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Original Article

A Case Study of Socio-Behavioural Dynamics of E-Waste Management in Navi Mumbai

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Abstract *- Sustainable e-waste management in rapidly urbanizing cities like Navi Mumbai remains a challenge despite robust regulatory policy frameworks. While technical and infrastructural barriers are well-documented, the socio-psychological drivers of policy adoption remain less understood. This study investigates the influence of individual intention and social cohesion on the extent of adoption of e-waste management policies in Navi Mumbai, India. The study design incorporated an extended Theory of Planned Behaviour framework. A quantitative analytical approach was employed, which analysed survey responses from a demographically diverse sample (n = 500) with advanced multivariate statistical analyses, including exploratory factor analysis, structural equation modeling, and K-means clustering. The model incorporated seven constructs, including Stakeholder Intention, Social Cohesion, Social and Institutional Trust, Infrastructure and Accessibility, Environmental Attitude, Policy Awareness, and Policy Adoption. The measurement model confirmed high internal consistency, convergent validity and discriminant validity across the constructs. The structural path analysis suggested a possible phase within the study population, where awareness and positive intention are growing. However, the direct path to formal adoption remains non-significant ($p > 0.05$, $R^2 = 0.020$). Supporting these insights, K-means cluster analysis identified four distinct behavioural profiles, including Proactive Adopters, Passive/Intentional Participants, Uninformed Informal Disposers and Non-Participants. Altogether, the findings of this study emphasizes that habit transformation in a society is a complex process, and presently there is a wide operational gap between stakeholder readiness and formal participation. Future policy frameworks may therefore benefit from targeted operational incentives and seamless infrastructural integration.*

Keywords *- E-Waste management, Theory of planned behaviour, Social cohesion, Behavioural intention, Policy adoption, Urban waste governance.*

1. Introduction

Electronic devices are indispensable tools that have revolutionized working experience, communication and access to information. They are seamlessly integrated into the modern lifestyle in the form of smartphones, laptops and smart home devices. However, significant environmental challenges such as management and disposal of large quantities of electronic waste (e-waste) have accompanied this digital transformation (Nisha et al. 2022). The composition of e-waste is complex, consisting of several hazardous substances like lead, mercury, brominated flame retardants and cadmium. These compounds pose serious ecological and health threats (Ankit et al. 2021).

The Central Pollution Control Board (CPCB), India defines e-wastes as ‘electrical or electronic equipment, including solar photovoltaic modules or panels or cells, whole or in part discarded as waste, as well as rejects from manufacturing, refurbishment and repair processes’ (CPCB Report 2024). Globally, an estimated 62 million tons of e-waste was produced in 2022, and this estimate is expected to increase by 32% by 2030. The report further estimated that less than a quarter (22.3%) of e-waste was recycled in 2022, and a large percentage was disposed informally (UNITAR Report 2024). The informal method of e-waste disposal involves unsafe practices such as open burning, acid leaching, and dumping in landfills (Ankit et al. 2021; MPCB Report 2007).

At present, India is among the top 5 e-waste generating countries worldwide. Precisely, between 2018 and 2023, a 72.5% surge in e-waste generation has been reported in India. Roughly, this accounts to 1.751 million tons of e-waste generated in 2023-24, 55.7% of which remained unprocessed or were informally disposed (CPCB Report, 2025). These improperly disposed e-wastes severely impact environmental health. Exposure to e-waste leachates causes neurological, respiratory and hormonal disorders. They are also associated with developmental defects in children and cancer (Ankit et al. 2021; MPCB Report 2007). Due to these concerns, there is an urgent need to improve awareness regarding the impacts of e-waste on human health and the

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environment. Alongside, effective policy implementations are necessary for its effective management.

To address the issues faced in managing e-waste in India, CPCB launched e-waste (Management and Handling) Rules in 2011, which were revised in 2016 and 2022 (CPCB Report 2025). In the latest update (3rd amendment of 2022 Rules) released in 2024, setting a minimum price for spare parts is mandatory for recyclers, and management of the end-of-life disposal of products is necessary for manufacturers. This policy intended to promote sustainable reuse and reduce illegal dismantling of electronic products (CPCB Report 2025). Additionally, it aimed at institutionalizing Extended Producer Responsibility (EPR). At present, several barriers persist during proper implementation of these policies. More precisely, actions such as setting a minimum price of products increases compliance costs for manufacturers. Also, proper recycling initiatives through formal e-waste collection systems are hindered due to lack of infrastructure in India. Adding to these challenges is poor consumer awareness, along with behavioural and social aspects, which increases the informal e-waste disposal rates (CPCB Report 2025; Islam et al. 2024; Tian et al. 2022; Arslan et al. 2024; Andeobu et al. 2021; Abalansa et al. 2021). Hence, besides infrastructural development, researchers increasingly focus on behavioural interventions and community participation drives to determine their role in success of policy implementation on sustainable e-waste management (Sajid et al. 2022; Vijayan et al. 2023; Silvestre et al. 2022; Islam et al. 2024). This, however, creates a new challenge of measuring social cohesion, especially in urban settings. It is because characteristics such as demographic diversity, mobility and socio-economic conditions vary considerably in an urban setting. Social cohesion can shape individual behavioural intentions by influencing social norms, trust and collective responsibility within communities.

Although several individual determinants of e-waste recycling, such as awareness, knowledge, convenience or intention, have received considerable attention, a critical gap remains in understanding the behavioural and social dynamics that influence the adoption of such policies at the community level. The present study addresses the research gap by examining individual behavioural intention alongside social cohesion and institutional trust, while simultaneously considering awareness, infrastructure and accessibility, environmental attitudes, digital engagement and sustainable recycling behaviour.

The research gap described above is particularly relevant to Navi Mumbai, where demographic diversity, varying levels of environmental awareness, different patterns of electronic consumption and both formal and informal waste-management practices are reflected within the same urban community (Prashant 2017). These characteristics distinguish Navi Mumbai from more established metropolitan cities (such as Delhi) and represent an appropriate setting for examining behavioural dynamics related to e-waste management policy adoption. Navi Mumbai is a planned satellite city in the state of Maharashtra. Developed to reduce population pressure on Mumbai, Navi Mumbai has evolved into an important technological and commercial centre characterized by rapid urban growth and expanding digital infrastructure. The city hosts major information technology parks, business districts, educational institutions and residential zones that support a large population of technology users.

Overall, this study aims to investigate the socio-behavioural dynamics influencing e-waste management policy adoption in Navi Mumbai, India. The key objectives of the study were (i) to validate the construct reliability of extended Theory of Planned Behaviour (TPB) framework for identifying individual, social and structural determinants, (ii) to examine the relationship among constructs, (iii) to identify distinct behavioural profiles based on policy awareness, trust and compliance patterns using K-means cluster analysis and (iv) to develop a contextual framework for more effective e-waste management.

1.1. Scope of the Study

The study focuses on adult and adolescent residents/stakeholders participating in e-waste management within Navi Mumbai. It examines self-reported behavioural intentions, perceptions, policy awareness and e-waste management practices. The study therefore extends from an individual intention towards an integrated socio-behavioural framework, which aligns with an established TPB framework (Ajzen, 1991). This framework emphasizes that attitudes, subjective norms and perceived behavioural control are determinants of intention and behaviour. In the context of e-waste research, extending TPB with behavioural factors can thus improve understanding of recycling intentions.

1.2. Novelty and Contribution

This study contributes to the existing literature by providing an empirical assessment of the interaction between individual behavioural intention and community-level social processes in e-waste management. Previous studies have individually examined determinants such as attitude, subjective norms, perceived behavioural control, awareness, convenience, habits and environmental concern. The novelty of the study lies in the approach that integrates behavioural intention with social cohesion, while simultaneously evaluating influence of institutional trust, accessibility of recycling infrastructure and policy awareness.

This case study is organized into five sections. Section 1 introduces the challenges of e-waste and the factors requiring more research for design and implementation of policies in global and Indian context, explaining the need for present study. It also outlines the research aim, objectives, scope, novelty, hypotheses and research questions. A review of the literature is presented in section 2. Section 3 provides details of the methodology, emphasizing on the modified approach followed in this study by integrating multiple

constructs. Sections 4 and 5 present the outcomes of this research and discuss them in the context of policy implementation, respectively. A concluding note is outlined in Section 6.

1.2.1. Research Hypothesis

H1: Stakeholders intention positively influences e-waste policy adoption.
H2: Social cohesion positively influences e-waste policy adoption.
H3: Social and institutional trust positively influences e-waste policy adoption.
H4: Environmental attitude positively influences e-waste policy adoption.
H5: Infrastructure and accessibility positively influences e-waste policy adoption.
H6: Policy awareness mediates the relationship between stakeholders intention and policy adoption.

1.2.2. Research Questions

1. What influence do selected constructs have on the adoption of e-waste management policies?
2. Are there any distinct behavioural profiles among urban stakeholders based on their policy awareness, trust and adoption patterns?

2. Literature Review

The surge in e-waste generation that has accompanied technological advancements is alarming. Presently, the rate at which e-wastes are produced surpasses the capacity of many countries worldwide, including India, to manage them effectively (CPCB Report 2024; UNITAR Report 2024). The classification of e-wastes is also much more complex compared to domestic, municipal or industrial wastes. This is because e-wastes contain a mixture of hazardous substances along with several valuable metals. Separating these individual compounds is extremely difficult and often results in environmental contamination (Ali et al. 2025; Buczko et al. 2024). Despite policy initiatives undertaken across the globe, dominance of informal sectors severely hinders proper e-waste management (CPCB Report 2025; Tian et al. 2022; Andeobu et al. 2021). Collectively, studies indicate that the structural and behavioural issues cannot be resolved solely through policy reforms.

Factual evidence from India further supports the complexity of challenges associated with dominance of informal sectors. For instance, the Ministry of Environment and Forests (MoEF) reported 28 operational e-waste treatment, storage, and disposal facilities in India in 2011. In the same year, a case study published by Gupta and Kaur (2011) highlighted that there are around 25,000 workers in informal e-waste sectors in Delhi alone. Together, they dismantle between 10,000 and 20,000 tonnes of e-waste annually.

Over the past decade, there has been a significant improvement in India's e-waste management infrastructure. A recent News Report stated that there are 322 registered e-waste recycling facilities across India. Collectively, they process over 2.2 million metric tonnes of e-waste per year. In addition, there are 72 registered refurbishers who process 92,042.18 metric tonnes of e-waste every year. Unfortunately, these developments still support very low percentages of the e-waste load. These e-wastes are processed under unregulated conditions and do not follow the necessary specialized steps for recycling, separation and recovery of components. Thus, they exacerbate environmental and health risks (Ankit et al. 2021; MPCB Report 2007). Altogether, these studies reflect on the gap between policy formulation and implementation, with engagement and participation of stakeholders remaining the main limiting factors (Monika and Kishore, 2010; Salvia et al. 2021; Brugh et al. 2018; Annamalai, 2015).

In the Indian context, lack of awareness, weak gain of incentives, and lack of convenience are often highlighted as direct causes of improper e-waste disposal behaviours (Kumar and Shukla, 2025; Adjei et al. 2026; Pham et al. 2023; Tian et al. 2022; Mohamad et al. 2022; Vijayan et al. 2023; Silvestre et al. 2022; Pedro et al. 2021). The studies further highlight that some unidentified challenges remain in effective e-waste management. Although there are reports stating that socially cohesive communities engage better in environmental programs and adhere better to environmental policies (Andeobu et al. 2021; Needhidasan et al. 2014; Sengupta et al., 2023; Garg et al. 2023), these insights remain underexplored in the context of e-waste management.

In general, researchers have tried to understand the impact of behavioural factors on waste management using theoretical frameworks such as Norm Activation Model (NAM), Value–Belief–Norm Theory and Theory of Planned Behaviour (TPB). The NAM considers awareness, environmental responsibility and moral obligations as key constructs (Ai and Rosenthal 2024). In addition to these, Value–Belief–Norm Theory considers motivation as an important construct (Hong et al. 2024). The Theory of Reasoned Action, on the other hand, emphasizes the importance of attitude and subjective norms (McEachan et al. 2016). Compared to these theories, the TBP, proposed by Ajzen (1991), combines perceived behavioural control with attitudes and social norms, and provides better insights into the effect of behavioural factors on environmental issues (Mohamad et al. 2022).

Hence, considering e-waste management, TPB can provide useful insights into the behavioural barriers to policy adoption. Building on this theoretical foundation, the present study conceptualizes behavioural intention and social interaction as primary drivers of policy adoption in e-waste management.

Additionally, the study uses social cohesion (constructs such as moral obligation and shared norms) as a measurable variable. Integrating Social cohesion within a TPB framework allows the study to examine how individual behavioural motivations interact with community-level social dynamics in shaping participation in e-waste governance. To the best of authors' knowledge, this

integrative research design has not been explored in the context of e-waste management in India. Hence, the study uniquely contributes to current literature. For an in-depth analysis, this study adopts a quantitative analytical approach. Also, advanced statistical analysis of quantitative surveys is done using techniques such as Exploratory Factor Analysis (EFA), Structural Equation Modeling (SEM), and Principal Component Analysis (PCA). In addition, K-means clustering has been used to identify the behavioural groups. Different integrative approaches have been used to study behavioural characteristics. For example, Michael et al. (2024) employed TBP and NAM to explore the factors of e-waste disposal intention and behaviour in Manipal, India. The survey data (n=415) identified knowledge, awareness, convenience, practicality, data security and personal norms as the primary variables for individual intents. Gautam and Jain (2022) also argued that emotions and economic value are essential to impact customer behaviour in e-waste recycling in their qualitative study. Another study done specifically on recycling behaviour of computer and mobile phone indicated that many individuals prefer storage or convenient selling options over formal disposal in India (Borthakur and Govind 2017). Other studies have highlighted the roles of environmental attitudes, economic value and social norms in shaping recycling behaviour (Pham et al. 2023; Vijayan et al. 2023; Silvestre et al. 2022). This study integrates stakeholder behavioural intention and social cohesion; a perspective underexplored in present literature. Such gaps in understanding the behavioural determinants of e-waste disposal are particularly evident in rapidly urbanizing metropolitan regions. Hence, based on the insights obtained from above studies (Michael et al. 2024; Gautam and Jain 2022; Borthakur and Govind 2017), the present study attempts to develop a framework that represents the influence of behavioural intention and social cohesion on formal e-waste management practices among urban stakeholders. Addressing this gap is essential for designing more effective policy interventions and promoting sustainable e-waste governance.

3. Methodology

3.1. Research Design and Framework

A quantitative analytical approach was adopted in this study to explore the determinants of psychological/ social intentions and behaviour among consumers in Navi Mumbai, India (Jarmolowicz et al. 2022). The three stages of research are represented in Figure 1.

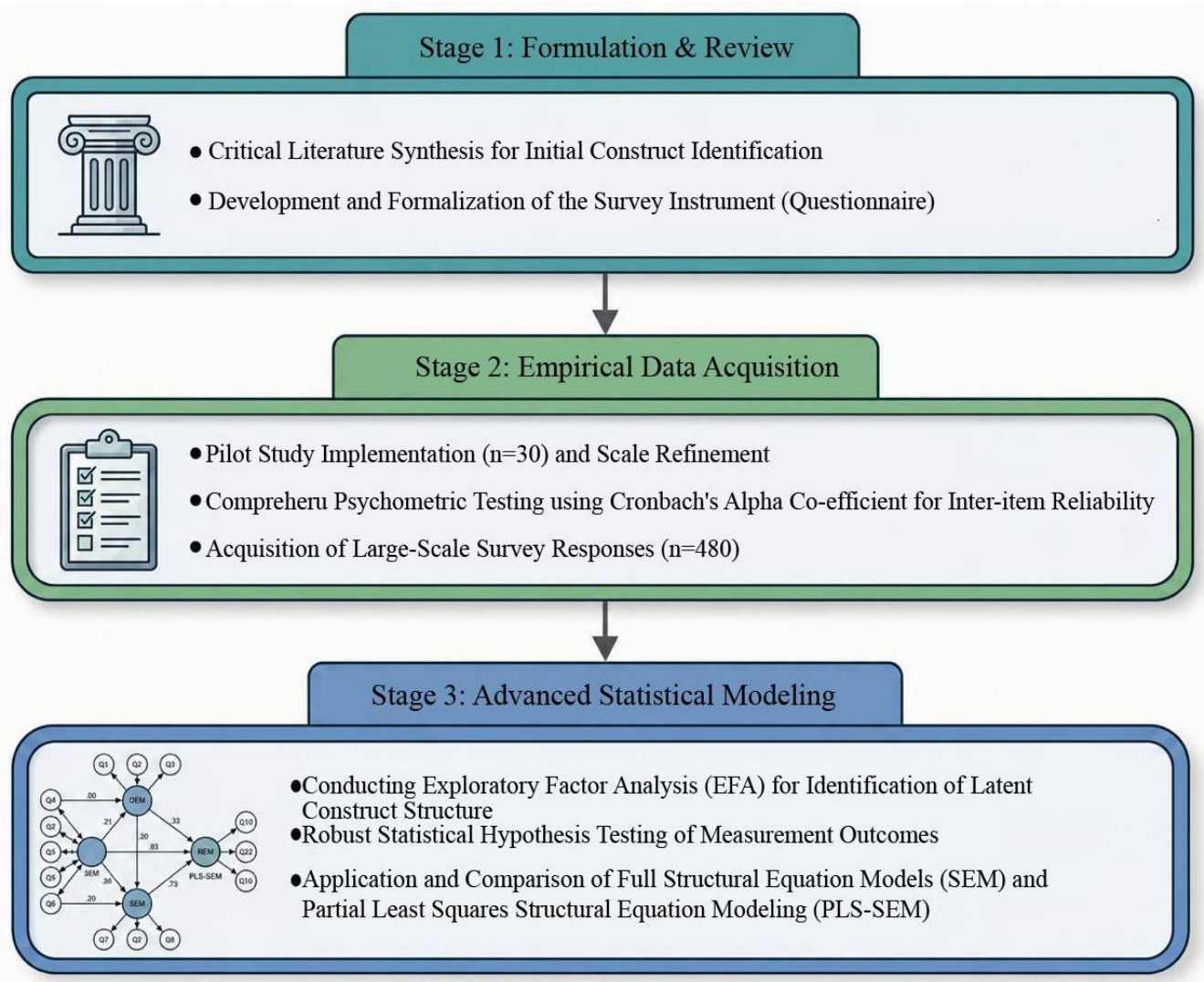


Fig. 1 Quantitative analytical approach for case study

3.2. Research Model Development

The theoretical model of this study is represented in Figure 2. The theoretical framework was developed based on TPB. It consisted of seven constructs selected based on literature review, and included Environmental Attitude (EA), Infrastructure & Accessibility (IA), Policy Adoption (PoA), Policy Awareness (PA), Stakeholders intention (INT), Social & Institutional Trust (ST), Social Cohesion (SC) (Tian et al. 2022; Arslan et al. 2024; Mohamad et al. 2022). The definition of each construct and their measures is provided in Appendix Tables 7 and 2, respectively. The constructs and their measures were designed in a way that improved overall prediction, model clarity, reduced redundancy, and ensured that each construct has a distinct theoretical role in explaining E-waste Recycling Intention (ERI) and E-waste Policy Adoption Behaviour (EPAB) (Mohamad et al. 2022).

3.3. Sampling Method and Sample Characteristics

An online survey was conducted with Navi Mumbai residents as sample population. The participants were mainly adult students, working professionals, homemakers, and retired individuals, with a few students aged 12-17 years. The diversity among sample population ensured representation of a community who has access to electronic devices and a basic understanding of recycling practices. Sample size was calculated using standard sample calculator and G* Power statistical tool ($p<0.05$) (Sekaran and Bougie 2016), which indicated a value of more than 385 as appropriate, considering population proportion as 50%. The overall sample size of this study was 530. Prior to analysis, the dataset was screened for missing values and outliers. In the preliminary analysis, surveys with more than 10% missing data were discarded. The final dataset of 500 cases had a 100% completion rate with no missing values across the 50 indicators. No duplicated entries or 'straight-lining' patterns were found, ensuring the quality of the primary data.

3.4. Data Collection

The survey was conducted using a quantitative analytical approach combined with stratified convenience sampling (Jarmolowicz et al. 2022; Etikan et al. 2016), which allowed targeting groups relevant to the research questions and, at the same time, were accessible and willing to participate. Stratified sampling was particularly appropriate for this research because behavioural attitudes toward e-waste recycling may vary across socio-demographic groups such as students, professionals, and homemakers. Therefore, dividing the population into relevant strata improved the representativeness of the sample and ensured that different stakeholder perspectives were adequately captured. A structured questionnaire (Appendix Table 8) was prepared and distributed online to the participants through social media, email, and academic networks. The questionnaire was pilot-tested with 30 respondents first to assess clarity, consistency, reliability and relevance. The Cronbach's alpha values for each construct exceeded 0.70, confirming reliability (Sekaran and Bougie, 2016). Hence, the questionnaire was distributed to a wider network. It collected demographic information (age, gender, education, occupation, household income) and responses for behavioural constructs (EA, IA, PA, INT, PoA, ST, SC), and noted participants' familiarity with e-waste practices and awareness. The responses were rated on a 5-point Likert scale from Strongly Disagree (1) to Strongly Agree (5).

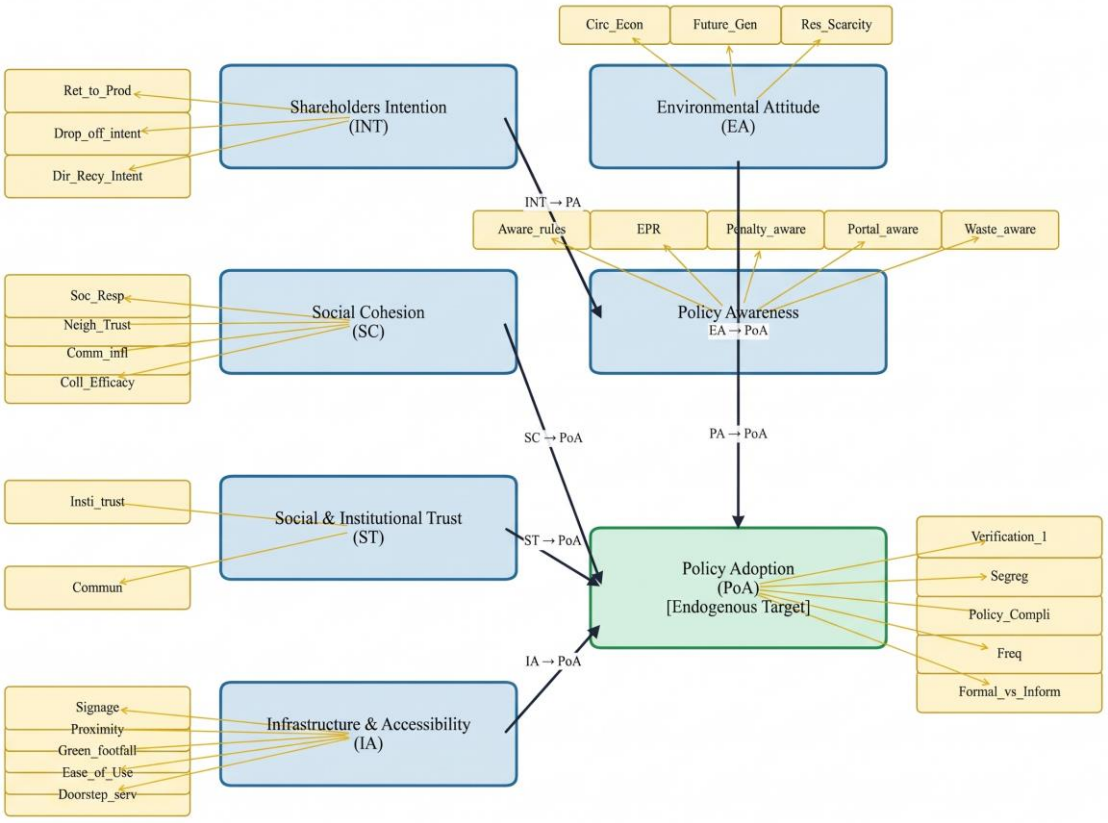


Fig. 2 Research framework for theory of planned behaviour with selected constructs

3.5. Ethical Considerations

Informed consent was obtained digitally from all adult participants before they filled the questionnaire. The younger participants (aged 12-17) were children of friends and family members of the researchers, and parental consent was obtained informally prior to their participation. Anonymity and confidentiality were maintained throughout data collection and analysis. Respondents had the right to withdraw at any time.

3.6. Data Analysis

Data analysis was conducted using a combination of descriptive statistics, multivariate statistical techniques, and structural modelling approaches to examine behavioural determinants of e-waste recycling intentions and practices. The analytical techniques were selected in order to identify the underlying psychological constructs associated with behavioural intentions and the structural relationships between them. Descriptive statistics were calculated to present the demographic characteristics of respondents and understand the distribution of responses across survey items. This step provided a preliminary overview of participants' awareness, familiarity, and behavioural perceptions related to e-waste recycling.

Exploratory Factor Analysis (EFA) was employed to identify latent constructs from observed variables (Fontaine, 2005). EFA is widely used in behavioural research to reduce measurement items into theoretically meaningful factors. The results of EFA helped to verify if the survey items were sufficient to represent the posited constructs such as EA, ST and PoA. The behavioural patterns and structural influences in e-waste management were studied through visual data analysis. These studies included construction of influence scores (Decision-Making Impact), heatmap of constructs, K-Means clustering for identifying behavioural segments among respondents, Principal Component Analysis (PCA) for dimensionality reduction, T-tests and ANOVA grouping comparisons, and Correlation and regression analysis exploring the strength of relationships (Stevens 2012). K-means clustering analysis was applied to classify participants into distinct behavioural groups based on their responses. This segmentation approach enabled the identification of stakeholder groups with similar behavioural tendencies toward e-waste recycling. To determine the clusters without subjective bias, three quantitative cluster validation indices were calculated, including (i) Elbow Method (Within-Cluster Sum of Squares, WSS), (ii) Average Silhouette Width and (iii) Calinski-Harabasz Index (Variance Ratio Criterion). Visualization tools such as Tableau and Python's Seaborn/Matplotlib libraries were used for construction of charts and heatmaps. Structural Equation Modeling (SEM) and Partial Least Squares SEM (PLS-SEM) were adopted to study relation between construct and variables (Hair et al. 2014). SEM is particularly suitable for behavioural research because it allows simultaneous examination of multiple relationships between latent variables and observed indicators (Hair et al. 2014). In addition, PLS-SEM was used to estimate the hypothesized paths and assess both direct and indirect effects among constructs. The inferential statistical analysis was conducted using SPSS, AMOS, SmartPLS, R and Python. The structural model was evaluated using path coefficients, their bootstrapped confidence intervals and significance levels, Coefficient of Determination (R^2), and effect sizes (f^2). Where applicable, model fit was additionally reported using the Standardized Root Mean Square residual (SRMR), Unweighted Least Squares Distance (d_ULS), Geodesic Distance (d_G) and Normed Fit Index (NFI) (Hair et al. 2014).

3.7. Data Validation and Reliability

Following EFA, the Confirmatory Factor Analysis (CFA) ensured internal consistency and construct-validity criteria (whether the observed variables adequately represented the underlying theoretical constructs). Reliability was assessed using Cronbach's alpha and Composite Reliability (CR), while convergent validity was assessed using Average Variance Extracted (AVE) and the magnitude of the standardized outer loadings. Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT). Cronbach's Alpha values above the recommended threshold of 0.70 indicated acceptable internal consistency (Sekaran and Bougie 2016; Hair et al. 2014; Goyal and Aleem 2023). Expert opinion was also taken from environmental behaviour and policy researchers to confirm validity of the present model design. CR values >0.70 and AVE values >0.50 were considered satisfactory indicators of measurement reliability and validity.

4. Results

4.1. Demographic Characteristics of Sample

Among the 500 survey participants, 53.6% were female and 46.4% were male. The age distribution showed 9% participants in age group 12-18, 28% were between 19–25 years, 37% were between 26–40 years, 21% were between 41–60 years, and 5% were above 60 years of age. The educational background of the participants was also diverse. Overall, 12% participants completed high school or lower school grades, 42% were undergraduates, 36% were postgraduates, and 10% completed Doctorate degrees. Occupation-wise, the participants included 29% students, 23% corporate professionals, 18% homemakers, 16% faculty and academic staff, and 14% e-waste handlers and informal sector workers. Thus, the study sample represented both consumers and informal stakeholders.

4.2. Survey Outcome for Descriptive Statistics

The highest number of positive responses was recorded for questions on education and awareness about e-waste, whereas the lowest number of positive responses was recorded for participants' active engagement in proper e-waste disposal. Overall, respondents strongly believed that electronic businesses should take responsibility and government incentives could help in supporting e-waste management policies. Also, a significant number of participants were willing to change their behaviour regarding e-waste handling and disposal. The main barriers to e-waste recycling were identified as lack of standardized disposal methods and inconvenience.

4.3. Survey Outcome for Visual Statistics

Figures 3 to 8 represent data visualizations for behavioural patterns and structural influences in e-waste management. The indicator evaluation showed mean decision-making scores around the neutral mid-point across the key variables (Figure 3). This indicates that while Navi Mumbai residents show moderate PA and INT, they are poorly manifested in to PoA. The correlation heatmap (Figure 4) demonstrated distinct intra-block convergent validity and inter-block discriminant patterns across indicator variables. The PA indicators exhibited moderate to strong positive intercorrelations (r = ~0.40–0.50). Similarly, ST showed consistent internal correlation (r = ~0.50–0.65$). However, correlations between PA and ST were weak (r = < 0.15). The K-means clustering (Figure 5) categorized respondents into four distinct behavioural groups; Proactive Adopters, Passive Participants, Uninformed Disposers and Non-Participants. The cluster centroids (based on mean Likert scores ranging from 1 to 5) and cluster distributions are summarized in Table 1. One-way ANOVA confirmed a statistically significant difference between cluster centroids across all seven constructs ($p < 0.001$). The PCA plot (Figure 6) confirmed these differences using dimension reduction. The cumulative variance of PC1 (9.3%) and PC2 (8.7%) was calculated as 18.0%. However, PCA was used only for scatter visualization. The K-means partitioning was performed in the seven-dimensional construct space, where distinct subgroup boundaries were confirmed by the cluster validation indices, including:

1. Elbow Method (WSS): The inflection point occurred at K=4.
2. Average Silhouette Width: It peaked at k=4 (0.418).
3. Calinski-Harabasz Index: It also peaked at k=4 (214.6).

The bootstrapping p-values (Figure 7) indicate that although the structural paths directly connect INT, SC, ST, EA and IA to PoA, these connections are non-significant ($p > 0.05$) and provide evidence of gap between intention and behaviour. Scatter plot mapping (Figure 8) illustrates the operational barriers that were constant across both low and high PA levels (> 4.0 on a 1–5 Likert scale). It indicates that even strong INT (larger bubbles) can be constrained by operational and infrastructural barriers such as collection inconvenience and a lack of standardized disposal systems.

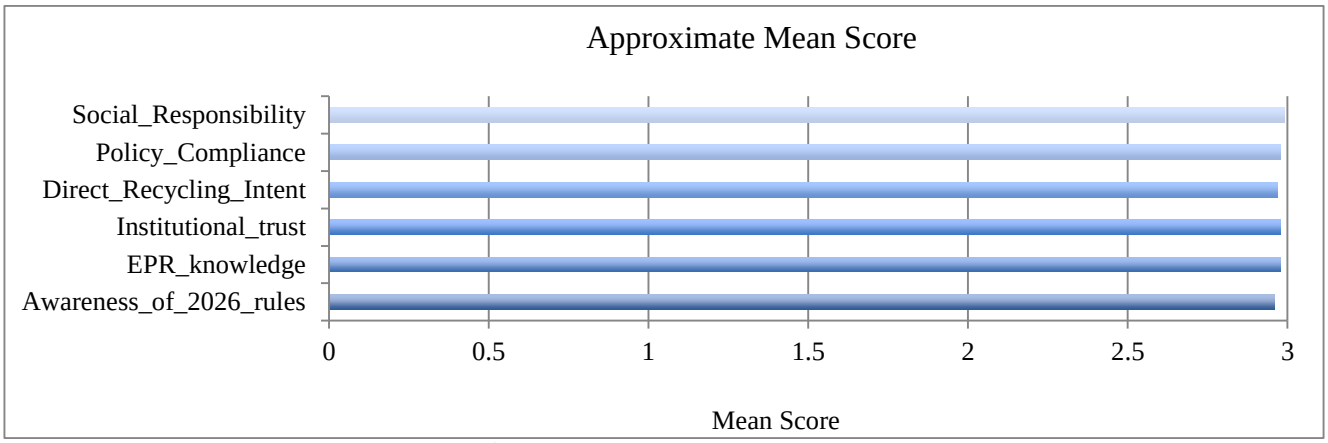


Fig. 3 Importance of selected variables based on mean decision-making scores

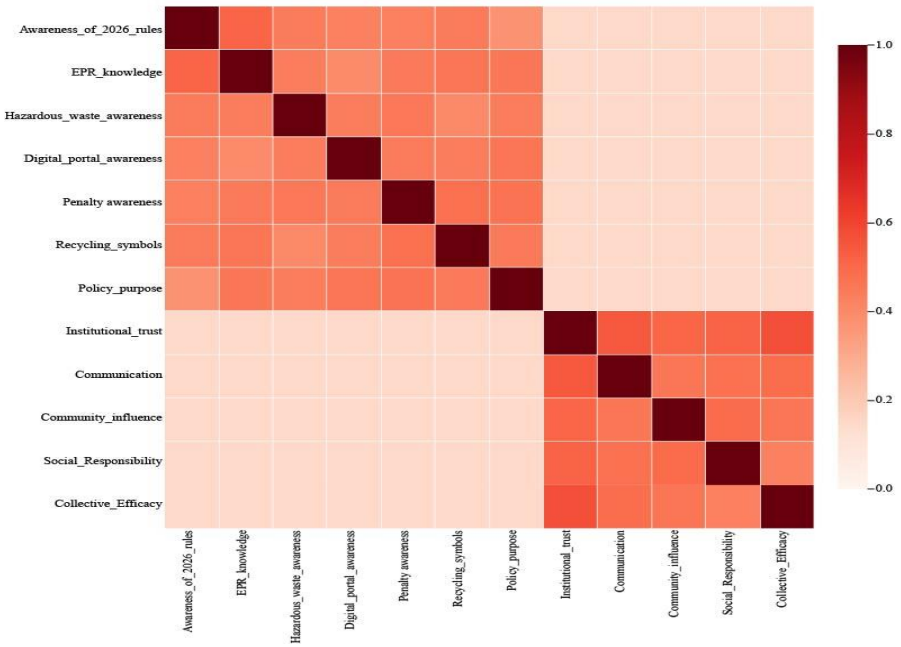


Fig. 4 Correlation heatmap of selected variables

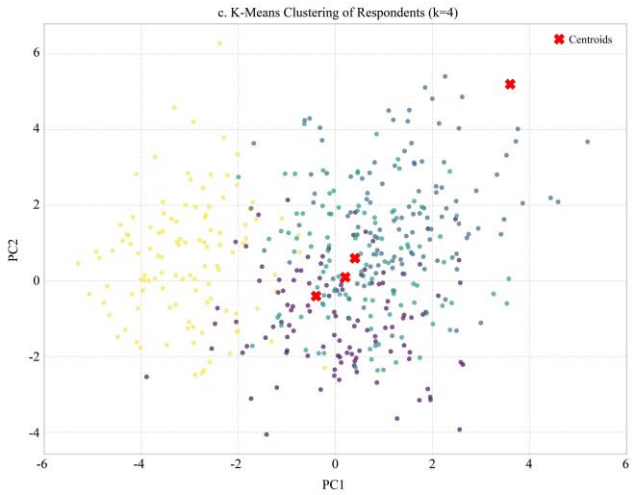


Fig. 5 K-Means clustering analysis showing respondent segmentation scatter plot

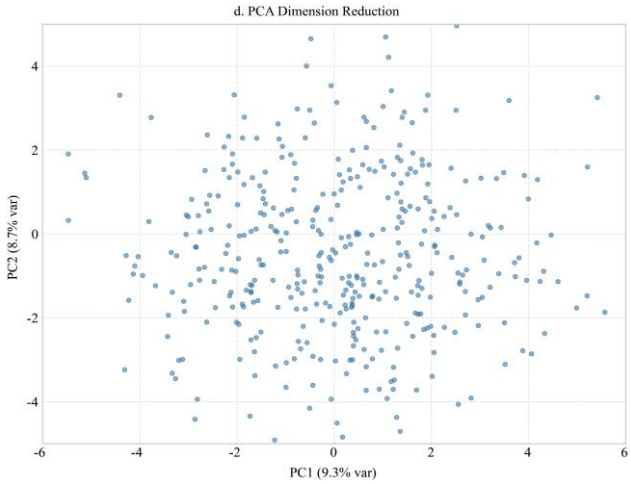


Fig. 6 Principal component analysis plot of respondent behavioural profiles

Table 1. K-Mean analysis representing cluster sizes and centroids

Construct	Proactive Adopters	Passive / Intentional Participants	Uninformed Informal Disposers	Non-Participants	F-statistic	p-value
	(n=62, 12.4%)	(n=215, 43.0%)	(n=148, 29.6%)	(n=75, 15.0%)		
PA	4.21	3.35	1.82	1.45	184.2	< 0.001
INT	4.45	3.82	2.91	1.62	212.5	< 0.001
ST	4.10	3.12	2.85	1.98	115.8	< 0.001
SC	3.95	3.28	2.64	1.80	128.4	< 0.001
EA	4.62	4.15	3.20	2.10	198.3	< 0.001
IA	3.88	2.75	2.41	1.85	142.1	< 0.001
PoA	4.15	2.10	1.95	1.22	265.7	< 0.001

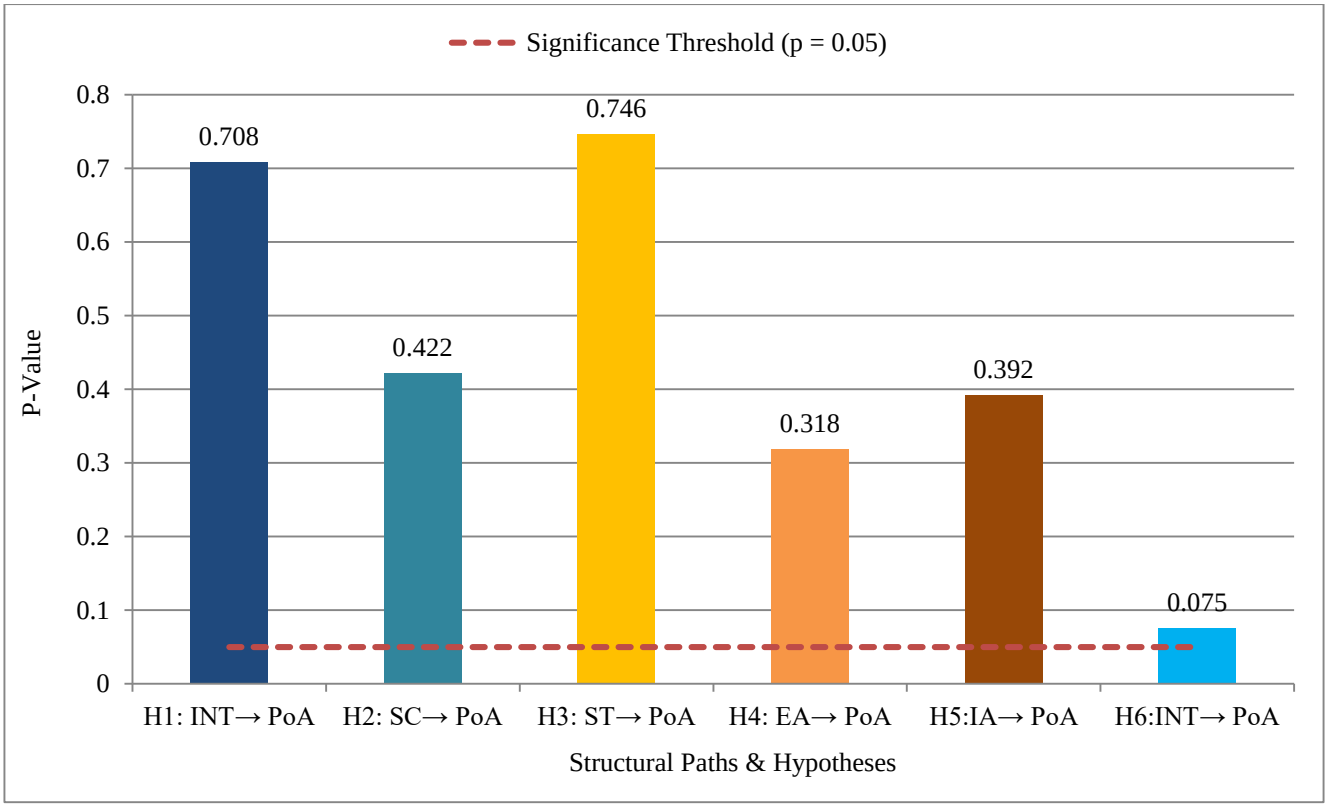


Fig. 7 Statistical significance analysis of predictor constructs via bootstrapping p-values

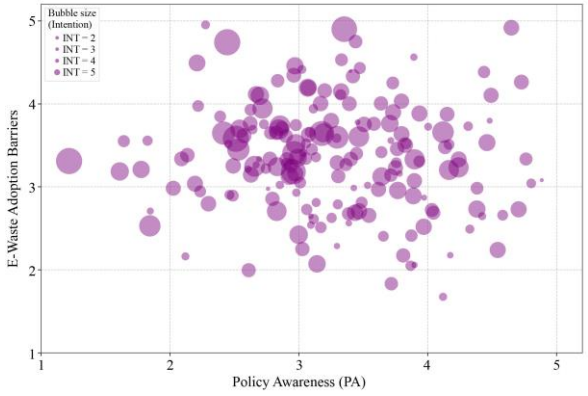


Fig. 8 Bubble scatter analysis evaluating e-waste awareness levels against perceived adoption barriers

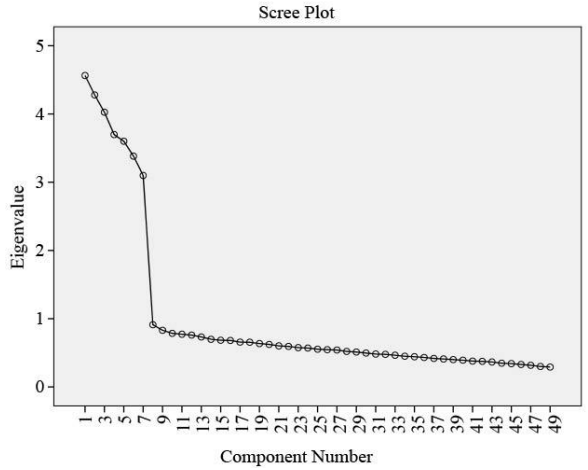


Fig. 9 Scree plot of factor Eigenvalues

4.4. Exploratory Factor Analysis

For factor analysis, the Kaiser–Meyer–Olkin (KMO) value of 0.864 indicated excellent suitability, and statistically significant Bartlett's Test of Sphericity (χ^2 = 9164.363, $p < 0.001$) confirmed correlations among the variables. Figure 9 represents the scree plot derived from Analysis of Moment Structures (AMOS). It illustrates a continuous decrease of eigenvalues with a clear plateauing effect after the seventh component, thereby supporting the extraction of seven relevant latent constructs from the dataset. These retained components collectively explained a substantial proportion of the total variance and represented the multidimensional socio-behavioural, technological, and policy-related determinants associated with e-waste management practices. The CFA conducted in AMOS revealed that all the factor loading thresholds exceeded 0.60 for all items ($p<0.001$), with most constructs exceeding 0.70. This confirmed construct validity.

4.5. Measurement Model

The measurement model was evaluated for reliability (Cronbach's $\alpha = 0.81$), convergent validity (AVE value of >0.50) and discriminant validity (HTMT < 0.85) across all seven constructs (EA, IA, PoA, PA, INT, ST, SC). The model fit indices (Table 2 and Table 3) further indicated a reasonably good fit, demonstrating that the structural model effectively explains the relationships among the constructs.

4.6. Structural Model

The drivers of PoA were estimated using PLS-SEM, and the structural path is represented in Figure 10. The relationships in the structural model were assessed based on beta (β) and f^2 values of the path coefficients obtained in PLS-SEM (Table 4). Contrary to expectations, the analysis indicated that the direct structural paths connecting primary constructs to PoA were statistically non-significant ($p > 0.05$). Specifically, these results indicate that high INT and PA fail to drive PoA. The predictive power of the structural model indicated low explanatory power within direct linear pathways (Table 5). However, the standardized PLS-SEM fit criteria (Table 6) confirmed robust structural specification. The SRMR confirmed acceptable overall model fit. The d_ULS and d_G also remained within satisfactory bootstrap quantile limits. The NFI reflected baseline alignment, which is typical of complex socio-behavioural field data.

Table 2. Quantitative outputs from measurement model

Construct	Item	Loading	Cronbach's α	CR (ρc)	AVE
Environmental Attitude (EA)	Circ_Econ	0.705	0.705	0.819	0.606
	Future_Gen	0.916			
	Res_Scarcity	0.695			
Infrastructure & Accessibility (IA)	Doorstep_serv	0.714	0.812	0.864	0.561
	Ease_of_Use	0.732			
	Green_footfall	0.811			
	Proximity	0.699			
	Signage	0.782			
Policy Adoption (PoA)	Formal_vs_Inform	0.703	0.807	0.835	0.508
	Freq	0.890			
	Policy_Compli	0.646			
	Segreg	0.586			
	Verification_1	0.702			
Policy Awareness (PA)	Aware_rules	0.783	0.806	0.862	0.556
	EPR	0.779			
	Penalty_aware	0.709			
	Portal_aware	0.687			

	Waste_aware	0.766			
Stakeholders intention (INT)	Dir_Recy_Intent	0.836	0.731	0.836	0.633
	Drop_off_intent	0.667			
	Ret_to_Prod	0.868			
Social & Institutional Trust (ST)	Commun	0.996	0.635	0.767	0.641
	Insti_trust	0.538			
Social Cohesion (SC)	Coll_Efficacy	0.926	0.794	0.831	0.558
	Comm_influ	0.730			
	Neigh_Trust	0.658			
	Soc_Resp	0.640			

Table 3. Discriminant validity (HTMT ratio)

Construct Pair	HTMT	Assessment
IA ↔ EA	0.114	Established
PoA ↔ EA	0.093	Established
PoA ↔ IA	0.083	Established
PA ↔ EA	0.090	Established
PA ↔ IA	0.085	Established
PA ↔ PoA	0.064	Established
INT ↔ EA	0.052	Established
INT ↔ IA	0.071	Established
INT ↔ PoA	0.106	Established
INT ↔ PA	0.104	Established
ST ↔ EA	0.126	Established
ST ↔ IA	0.057	Established
ST ↔ PoA	0.075	Established
ST ↔ PA	0.103	Established
ST ↔ INT	0.080	Established
SC ↔ EA	0.082	Established
SC ↔ IA	0.063	Established
SC ↔ PoA	0.084	Established
SC ↔ PA	0.121	Established
SC ↔ INT	0.052	Established
SC ↔ ST	1.015	High

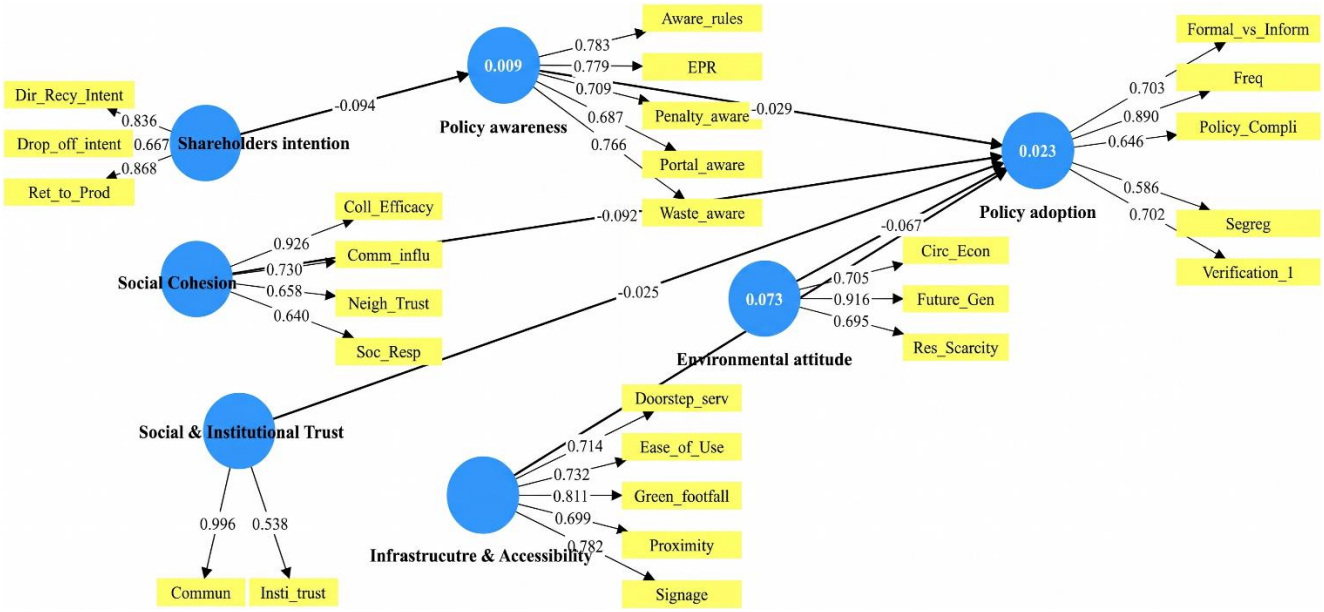


Fig. 10 PLS-SEM path diagram of latent constructs and indicators

Table 4. Structural model: Path coefficients and hypothesis tests (Bootstrapping)

Path	β	SE	t	p	95% CI	f^2	Decision
EA → PA	-0.067	0.067	0.999	0.318	[-0.198, 0.064]	0.005	Not Supported
IA → PA	0.073	0.086	0.856	0.392	[-0.096, 0.242]	0.005	Not Supported
PA → PoA	-0.029	0.064	0.460	0.645	[-0.154, 0.096]	0.001	Not Supported
INT → PA (Direct)	0.003	0.007	0.375	0.708	[-0.011, 0.017]	0.000	Not Supported
INT → PA	-0.094	0.053	1.783	0.075	[-0.198, 0.010]	0.009	Not Supported
ST → PoA	-0.025	0.078	0.324	0.746	[-0.178, 0.128]	0.001	Not Supported
SC → PoA	-0.092	0.114	0.803	0.422	[-0.315, 0.131]	0.009	Not Supported
INT → PA → PoA (Indirect)	0.003	0.007	0.375	0.708	[-0.014, 0.015]	0.000	Not Supported

$f^2 \geq 0.02$: Small effect; $f^2 \geq 0.15$: Medium effect; $f^2 \geq 0.35$: Large effect; $f^2 < 0.02$: No meaningful effect

Table 5. Explanatory power of endogenous constructs

Endogenous Construct	R^2	Adjusted R^2
Policy awareness	0.009	0.007
Policy adoption	0.020	0.008

Table 6. Model fit and quality indices table

Metric / Index	Criterion Threshold	Obtained Model Value	Assessment / Status
SRMR	< 0.080 (Good fit) < 0.100 (Acceptable)	0.078	Acceptable Model Fit
d_ULS	Lower values, < 95% bootstrap quantile	0.842	Satisfactory
d_G	Lower values, < 95% bootstrap quantile	0.315	Satisfactory
NFI	> 0.900 (Ideal)	0.812	Marginal / Baseline

5. Discussion

The present study was carried out to determine the influence of stakeholders' intentions and social cohesion on the adoption of e-waste management policies in Navi Mumbai, India. The literary insights obtained through a review of existing literature during the pre-preparatory phase of the survey provided a comprehensive understanding of the systemic flow in e-waste handling practices (Islam et al. 2024; Andeobu et al. 2021; Andersen and Halse 2023; Needhidasan et al. 2014), the engagement of stakeholders at different levels (Ankit et al., 2021; Andeobu et al., 2021; Liu et al., 2022; Newig et al., 2023) and associated barriers (Nisha et al. 2022; Arslan et al. 2024; Jangre et al. 2022; Munni et al. 2024). A Sankey diagram represented in Figure 11 represents major pathways of e-waste management discussed in the literature. It indicates that a significant portion of e-waste originating from households and commercial sectors are handled informally by aggregators and dismantlers. Due to lack of standardized recycling infrastructure in India, the processes used in the treatment and recycling of e-waste remain unclear and undocumented (Liu et al. 2023). It is, however, clear that a large quantity is ultimately dumped in landfills (Roy et al. 2022; Parvez et al. 2021). Hence, the existing practices need significant improvement in policy formulation and implementation.

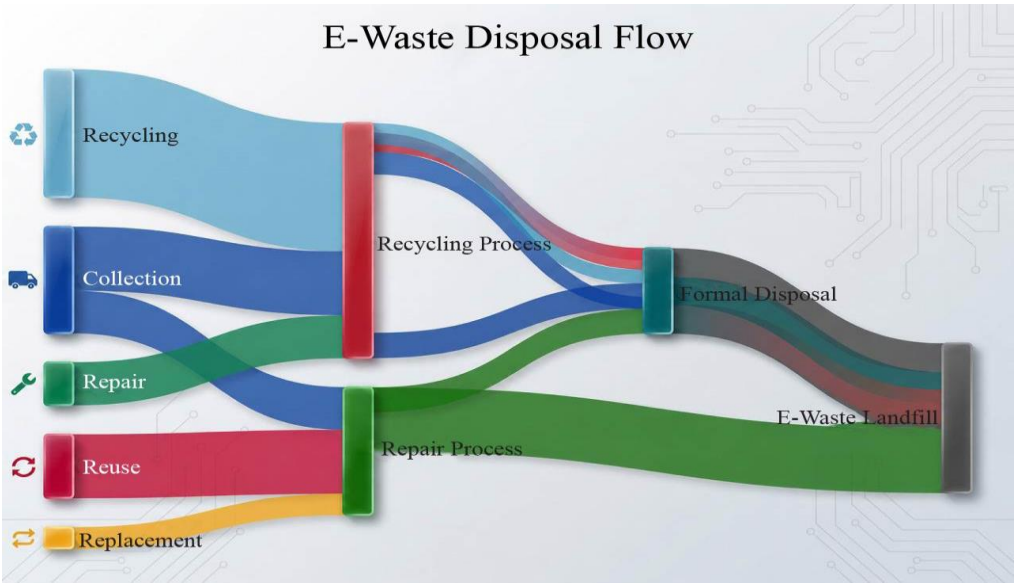


Fig. 11 Sankey diagram for e-waste disposal

In the overall process of e-waste management, the role of producers, authorized recyclers, and government bodies are constrained (Newig et al. 2023; Munni et al. 2024; Liu et al. 2023). Hence, the present study was designed to obtain insights into the behavioural and social variables of a community that can strengthen policy enforcement. The key findings of the study are highlighted below:

1. A critical intention-behaviour gap remains among population of Navi Mumbai.
2. Lack of standardised infrastructure and inconvenience are the main barriers in e-waste recycling practices.
3. Although survey findings suggested awareness and willingness for formal e-waste disposal practices, these observations were statistically insignificant in predicting the relationship between PA/EA and PoA.
4. SC and ST did not demonstrate statistically significant direct effects on PoA. Hence, the roles of these constructs in PoA need further evaluation.
5. Four distinct behavioural groups, Proactive Adopters, Passive Participants, Uninformed Disposers and Non-Participants, identified in the studied community indicate the need for tailored interventions to address these populations, keeping in mind the unique requirements, barriers and motivations.

These key findings collectively address the research questions. The implications and relevance of each research question is further discussed in this section.

5.1. Influence of Selected Constructs on E-Waste Management Policy Adoption

This section addresses research questions 1 related to the influence of selected constructs on e-waste policy adoption behaviour**.** The bootstrapped PLS-SEM path analysis revealed that none of the selected constructs exert a statistically significant direct influence on policy adoption. These findings demonstrate that perceptual and psychological constructs show no significant direct associations with policy adoption.

Although other studies from Brazil and India emphasize that heightened PA, social norms and stronger social collaborations can bridge the gap between ERI and EPAB (Echegaray and Hansstein 2017; Arya and Kumar 2020; Vijayan et al. 2023; Silvestre et al. 2022), the empirical data from present survey indicate that these psychological drivers are neutralized in the presence of real-world operational friction.

In Navi Mumbai, systemic barriers such as the absence of standardized collection hubs, lack of convenient doorstep pickup, and the overwhelming convenience of the informal sector (kabadiwalas) pose a barrier between INT and PoA. In this scenario, the incentive-based strategies reported by Gautam and Jain (2022) may influence public behaviour. However, for economic incentives as an influencing factor, contradicting evidence has been reported in literature (Sajid et al. 2022). Hence, more in depth research studies are necessary to understand its role on behaviour and policy implementation.

5.2. Distinct Behavioural Profiles among Urban Stakeholders

This section addresses Research Question 2 and identifies four distinct non-overlapping behavioural profiles, including Proactive Adopters, Passive Participants, Uninformed Disposers and Non-Participants. The proactive adopters represent a minority segment of the urban population that exhibit high PA, ST and PoA. They actively seek authorized collection drives and demonstrate strong environmental commitment. The passive participants represent the majority segment that exhibit moderate PA and low ST. This population represent a segment with high perceived operational friction, mainly due to convenience offered by informal collectors. Although they express general INT and EA, their PoA is almost non-existent. The uninformed disposers have very low PA, and they conveniently rely on informal sectors, while also disposing e-waste through municipal solid wastes systems. They do not recognize formal regulatory compliance or environmental toxicity risks. Lastly, the non-participants were identified as the strongest barrier to EPAB. They have no PA and were non-compliant with formal e-waste policies.

To achieve public compliance, it is necessary to enforce strategies that are non-uniform and tailored to the above populations (Newig et al., 2023; Ankit et al., 2021). The findings from similar urban contexts across India and developing economies have demonstrated that stakeholder engagement is strongly affected by digital accessibility, institutional perception, and neighborhood-level infrastructure (Andeobu et al., 2021; Liu et al., 2022; Nisha et al., 2022).

5.3. Behavioural and Structural Factors Impacting Policy Adoption Behaviour

Among structural factors, the survey identified lack of standardized infrastructure and inconvenience as major barriers to effective policy implementation. Precisely, despite awareness and positive intent, many respondents were discouraged to practice proper e-waste recycling and disposal methods due to limited access to such infrastructure or inconvenience to locate them. At the same time, the non-significant behavioural paths including INT, EA and ST → PoA indicated that community trust cannot offset a fragmented formal disposal system. This is because the effective influence of behavioural and social constructs is reduced in absence of integrated systems that make responsible disposal both easy and accessible. To an extent, this behaviour can be explained based on the Health Belief Model. It explains that adopting behaviour to mitigate the health risks not only depends on the risk itself but also the severity of consequences in case of non-compliance, perceived tangible benefits and number barriers involved (Nancy and Marshall, 1984).

The positive relation between INT and ST is often described as ‘constructed governance’ which implies that active participation in policy implementation from stakeholders’ inculcates a sense of responsibility and

commitment, resulting in community (or at least group) cohesion (Pedro et al. 2021). Additionally, studies undertaken to understand INT associates EA, ST and PoA as common influencing factors that are often shaped by social structures in any community (Echegaray and Hansstein 2017; Arya and Kumar 2020; Vijayan et al. 2023; Gautam and Jain 2022). In this context, a study from Pune city reported improved e-waste collection and disposal practices through involvement of retail shops and service centres (Singh et al. 2022). Hence, based on current findings and above studies, improving the accessibility and clarity of formal e-waste collection systems may be a relevant policy consideration.

5.4. Limitations

The present study offers valuable insights into the behavioural and structural factors influencing e-waste management policy adoption. However, there are certain limitations of the study which are acknowledged in this section. Firstly, the data collected through online surveys may be subject to response bias. Behavioural studies commonly report that participants overstate positive attitudes (such as compliance with ERI and EPAB) in an attempt to sound socially desirable (Latkin et al., 2017; Bispo Júnior, 2022). In such cases, the inferential data will be significantly biased. Secondly, the sample size and distribution representing the population of Navi Mumbai may not be generalised to other urban or rural settings in India or globally. Thirdly, the survey conducted through online platforms may have resulted in selection bias towards participants with greater digital access, familiarity and engagement. Finally, the use of a common questionnaire for multiple constructs introduces the possibility of common-method bias. Future studies could strengthen the evidence base through longitudinal designs, objective records of collection and recycling behaviour, mixed-mode sampling and direct engagement with formal and informal e-waste workers.

6. Conclusion

The multifaceted nature of e-waste management poses several barriers in policy adoption and implementation. The findings of this study indicate that e-waste management behaviour in Navi Mumbai is influenced by complex socio-behavioural and infrastructural challenge. Precisely, the PLS-SEM framework emphasized that public willingness and awareness alone do not drive policy adoption, and there is an acute Intention-Behavior gap in Navi Mumbai. Closing this gap requires shifting municipal focus from passive public awareness campaigns to structural interventions. The study contributes to the existing literature by extending the behavioural perspective on e-waste management beyond individual intention to include social cohesion, institutional trust and structural accessibility within a single analytical framework. The identification of distinct behavioural profiles further suggests that a uniform intervention strategy may be less effective than approaches tailored to differences in awareness, intention and participation. From a policy perspective, the findings support an integrated approach in which awareness programmes are accompanied by visible and accessible collection systems, clear communication of formal disposal pathways, community-level engagement and effective institutional support. Such measures may help reduce the gap between willingness to recycle and actual participation in formal e-waste management.

Author Contribution

SN and SGP conceived and designed research. SN conducted experiments. SGP contributed to analytical tools. SN and SGP and GKM analyzed data. SN wrote the manuscript. All three authors read and approved the manuscript.

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Appendix

Table 7. Definition of study variables and constructs

Constructs and Variables	Definition
Constructs	
Environmental Attitude (EA)	Personal view, concern and good attitude towards environmental conservation and sustainable waste management procedures.
Infrastructure & Accessibility (IA)	Availability, ease and accessibility of e-waste collection centres, recycling facilities, transportation systems and accompanying technological infrastructure.
Policy Adoption (PoA)	The extent to which individuals adopt, support and integrate e-waste management rules and guidelines into their daily waste management procedures.
Policy Awareness (PA)	Knowledge of e-waste management rules, legislation, EPR, recycling techniques and environmental implications of inappropriate e-waste disposal.
Stakeholders intention (INT)	Willingness and intended involvement of persons in responsible activities for e-waste management such as segregation, recycling and formal disposal techniques.
Social & Institutional Trust (ST)	Leave e-waste practices to be implemented and effectively managed by government agencies, local authorities, recycling systems, communities and informal waste sectors.
Social Cohesion (SC)	The extent to which individuals share responsibility with other community members in supporting responsible e-waste management practices.
Variables	
E-waste Recycling Intention (ERI)	Motivational factors and intention to recycle e-waste in the near future.
E-waste Policy Adoption Behaviour (EPAB)	Individual acts made to recycle e-waste, such as returning, donating, or disposing of electronic devices at recycling centres.

Table 8. Measures for the constructs used in the study

Construct	Abbreviation	Indicator	Survey Questions for 5-Point Likert Scale
Environmental Attitude (EA)	Circ_Econ	Circular Economy	I strongly believe that old electronic parts should be repaired and reused.
	Future_Gen	Future Generations	I am aware that I need to protect the environment for future generations, and that's why I dispose of e-waste cautiously.
	Res_Scarcity	Resource Scarcity	I am aware that gadgets have precious metals which should be recovered since we are already facing shortage of many metals.
Infrastructure & Accessibility (IA)	Doorstep_serv	Doorstep service	I would like a doorstep service for discarding heavy or old electronics.
	Ease_of_Use	Ease of Use	The e-waste collection boxes are simple to use.
	Green_footfall	Green footfall	I know surrounding areas that has e-waste disposal bins.
	Proximity	Proximity	I would like an authorized e-waste collection point or bin near my home or workplace.
	Signage	Signage Visibility	I would like to see directions pointing toward e-waste collection bins in public places.
Policy Adoption (PoA)	Formal_vs_Inform	Formal vs Informal	I always obey all local rules and legislation when it comes to disposing of any electronic gadget in my home.
	Freq	Frequency	I always recycle my old or broken electronics instead than leaving them unused in drawers, closets or storage for years.
	Policy_Compli	Policy Compliance	Instead of informal scrap dealers, I take my e-waste to government-approved recycling sites.
	Segreg	Recycling symbols	I am familiar with the official recycling symbols and labels on electrical items and their packaging.
	Verification_1	Verification 1	I always make sure that whatever recycling service or vendor I use is officially certified and authorised by the environmental board.
	Aware_rules	Awareness of 2026 rules	I know the government has established several new guidelines for e-waste disposal starting this year (2026).

Policy Awareness (PA)	EPR	EPR knowledge	I know that the EPR law requires electronic producers to accept back obsolete electronics.
	Penalty_aware	Penalty awareness	I know homes and businesses get fined or penalised for dumping electronic waste illegally.
	Portal_aware	Digital portal awareness	I am aware of the government's official digital portals and websites to trace and deal with electronic waste.
	Waste_aware	Hazardous waste awareness	I know there are dangerous and hazardous compounds in outdated gadgets that can be harmful to the environment if they go into the ordinary trash.
Stakeholders Intention (INT)	Dir_Recy_Intent	Direct Recycling Intent	In the next coming months, I truly intend to organise and recycle my old technological devices.
	Drop_off_intent	Drop-off intent	I'm very happy to haul my old equipment to approved public e-waste containers or collection centres.
	Ret_to_Prod	Return to Producer	I will be happy to return my old devices back to the original manufacturer, if such offers exist.
Social & Institutional Trust (ST)	Commun	Communication	Communications I believe the public knows the guidelines and updates on e-waste disposal.
	Insti_trust	Institutional trust	I trust local government and environmental agencies to recycle and dispose of e-waste in a safe and responsible manner.
Social Cohesion (SC)	Coll_Efficacy	Collective Efficacy	I think we can work together in our neighbourhood to reduce a lot of damage from e-waste.
	Comm_influ	Community influence	I recycle electronics when my friends, family or celebrities recycle.
	Neigh_Trust	Neighbourhood Trust	I trust my neighbours to dispose of e-waste properly.
	Soc_Resp	Social Responsibility	I think it's my responsibility and my duty to get rid of electronic devices the right way to protect my community.