology-enabled business models for sustainability (BMfs), among them Bintix, Recykal, WeVOIS Labs, RecycleKaro, TheKabadiwala; approx 100 ventures have entered Indian solid waste management sector (Tracxn, March 2025) with a promise to generate wealth from the collection of waste. These ventures drive collection through digital apps and app interface for scheduling collection, rewards, payments. These apps, had to compete with traditional waste collectors predominantly dominated by informal sector which is relationship based and deeply entrenched (IDR, 2026). Whether this reflects unit economics or an unmeasured consumer preference for human mediated over fully digital service has not been tested directly at the household level. This paper addresses two related demand-side questions, detailed in Section 2.

Two literature streams might jointly answer this question however they rarely intersect. Supply-side business model research (e.g., Bocken, Short, Rana & Evans, 2014) established how waste-tech firms configure value proposition and capture value treating consumer psychology as exogenous factor. Demand-side pro-

environmental behaviour (PEB) on Indian households is dominated by applying Theory of Planned Behaviour (TPB; Ajzen, 1991), recent field studies at Jaipur and Indore (Jampala & Shivnani, 2024) and e-waste recycling (see review in Section4), typically these studies stop at behavioural intention and rarely integrate institutional trust, moral norm and channel-format preference within a single model.

This paper addresses four gaps. First, integration of six theoretical streams namely TPB, the Norm Activation Model (NAM), Value-Belief-Norm theory (VBN), institutional trust, deterrence theory, and the Technology Acceptance Model (TAM) together with Service-Dominant Logic (S-D Logic), into a single testable model of household segregation behaviour. Second, it elevates the channel-preference (app-plus-human versus app-only), treated elsewhere as an app design factor, to a verifiable measured construct that can get tested through a well-defined hypotheses (H9). Third, it tests, for the first time in an Indian household sample to our knowledge, whether deterrence and incentive perceptions actually move segregation behaviour (H6), a lever mostly evidenced only outside India. Fourth, it attempts to bridge consumer-level psychological traits to firm level BMfS usage (Bintix, Recykal) thus connecting the demand-side model to the supply-side business model literature it intends to complement.

Subsequent sections detail on the objectives, scope, Literature review on theoretical background, conceptual model, constructs to theory mapping, hypotheses, instrument and contributions.

2. Objectives

The objective of this research is to operationalize RQ4 from the parent doctoral study: Understand Stakeholder perspectives focussed on Consumers (Nanduri & Shenoy, 2025). RQ4 is further divided into two related questions. First, what drives household segregation behaviour itself. Second, what channel do households prefer for service delivery. Specifically, whether they want human mediated or fully digital collection.

3. Scope and Methodology

This paper purposefully scoped as a conceptual and instrument development contribution: it represents the theoretical model, the latent constructs-to-item mapping, and the measurement instrument ahead of field tests, following the tradition of design papers and registered reports that precede a confirmatory PLS-SEM study. The instrument is intended to be deployed for field study among approximately 400 household decision makers predominately Mass affluent/emerging HNI individual dominant gated community in Hyderabad (~2000 flats), a purposive sample chosen to hold infrastructure, consumer economic profile and digital access roughly constant while isolating psychological variance.

4. Literature Review (Theoretical Background)

4.1 The behavioural core: Theory of Planned Behaviour (TPB)

Theory of Planned behaviour (TPB) is the default lens for waste management research, more extensively so in the western world than in India (Tonglet, Phillips & Read, 2004). Applying a default lens alone is not a finding. What really helps is identifying which construct dominates in this sample and why. The core construct proposed by Ajzen (1991) consists of attitude, subjective norms, perceived behavioural control (intention, behaviour). In general terms as per TPB, behaviour is a product of what I believe will happen, who expects it of me, whether I feel capable of doing it. The framework was recently also tested by Jampala & Shivnani (2024) a study investigating waste segregation intentions and behaviour in Tier II Indian cities(Jaipur/Indore). Their findings concluded that the TPB influences the behaviours but varies across Indian Tier-II cities; structural factors and location specific norms dictate actual, varied disposal behaviours. If this much of variation is found in Two cities, applying the same lens for metro cities especially to mass affluent/emerging HNI participant profile would contribute adding waste management sector specific insights to the existing Body of the Knowledge.

4.2 Beyond calculation: moral obligation (NAM/VBN)

TPB is about ‘what happens to me whereas Norm Activation Model(NAM)/Value Belief Norm Theory talks about the personal/moral norms – perceived obligation activated by awareness of consequences and ascribed responsibility (Schwartz, 1977). Speaking in layman terms, what NAM really meant is – I act not because it benefits me, but because not acting would feel wrong. When this notion is complemented by Value Belief Norm

Theory (VBN) proposed by Stern (2000), an extension beyond NAM, it traces moral norm back to underlying values. VBN illuminates ecological worldview, awareness of consequences, ascribed responsibility, personal norm. Together both these frameworks are core to the individual behaviour when it comes to source segregation behaviour and what drives those individuals. In the recent past this was qualitatively tested at Ujjain for Solid Waste Management, India by Sahoo et al. (2022), however not measured as a distinct quantitative construct. Their core finding includes guilt and fear when sorting incorrectly and waste segregation gaining acceptance as social norm. This dimension has not yet been quantified as a distinct construct alongside TPB in an Indian sample; a gap this research address.

4.3 The trust chain: why segregation is a downstream bet

Household that makes the effort to segregate at source often have no way of knowing what happens to the sorted waste after collection, a disconnect many grapple with. This is where the traceability gap app-based solution attempting to close (Bintix, n.d; Recykal, n.d). This is corroborated by Nguyen-Van, Stenger & Tiet (2021), whose broader meta-analysis of social incentive factors also identifies institutional trust as a distinct driver of pro-environmental behaviour (see also Section 4.4). Institutional trust is all about the trust that the system (municipality/private collector) does what it claims to do with waste after collection. Most of the studies (some recent examples - Wan, Shen & Yu (2014, Hong Kong); Rompf, Kroneberg & Schnaudt (2017, Switzerland); Hachana, Najar & Ivanaj (2025, France)) done on Institutional trust are western centric thereby it makes a strong case to understand what Indian household (50% collection rate) really think about their waste collectors/municipalities, which plausibly yields more practical insight for industry and academia.

4.4 Deterrence and incentives

Indian SWM policy includes fines for commercial and industrial sector defaulters, but not for individual households, unlike Singapore, China, Europe where house-hold level enforcement exists. Deterrent theory/Incentive based Pro-Environmental Behaviour (PEB) concerns about expected effect of fines/enforcement(deterrence) versus rewards/recognition (incentive) on behaviour. Osbaldiston & Schott (2012) analyzed 87 published reports containing 253 experimental treatments to see what actually drives real, observed PEB and concluded there is no single 'silver bullet' intervention; instead proposes that combining clear instructions with psychological motivators works best; Nguyen-Van, Stenger & Tiet (2021) study evaluated non-monetary incentives, social incentives rather than economic rewards identified internal social influence as vital for PEB, and found that network connections matter for policy success. Both the studies are meta-analyses synthesising western empirical evidence not primary studies conducted in an Indian setting. The deterrence/incentives approach remains untested in Indian households. The rewards already through app-based collections for e-waste; dry waste; plastic waste may plausibly have a positive influence, a notion tested for the first time in this research.

4.5 Channel preference: the human-versus-digital design choice

The Technology Acceptance Model (TAM) holds that perceived usefulness and perceived ease of use drive intention to adopt a digital channel or technology (Davis, 1989). An established stream extends TAM with a need-for-interaction (NI) construct: the extent to which customers value human contact over self-service technology (Dabholkar, 1996; Meuter et al., 2000). This notion is further extended by Service-Dominant Logic, which explains why the preference exists (Vargo & Lusch, 2004). Several solutions that work in the western world illustrate this: Too Good To Go, an app selling surplus food at a discount (Denmark); Mudjeans, a subscription-based circular denim model (Netherlands); Fairphone, a mobile phone consumers can repair themselves (Netherlands); and SafeChem, which provides chemicals as a service (Germany). Nevertheless, the type of waste generated in the West differs sharply from India, and most business-model patterns that work in western contexts may not transfer directly. Researchers such as Bocken et al. (2014), Lüdeke-Freund et al. (2018), and Schroedel (2023) have performed extensive analysis of these business models and proposed patterns for Business Models

for Sustainability; several of these patterns appear to be replicating in the Indian context as well. This research also performs a business-model pattern analysis on Indian tech-enabled ventures using the Tracxn database, to establish what is working in India and complement the western studies.

The Indian household customer profile differs: looking for rewards, cost-conscious, with social norms around waste management still vaguely formed. Many ventures entered app-based collection over the last five-plus years, built around cash-for-trash, reward redemption, and recognition mechanics. Yet analysis of the Tracxn database of close to 300 tech-enabled ventures shows that around 60 have shut down, attributed to under-performance (Tracxn database).

The popular academic narrative for app-only waste-collection underperformance is supply-side — unit economics, last-mile labour cost, consumer awareness. Few design-thinking studies have asked households directly whether they would prefer to engage with a person first, even if the app itself worked perfectly. Service-Dominant Logic (Vargo & Lusch, 2004) proposes that value is co-created through interaction, not delivered through a product or transaction alone, meaning a human collection touch point backed by app or no app isn't a delivery inefficiency – it may itself be part of the value. Whether a compensatory response to automation (Mende et al., 2019) by integrating kabadiwala into collection rather than relying on app self-service improves app performance requires field validation. The main objective of this research is to test TAM and NI constructs against demand-side expectations, a novel contribution to the solid waste management sector.

5. Integrated conceptual model

This paper operationalizes RQ4 from the parent doctoral study: Stakeholder perspectives focused on Consumers (Nanduri & Shenoy, 2025). RQ4 is further divided into two related questions. First, what drives household segregation behaviour itself. Source segregation is the foundational step in effective waste management (Annepu, 2012). Second, what channel do households prefer for service delivery. Specifically, whether they want human mediated or fully digital collection. Figure 1 integrates both questions into a single model.

Seven theory-anchored latent constructs → segregation behaviour, channel preference, and the bridge to BMfS firms (structural paths only)



Figure 1. Integrated behavioural framework for household waste segregation and channel preference (constructs, theoretical anchors, and the bridge to firm-level BMfS usage).

6. Conceptual Mapping of Constructs to Theory

Table 1 establishes the mapping between each latent construct, its theoretical anchor, and its hypothesized primary path in the model. This establishes the necessary linkage between the narrative framework above and the item-level instrument in Section 8.

Construct (code)	Theoretical anchor	Core idea in this study	Primary hypothesized path

Attitude toward segregation (ATT)	TPB (Ajzen, 1991)	Evaluative belief that segregating waste is worthwhile / environmentally correct	ATT → INT/BEH (H1)
Subjective norms (SN)	TPB (Ajzen, 1991)	Perceived family, neighbour and RWA expectations to segregate	SN → INT/BEH (H2)
Perceived behavioural control (PBC)	TPB (Ajzen, 1991)	Perceived space, time, knowledge and household-help capacity to segregate	PBC → INT/BEH (H3); PBC → APP (H8)
Personal / moral norm (PN)	NAM (Schwartz, 1977); VBN (Stern, 2000)	Felt personal obligation / anticipated guilt, partly mediated through attitude	PN → INT/BEH, partly via ATT (H4)
Institutional trust (IT)	Wan, Shen & Yu (2014); institutional-trust PEB literature	Trust that segregated waste is genuinely processed downstream, not re-mixed	IT → INT/BEH (H5); low IT → HYB (H7)
Perceived deterrence & incentives (DI)	Deterrence theory; incentive-based PEB literature	Expected effect of fines, recognition and rebates on household behaviour	DI → INT/BEH (H6)
Channel preference – hybrid (HYB)	TAM (Davis, 1989); S-D Logic (Vargo & Lusch, 2004)	Preference for app-scheduled, human-delivered collection; value co-created through relational contact	Low IT & low PBC → HYB (H7); HYB > APP (H9)
Channel preference – app-only (APP)	TAM (Davis, 1989)	Preference for fully digital, self-service collection with no human interaction	High digital fluency & PBC → APP (H8)
Self-reported segregation behaviour (BEH)	Tonglet et al. (2004)	Frequency and consistency of dry/wet/hazardous separation, incl. domestic-help oversight	Outcome variable
BMfS prior usage & satisfaction (USE)	Bridge to firm-level thesis	Household-level exposure to Bintix, Recykal, Banyan Nation and satisfaction with them	controlling ATT & PBC (H10)

Table1: Construct to theory conceptual mapping**7. Findings to be Tested (Hypotheses)**

Listed below eleven Hypotheses statements derived from the mapping above covering two behavioural streams, the channel preference model, and the bridge to firm level usage. H9 is paper's central applied contribution: an individual level test of consumer preference explanation for the well documented struggles of emerging app-driven waste collection ventures in India. Relative ranking among predictors (H2, H3, and H5) is not hypothesized

directly; it is assessed post hoc through IPMA (Section 9), consistent with this paper's predictive rather than confirmatory framing.

ID	Hypothesis
H1	Attitude toward segregation positively predicts self-reported segregation behaviour.
H2	Subjective norms positively predict segregation behaviour
H3	Perceived behavioural control positively predicts segregation behaviour
H4	Personal/moral norm positively predicts segregation behaviour, partly mediated through attitude.
H5	Institutional trust positively predicts segregation behaviour
H6	Perceived deterrence and incentives positively predict segregation behaviour.
H7	Low institutional trust and low PBC jointly predict preference for the hybrid (app + human) channel over the app-only channel.
H8	Higher digital fluency and higher PBC predict preference for the app-only channel.
H9	Preference for the hybrid channel is significantly higher than preference for the app-only channel across the sample; this is the consumer-side explanation for the documented failure of pure-app BMfS in Indian waste-tech.
H10	Respondents with prior usage of Bintix, Recykal or other collection apps report higher segregation behaviour, controlling for attitude and PBC.
H11 (opt.)	There is a stated preference for a single integrated waste solution over category-specialised services.

8. Proposed Instrument

The instrument consists approximately 48 reflective items across ten construct blocks, measured predominantly on 5-point Likert agreement scales along with three dichotomous (Yes/No) prior-usage items. In addition, there are two frequency-anchored behaviour items. Items are randomized within construct blocks at deployment to reduce response-set bias, and “not applicable” options are offered on items presupposing domestic help (PBC4, BEH4). Channel preference is measured as two independent six- and four-item blocks (HYB, APP) rather than a single bipolar scale, for the reasons set out in Section 4.5. Table 3 gives one illustrative item per construct. For full instrument and operationalization details write to the primary author.

Construct	Codes	n	Sample item	Anchor
Attitude (ATT)	ATT1–ATT5	5	“Source-segregating household waste is a worthwhile use of my time.”	5-pt agreement
Subjective norms (SN)	SN1–SN4	4	“The RWA / community management encourages residents to segregate.”	5-pt agreement
Perceived behavioural control (PBC)	PBC1–PBC5	5	“I know clearly which items go into dry, wet, and hazardous categories.”	5-pt agreement / confidence
Personal / moral norm (PN)	PN1–PN4	4	“I would feel guilty if our household contributed to a waste problem in the city.”	5-pt agreement

Institutional trust (IT)	IT1–IT5	5	“I believe segregated waste is actually processed separately, not mixed again later.”	5-pt agreement
Deterrence & incentives (DI)	DI1–DI4	4	“Financial rewards or rebates for segregation would encourage our household.”	5-pt agreement
Hybrid channel preference (HYB)	HYB1–HYB6	6	“I trust the process more when I can see and speak to the collection staff.”	5-pt agreement
App-only channel preference (APP)	APP1–APP4	4	“An app that handles scheduling, tracking, and payment is enough; I do not need to meet the collector.”	5-pt agreement
Segregation behaviour (BEH)*	BEH1–BEH5	5	“Our household uses separate, dedicated bins inside the house for dry, wet, and hazardous waste.”	5-pt agreement / frequency
BMfS prior usage (USE)*	USE1–USE4	4	“Overall, how satisfied are you with the waste-tech services you have used?”	Yes/No + 5-pt satisfaction
Optional: system preference & WTP (OPT)*	OPT1–OPT2	2	“I would be willing to pay a small monthly fee for a single integrated waste collection service.”	5-pt agreement

Table3. Instrument proposed for field Testing

A behaviourally re-engineered version of the outcome scale (BEH) will be used at pilot stage to increase variance and reduce social-desirability bias: rather than asking directly whether the household segregates, items probe concrete, checkable practices (e.g., dedicated in-home bins for each stream, physical hand-over of separated containers to the collector, and explicit instruction/monitoring of domestic staff), which are less susceptible to a uniform “yes, we segregate” response set than global agreement items. This addresses a measurement gap in prior Indian studies. Kaur & Kaur (2024) label their outcome as 'practice of waste segregation.' Their actual measure is a 2-item perceptual scale on felt duty and self-assessed knowledge, not concrete, checkable behaviour.

*denotes items excluded from the 37-item predictor count used in the Hair et al. (2022) sample-size calculation (Section 9): BEH as the outcome variable, USE as the firm-usage bridge, and OPT as optional items

9. Proposed Method (Design Summary)

Setting and Sample Frame: Single gated community; Mass affluent/emerging HNI individual (household) participant only as a controlled choice which holds infrastructure and digital access roughly constant;

Sample Size: target $n = 400$, justified by three converging methods rather than one — Cochran's finite-population formula at 95% CI (≈ 322 at $N = 2,000$, $\pm 5\%$), Hair et al.'s (2022) 10:1 indicator-to-response rule for PLS-SEM (≈ 370 for 37 reflective items), and Kock & Hadaya's (2018) inverse-square-root method for medium effects at 80% power (≈ 160).

The 37 reflective item figure refers to the eight core reflective predictor constructs (ATT through APP); the full instrument totals 48 items once the outcome(BEH), usage-bridge(USE), and optional(OPT) blocks are included

Analysis: PLS-SEM in SmartPLS 4 or SEMinR (R). PLS-SEM is preferred over covariance-based SEM given the exploratory framing, the inclusion of a relatively new construct (channel preference), and the predictive (rather than confirmatory) emphasis on ranking traits by their nudge-design value. Standard assessment: indicator loadings, composite reliability, AVE, HTMT for discriminant validity, path coefficients with bias-corrected bootstrapped CIs (5,000 resamples), f^2 , Q^2_{predict} , and importance-performance map analysis (IPMA) to convert

path coefficients into actionable design priorities.

For detailed design considerations refer Annexure A.

10. Expected Contributions

Three contributions are anticipated. First, an empirically grounded ranking of psychological and contextual drivers of household segregation in an Indian metro. Second, an explicit consumer-side test of whether the failure of pure-app waste-tech in India reflects a structural preference for human-mediated service, not merely operational shortfall (H9). Third, a bridge to the firms-side thesis: by checking actual usage of Bintix, Recykal, and other apps (H10), the study connects citizen psychology to BMfS adoption, allowing the closing discussion to move from "which firms succeed" to "why they succeed with whom".

11. Limitations

- Single-city, single-segment design: findings will not generalise to low- or middle-income households or to non-metro contexts, consistent with the exploratory, non-generalising scope of the parent thesis.
- Self-reported behaviour is subject to social desirability bias; this is only partially mitigated by anonymity, Likert framing, and the behaviourally re-engineered BEH scale (Section 8).
- The cross-sectional design supports predictive, not causal, interpretation of PLS-SEM path coefficients.
- Cross-country contrasts (Singapore, EU, US) are used as motivational framing in the literature review only and are not empirically tested in this design.

12. Conclusion

This paper documents the conceptual model and instrument prior to fielding, in the spirit of a design/registered-report contribution. Ethics clearance and survey deployment are planned as a subsequent stage; the full 48-item questionnaire, response-anchoring conventions, and construct-to-item crosswalk are available from the authors on request.

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Decision	Choice	Rationale
Unit of analysis	Individual respondent reporting on household-level behaviour	Segregation is a household decision in India; the individual is the proxy for household waste practice.
Sample segment	HNI gated community in Hyderabad (~2,000 flats, target n=400)	Homogeneity controls for income, infrastructure, and digital access — isolating psychological variance. Emerging HNI households produce the dry/package waste streams that successful Indian BMFS firms typically target. This is a design assumption, not an empirically tested claim in this study
Behaviour measurement	Self-reported (Likert + frequency)	Standard in PEB literature. Observed measurement (RWA/municipality records) was considered but rejected on access and operational grounds. Social desirability acknowledged as a limitation.
Cross-country comparison	Referenced in literature review only; not empirically tested	Singapore / EU / US data is used as motivational framing for the gap, not as a comparison benchmark. Keeps the study focused and avoids over-reach in an exploratory design.
Channel preference operationalisation	Two separate latent constructs: hybrid (app + human) AND app-only	Earlier draft considered a single bipolar scale. Switched to two constructs so respondents can favour both, neither, or one — methodologically cleaner and recognises that the realistic options in HNI communities are hybrid vs full-digital, with pure-human rarely chosen. Directly tests H9 — the consumer-side explanation for pure-app failure.
Single-solution preference	Two optional items added at end of instrument	Captures the aggregator-vs-specialist tension: consumers prefer one integrated service over multiple category-specialised apps. Converts into willingness-to-pay for subscription-model design insight.
Pure-human-only channel	Excluded from instrument	Not a realistic option in gated communities where domestic help, RWA staff, and digital touchpoints are already present. Including it would inflate item count without analytic value.
SEM method	PLS-SEM (SmartPLS 4 or SEMinR in R)	Exploratory framing, predictive (not confirmatory) emphasis, inclusion of a relatively new construct (channel preference), and the goal of ranking trait importance for design — all favour PLS-SEM over covariance-based SEM.
Sample size rule	n = 400 target; distribute to ~530 flats assuming ~75% completion	Satisfies three independent criteria: Cochran finite-population (322 at ±5%, 95%), Hair 10:1 rule (370 for 37 reflective items), and Kock & Hadaya inverse-

		square-root (160 for medium effects at 80% power). Layered defensibility for examiners/reviewers.
Bridge to firms study	4 items on Bintix / Recykal / Other apps usage and satisfaction	Tests H10 and lets the closing discussion connect citizen psychology to BMfS adoption — moving from 'which firms succeed' to 'why they succeed with whom'.
Item count	~48 (above original 35–40 target)	Additions in channel-preference and BMfS-usage sections are high-value for design diagnosis. Trade-off is respondent fatigue, partially mitigated by short Likert items and gated-community context (higher engagement).