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Socio-Demographic Determinants of Consumer Practices In e-Waste Management

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Abstract

The growing volume of Waste Electrical and Electronic Equipment (WEEE) poses significant environmental and public health risks, particularly in countries where informal recycling dominates. Although consumer behaviour is central to improving recovery and recycling, evidence on how socio-demographic and socio-economic factors shape e-waste management (EWM) remains limited at a large, multi-state scale in India. A cross-sectional survey was conducted among 5,690 respondents across eight north-western states of India. Data were collected using a structured, theory-based and psychometrically validated questionnaire derived from an extended Theory of Planned Behaviour (TPB) framework. Socio-demographic and socio-economic determinants of knowledge, awareness and EWM practices were examined using chi-square tests, ANOVA and multivariate regression. Knowledge, awareness and practices differed significantly across education, occupation, income and socio-economic status (SES), but not by gender or marital status. Younger respondents, graduates and professionals showed higher knowledge of e-waste hazards and policies. While 55.5% of respondents demonstrated high knowledge, awareness levels were uneven: financial benefits of EWM were recognised by 68.3% of respondents, whereas only

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58.1% were aware of the technical aspects, such as material recovery. SES emerged as a consistent predictor of responsible practices, showing a positive gradient that plateaued at higher SES levels. The study also revealed marked state-level differences, highlighting disparities in public communication and access to formal recycling infrastructure. This study contributes large-scale, multi-state evidence that socio-demographic and socio-economic inequalities, together with regional disparities, strongly shape consumer engagement in EWM. By documenting the specific population groups and states where gaps are largest, the findings offer a practical basis for targeted awareness efforts, incentive-based interventions and improvements in collection systems. These insights can support policy implementation under India's E-Waste Rules and advance circular economy objectives under SDG 12.

Keywords: E-waste management; Consumer behaviour; Socio-demographic factors; Socio-economic status; Awareness; Circular economy.

Introduction

The generation of Waste Electrical and Electronic Equipment (WEEE), commonly referred to as e-waste, has emerged as one of the most significant environmental challenges of the 21st century. In 2022 alone, the world generated approximately 62 million tonnes of e-waste, of which less than one-quarter was formally collected and recycled (UNITAR, 2023; Widmer, 2005). Rapid technological advancements, shorter product lifecycles, and consumer-driven replacement cycles have intensified this problem, leading to natural resource depletion, environmental pollution, and public health risks (Kumar, Holuszko & Espinosa, 2017; Tansel, 2017).

India is among the largest generators of e-waste in the Asia-Pacific region, producing around 2 million tonnes annually (Manish, 2019). Despite the introduction of the E-Waste Management Rules in 2011 and subsequent amendments in 2016, 2018, and 2023, a substantial gap persists between e-waste generation and its environmentally sound disposal (MoEFCC, 2023). The coexistence of a regulated formal sector with a vast informal recycling economy further complicates management, as unsafe practices expose workers to toxic substances and exacerbate environmental degradation (Dutta, 2021; Bagwan, 2024). In this context, regulatory frameworks and Extended Producer Responsibility (EPR) initiatives provide an essential foundation, but their effectiveness ultimately depends on consumer participation (Manomaivibool, 2009; Borthakur & Govind, 2018; Awasthi et al., 2016).

Consumers, as the end-users and ultimate decision-makers in the disposal of electrical and electronic products, play a central role in ensuring effective e-waste management (EWM). Prior studies show that many consumers either store obsolete electronics or discard them with household waste, reducing opportunities for proper recovery and recycling (Awasthi et al., 2018; Parajuly et al., 2020; Borthakur & Govind, 2018). Consumer behaviour is shaped by socio-demographic

factors such as age, gender, education, income, occupation, and place of residence, which influence awareness, attitudes, and intentions (Saphores, Nixon & Ogunseitan, 2006; Wang et al., 2019). These characteristics, in turn, shape how individuals manage e-waste, whether through recycling, resale, repair, or inappropriate disposal. For example, younger populations tend to replace devices more frequently, whereas higher educational attainment is associated with stronger environmental awareness and greater participation in recycling (Dwivedy & Mittal, 2013; Aboelmaged, 2021).

From a theoretical standpoint, this study is guided by an extended Theory of Planned Behaviour (TPB) framework, which integrates traditional TPB constructs such as attitudes, subjective norms and perceived behavioural control with additional elements such as awareness, knowledge, responsible consumer behaviour, and co-creation. These extensions strengthen explanatory power and allow a more comprehensive understanding of consumer behaviour in EWM. Prior research shows that socio-demographic and socio-economic variables shape these constructs by influencing access to information, environmental concern, and perceived ability to act (Ajzen, 1991; Bamberg & Möser, 2007). Based on this framework, the present study assumes that variations in education, occupation, income, and socio-economic status (SES) will be reflected in differences in knowledge, awareness, attitudes, and EWM practices.

Although research on e-waste behaviour is growing, there is still limited evidence from multi-state studies in India, especially on how socio-demographic and socio-economic factors shape consumer practices in regions where informal recycling is dominant (Kumar, 2019; Bhardwaj et al., 2023). Understanding these patterns is important for designing targeted interventions that support responsible disposal and align with Sustainable Development Goal 12 on responsible consumption and production (United Nations, 2021).

While several studies, including those conducted in other Indian states, have examined consumer awareness and attitudes toward e-waste (Sudhir et al., 2009; Ramachandra & Saira, 2004), they are often limited by single-state coverage, relatively small samples, or descriptive designs that do not systematically analyse socio-demographic or socio-economic gradients. Most existing research also focuses on awareness levels or specific product categories, rather than comparing patterns across multiple states with diverse socio-economic profiles (Awasthi et al., 2018; Borthakur & Govind, 2018). Therefore, there is a clear need for a large-scale, multi-state study that uses a theory-based and validated measurement scale to examine how education, occupation, income, and socioeconomic status collectively shape consumer practices. The present study responds to this gap by analysing data from a large cross-sectional sample of 5,690 respondents across eight north-western states of India, offering one of the most extensive consumer-level assessments of e-waste behaviour to date.

This study also forms part of a larger, multi-phase research work on consumer e-waste behaviour in India. In earlier phases, a comprehensive, theory-driven behavioural scale was developed and psychometrically validated to measure knowledge, awareness, attitudes, perceived behavioural control, and responsible e-waste practices, following established guidelines for scale development (DeVellis, 2016; Boateng et al., 2018; Nunnally & Bernstein, 1994). Building on this foundation, the present work specifically examines the socio-demographic and socio-economic determinants of knowledge, awareness, and EWM behaviour to date.

The present study examines how socio-demographic factors influence consumer practices in EWM. By integrating insights from behavioural theories and empirical evidence, it seeks to build a clearer understanding of how consumers approach e-waste. Specifically, the study aims to describe the socio-demographic profile of participants who use electrical and electronic equipment and to analyse how socio-economic factors influence their knowledge, awareness, attitudes, and practices related to EWM.

Accordingly, the study addresses the following research questions: RQ1: How do socio-demographic characteristics (age, gender, education, occupation, income) influence consumers' knowledge of e-waste? RQ2: How do socio-economic categories (SES) shape consumers' awareness of EWM? RQ3: Are there significant differences in EWM practices across socio-demographic and socio-economic groups? RQ4: To what extent does socioeconomic status predict EWM behaviour?

Review of Literature

Understanding how socio-demographic characteristics shape consumer practices in EWM has been a central focus of global research. Variables such as age, gender, education, income, occupation, and household structure are frequently examined for their influence on awareness, disposal behaviour, and participation in formal recycling systems. However, across regions, findings remain mixed and context-dependent, suggesting that socio-demographics alone cannot fully explain consumer e-waste practices.

Evidence from national contexts illustrates this diversity. In India, Dwivedy and Mittal (2013) found that income, education, age and household size significantly affected willingness to participate in organised recycling schemes. Similarly, Sivagami and Arun Senthil Ram (2018) reported that age, family type, family size, occupation, and religion influenced perceptions and disposal methods, with education playing a key role. Broader surveys also show demographic differences in awareness, disposal choices, and reliance on informal scrap dealers (Nisha et al., 2022), suggesting that socio-economic conditions shape access to information and responsible disposal options.

International studies also highlight the influence of socio-demographic determinants. de Oliveira Neto et al. (2022) observed that higher-income and better-educated households are more likely to adopt formal disposal practices, while lower-income groups frequently store or dispose of e-waste informally. A spatial analysis conducted by Adzania et al. (2022) showed that sub-districts with higher proportions of males and moderately educated populations generated more e-waste, emphasising the role of demographic composition in predicting e-waste generation. Likewise, Bazancir and Ok (2025) demonstrated that age structure, education, occupation, and income collectively predict regional e-waste generation hotspots, supporting the view that socio-demographic patterns help shape waste generation and recovery needs.

Conversely, several studies challenge the assumption that socio-demographics consistently predict e-waste behaviours. Almulhim (2022) reported no significant differences in awareness or willingness to participate in sustainable EWM based on age, gender, marital status or education in Saudi Arabia. A similar pattern appears in a theory-based study by Vijayan et al. (2023), and it was found that once psychological constructs such as attitudes, subjective norms and perceived behavioural control were considered, demographic variables lost explanatory significance. In developing-economy contexts, Sajid et al. (2025) further showed that knowledge, anticipated emotions (guilt, pride) and risk perceptions exert stronger influence on recycling intentions than demographic characteristics, indicating that socio-demographics may have only indirect effects.

Recent behavioural research also highlights the importance of digital determinants. Sharma et al. (2024) found that among Indian millennials, electronic word of mouth (eWOM) and perceived usefulness of online collection portals significantly strengthened intentions to dispose of e-waste responsibly. These findings suggest that digital engagement, not merely demographic characteristics, can shape behavioural outcomes, especially among younger or more technologically connected populations. Integrative reviews consolidate these insights. Newaz et al. (2024) concluded that although socio-demographic variables are frequently included in behavioural models of e-waste, their explanatory power varies considerably across contexts, populations and outcomes. Conceptual work by Vighnesh (2021) and modelling studies such as Delcea et al. (2020) likewise affirm that demographic factors interact with psychographic, infrastructural, and contextual elements, rather than operating as standalone predictors.

Taken together, the literature suggests that socio-demographic factors do influence e-waste knowledge, awareness and practices but often in non-uniform, indirect or context-specific ways. Their effects tend to become meaningful when viewed alongside psychological determinants (attitudes, norms, and perceived control), situational factors (access, convenience), digital enablers (online platforms, and eWOM) and structural conditions (formal-informal sector dynamics). In India, the substantial influence of the informal recycling sector, socio-cultural diversity, and uneven access to formal collection systems further complicate behavioural outcomes, and findings

from existing studies are fragmented and often limited to single-state or small-sample contexts. Accordingly, there is a clear need for large-scale, multi-state, theory-driven assessments that systematically examine how socio-demographic and socio-economic gradients shape consumers' knowledge, awareness and EWM practices. The present study addresses this gap by analysing a large cross-sectional sample across eight north-western Indian states, providing robust empirical evidence to support targeted and inclusive policy interventions for effective EWM.

Table 1: Socio-demographic characteristics of participants (N = 5,690).

Variable	Category	Frequency (n)	Percentage (%)
Age group	18–30 years	2,585	45.4
	31–40 years	1,393	24.5
	41–50 years	869	15.3
	51–60 years	549	9.6
	60 years and above	294	5.2
Gender	Male	3,252	57.2
	Female	2,435	42.8
	Others	3	0.1
Education level	Illiterate	141	2.5
	Primary school	184	3.2
	Middle school	209	3.7
	High school	522	9.2
	Intermediate/Diploma	648	11.4
	Graduate	2,631	46.2
	Professional degree	1,355	23.8
Occupation	Unemployed	1,502	26.4
	Elementary occupation	490	8.6
	Plant & machine operators	111	2.0
	Craft workers	121	2.1
	Agricultural & fishery workers	165	2.9
	Sales workers	465	8.2
	Clerks	588	10.3
	Technicians	334	5.9
	Professionals	1,568	27.6

Variable	Category	Frequency (n)	Percentage (%)
	Managers	346	6.1
Monthly family income (INR)	≤ 6,767	373	6.6
	6,768 – 20,273	600	10.5
	20,274 – 33,792	662	11.6
	33,793 – 50,559	907	15.9
	50,560 – 67,586	1,063	18.7
	67,587 – 1,35,168	935	16.4
	≥ 1,35,169	1,150	20.2
Marital status	Single	2,756	48.4
	Married	2,872	50.5
	Divorced	36	0.6
	Separated	26	0.5
Family type	Nuclear	3,190	56.0
	Joint	2,500	44.0
Socioeconomic status (Kuppuswamy 2024)	Lower (V)	80	1.4
	Upper-lower (IV)	824	14.5
	Lower-middle (III)	1,086	19.1
	Upper-middle (II)	2,788	49.0
	Upper (I)	912	16.0

Source: Authors' compilation

Materials and Methods

Study Design and Setting

This cross-sectional study was conducted across the north-western states of India, specifically Delhi, Punjab, Haryana, Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, and Uttarakhand. The study covered a diverse population segment, ensuring representation from both urban and semi-urban areas. This study forms one component of a larger multi-phase project on consumer e-waste behaviour, in which an extended TPB-based scale was developed and psychometrically validated (Dave K et al 2025- under review).

Study Participants and Data Collection Procedure

A total of 5,690 respondents were enrolled, providing a broad cross-section of individuals using electrical and electronic equipment. Data were collected through in-person interviews using a mall-intercept approach, where participants were approached in public spaces such as shopping malls, markets and community centres across the study states. This method ensured the inclusion of diverse respondents actively engaged in consumer practices. Each interview session lasted approximately 40 minutes. Verbal informed consent was obtained from all participants prior to administering the questionnaire, and confidentiality of responses was assured.

Data Collection Tools

Data were collected using a structured questionnaire developed in two phases. In Phase I, constructs were derived from established theoretical frameworks and operationalised through pre-testing, followed by validity and reliability checks (Cronbach's alpha) (Dave K. et al., 2025, under review). For the present phase, only the constructs aligned with the objectives of this sub-study were applied. The questionnaire comprised three major sections.

- The first section captured socio-demographic details such as age, gender, marital status, family type, income, education, and occupation.
- The second section assessed SES using the updated Kuppuswamy Scale (2024), which considers education, occupation and income.
- The third section measured respondents' knowledge, awareness, attitudes and practices related to EWM using a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree'.

The questionnaire used in this study was designed as part of an extended TPB framework, incorporating additional constructs such as Responsible Consumer Behaviour (RCB), Co-creation (CoC) and Awareness, all of which were validated in earlier phases of the larger research project.

Reliability and Validity

All variables were thoroughly validated and tested for reliability. Internal consistency was confirmed through Cronbach's alpha, with values meeting the acceptable threshold for social science research (Nunnally, 1978)

Data Analysis

Data were entered and analysed using SPSS version 26 and Microsoft Excel. Descriptive statistics were used to present the socio-demographic characteristics of respondents. Inferential statistics, including chi-square tests, ANOVA and regression analysis, were applied to examine associations

between socio-demographic and socio-economic variables and consumer EWM practices. A significance level of $p < 0.05$ was considered statistically significant.

Results

Socio-demographic Profile of Participants A total of 5,690 participants were included in the study from eight north-western states of India. Table 1 presents their socio-demographic characteristics. Nearly half of the participants (45.4%) were in the 18–30 years age group, with a mean age of 35.3 years (SD = 12.6). Males accounted for 57.2%, females for 42.8%, and a negligible proportion (0.1%) identified as 'Others'.

In terms of education, a large majority had higher education, with 46.2% graduates and 23.8% professionals, while only 2.5% were illiterate. Occupation-wise, professionals (27.6%) and unemployed individuals (26.4%) represented the largest groups. The distribution of monthly family income showed that 20.2% of participants were in the highest income bracket ($\geq Rs.1{,}35{,}169$), while 6.6% fell in the lowest ($\leq Rs.6{,}767$).

Almost half of the participants (50.5%) were married, and 48.4% were single. With respect to household structure, 56.0% lived in nuclear families and 44.0% in joint families. According to the Kuppuswamy scale (2024), nearly half of the participants (49.0%) were classified as upper-middle class, followed by the lower-middle (19.1%) and upper class (16.0%).

Table 2: State-wise distribution of participants (N = 5,690)

State	Frequency (n)	Percentage (%)
Delhi	303	5.3
Punjab	363	6.4
Haryana	366	6.4
Gujarat	465	8.2
Rajasthan	595	10.5
Uttar Pradesh	2,334	41.0
Madhya Pradesh	1,063	18.7
Uttarakhand	201	3.5
Total	**5,690**	**100.0**

Source: Authors' compilation

State-wise Distribution of Participants

Table 2 shows the distribution of participants across states. The largest share was from Uttar Pradesh (41.0%), followed by Madhya Pradesh (18.7%), Rajasthan (10.5%), and Gujarat (8.2%). Delhi (5.3%) and Uttarakhand (3.5%) accounted for the lowest shares of the total sample. The

allocation of participants was based on sample size calculations derived from the population size and city-wise distribution (Census of India, 2011), ensuring proportional representation across states.

State-wise Socio-Demographic Variations

Table 3 presents socio-demographic variations across states. In most states, the 18–30-year group accounted for the highest proportion of participants, especially in Uttar Pradesh and Madhya Pradesh. Punjab recorded a higher proportion of female participants, whereas Uttar Pradesh and Madhya Pradesh had larger male representation. Education levels varied across states, with Delhi and Uttar Pradesh showing higher concentrations of graduates and professionals, while Rajasthan had a comparatively larger share of participants with lower levels of schooling.

Income distribution also reflected regional diversity: Uttar Pradesh had the largest number of high-income participants, whereas Rajasthan and Gujarat had relatively higher proportions in lower-income brackets. Socioeconomic classification revealed that the upper-middle class was the most common across all states, with Delhi and Punjab showing particularly high representation in this category.

Table 3: State-wise distribution of socio-demographic characteristics of participants (N = 5,690)

Vari	Cate	Delhi	Pun	Hary	Guj	Raj	UP	MP	UK	Total
Age group	18–30	156	320	171	66	139	1,081	629	23	2,585
	31–40	106	14	104	52	88	717	236	76	1,393
	41–50	30	25	63	106	110	336	122	77	869
	51–60	8	4	22	157	103	166	71	18	549
	60+	3	0	6	84	155	34	5	7	294
Gender	Male	178	56	210	326	352	1,342	647	141	3,252
	Female	125	307	156	139	243	992	413	60	2,435
	Others	0	0	0	0	0	0	3	0	3
Education	Illiterate	0	1	0	16	84	24	13	3	141
	Primary school	0	1	2	35	104	12	3	27	184
	Middle school	0	1	18	30	102	18	21	19	209
	High school	19	66	62	31	75	137	104	28	522
	Intermediate / Diploma	25	32	36	29	77	270	143	36	648
	Graduate	196	229	172	257	83	1,040	582	72	2,631

Vari	Cate	Delhi	Pun	Hary	Guj	Raj	UP	MP	UK	Total
	Professional degree	63	33	76	67	70	833	197	16	1,355
Occupation	Unemployed	114	230	124	82	133	560	236	23	1,502
	Elementary occupation	19	20	7	46	159	174	38	27	490
	Plant & machine operators	1	0	5	4	62	10	21	8	111
	Craft workers	7	4	11	7	17	41	24	10	121
	Agricultural /fishery workers	3	2	13	13	40	33	51	10	165
	Sales workers	20	19	39	16	35	168	132	36	465
	Clerks	52	8	30	145	53	194	104	2	588
	Technicians	18	13	37	20	27	91	122	6	334
	Professionals	56	51	89	69	48	897	282	76	1,568
	Managers	13	16	11	63	21	166	53	3	346
Family type	Nuclear	178	242	188	332	318	1,225	594	113	3,190
	Joint	125	121	178	133	277	1,109	469	88	2,500
Monthly income (INR)	≤ 6,767	4	8	19	76	84	139	14	29	373
	6,768–20,273	6	32	24	27	105	269	96	41	600
	20,274–33,792	28	43	27	57	75	232	184	16	662
	33,793–50,559	86	61	36	139	79	308	178	20	907
	50,560–67,586	80	56	56	96	78	443	215	39	1,063
	67,587–1,35,168	50	60	90	42	86	415	155	37	935
	≥ 1,35,169	49	103	114	28	88	528	221	19	1,150
SES (Kuppuswamy 2024)	Lower / Upper-Lower	12	22	40	96	197	333	146	58	904
	Lower-Middle	60	67	82	70	174	335	236	62	1,086

Vari	Cate	Delhi	Pun	Hary	Guj	Raj	UP	MP	UK	Total
	Upper-Middle	194	228	179	268	203	1,156	498	62	2,788
	Upper	37	46	65	31	21	510	183	19	912

Variable:Vari; Category:Cate; Rajasthan:Raj; Gujarat:Guj; Haryana:Hary; Punjab:Pun; Uttarakhand:UK; Madhya Pradesh:MP Uttar Pradesh:UP

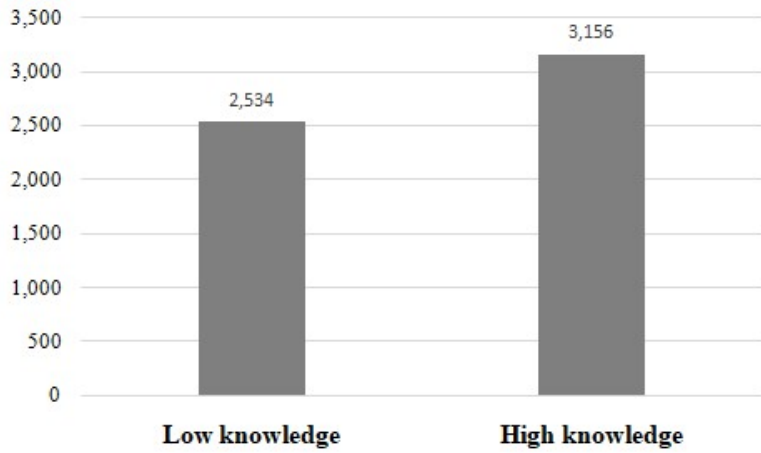

Figure 1: Distribution of Knowledge Levels among Respondents (N = 5,690)
Source: *Authors' compilation*

Knowledge of E-waste among 5,690 Participants

Knowledge regarding E-Waste was measured using a seven-item construct covering environmental hazards, toxic substances, exchange schemes, disposal guidelines, and relevant policies (Table 4). A composite knowledge score was computed by summing responses. Respondents with lower selections (3/2/1) and a total score <28 were categorised as having low knowledge; those with higher scores were classified as having high knowledge.

Overall, 55.5% of participants demonstrated high knowledge, while 44.5% had low knowledge (Table 5), indicating that although more than half were relatively informed, a considerable proportion still lacked adequate understanding. State-level differences in knowledge were observed (Table 6). Respondents from Uttar Pradesh (69.8%) and Uttarakhand (66.7%) reported the highest proportions of high knowledge, whereas Rajasthan reported the lowest (4.2%).

In Delhi, 59.4% of respondents fell in the low-knowledge category. Mean scores reflected similar patterns, with the highest observed in Uttar Pradesh (M = 4.15, SD = 0.53) and Uttarakhand (M = 4.09, SD = 0.62), and the lowest in Rajasthan (M = 3.01, SD = 0.53). Differences across states were statistically significant ($p < 0.001$).

Table 4: Knowledge Construct and Measurement Items

Construct	Item Code	Statement
Knowledge	K1	I know electrical and electronic appliances can become waste with time.
	K2	I know companies provide offers to exchange old electrical and electronic items.
	K3	I know that there are toxic substances present in e-waste.
	K4	I know that improper disposal of electrical and electronic equipment can harm the environment.
	K5	I know e-waste management helps to reduce landfills and release of toxins.
	K6	I know there are policies and guidelines available regarding e-waste management.
	K7	I know the right methods to safely dispose of my e-waste at the right time.

Source: Authors' compilation

Table 5: Knowledge Levels and Mean Scores by State, Gender and Age (N = 5,690)

Variable	Low Knowledge n (%)	Category	High Knowledge n (%)	Mean (SD)	χ^2 / F	Result
State	Delhi-NCR	180 (59.4)	123 (40.6)	3.75 (0.61)	χ^2 = 872.46, F = 147.00	***
	Punjab	179 (49.3)	184 (50.7)	3.87 (0.52)		
	Haryana	161 (44.0)	205 (56.0)	3.96 (0.53)		
	Gujarat	183 (39.4)	282 (60.6)	3.92 (0.83)		
	Rajasthan	570 (95.8)	25 (4.2)	3.01 (0.53)		
	Uttar Pradesh	706 (30.2)	1,628 (69.8)	4.15 (0.53)		
	Madhya Pradesh	488 (45.9)	575 (54.1)	3.93 (0.58)		
	Uttarakhand	67 (33.3)	134 (66.7)	4.09 (0.62)		
Gender	Male	1,423 (43.7)	1,829 (56.3)	3.93 (0.67)	χ^2 = 4.38, F = 2.19	NS
	Female	1,111 (45.6)	1,324 (54.4)	3.90 (0.66)		
	Others	0 (0.0)	3 (100.0)	4.33 (0.08)		

Variable	Low Knowledge n (%)	Category	High Knowledge n (%)	Mean (SD)	χ^2 / F	Result
Age	18–30	1,086 (42.0)	1,499 (58.0)	3.96 (0.64)	χ^2 = 70.33, F = 17.79	***
	31–40	579 (41.5)	814 (58.5)	3.99 (0.59)		
	41–50	404 (46.5)	465 (53.5)	3.88 (0.67)		
	51–60	273 (49.7)	276 (50.3)	3.78 (0.74)		
	60+	192 (65.3)	102 (34.7)	3.51 (0.84)		

Source: Authors' compilation

Table 6: Knowledge Levels and Mean Scores by Education, Occupation and Income (N = 5,690)

Variable	Low Knowledge n (%)	Category	High Knowledge n (%)	Mean (SD)	χ^2 / F	Result
Education	Illiterate	108 (76.6)	33 (23.4)	3.30 (0.75)	χ^2 = 380.78, F = 114.68	***
	Primary	156 (84.8)	28 (15.2)	3.25 (0.71)		
	Middle	158 (75.6)	51 (24.4)	3.38 (0.66)		
	High school	298 (57.1)	224 (42.9)	3.75 (0.70)		
	Intermediate	320 (49.4)	328 (50.6)	3.85 (0.71)		
	Graduate	989 (37.6)	1,642 (62.4)	4.01 (0.59)		
	Professional degree	505 (37.3)	850 (62.7)	4.07 (0.61)		
Occupation	Unemployed	677 (45.1)	825 (54.9)	3.89 (0.63)	χ^2 = 228.62, F = 26.42	***
	Elementary	283 (57.8)	207 (42.2)	3.61 (0.74)		
	Plant /Machine ops	91 (82.0)	20 (18.0)	3.38 (0.59)		
	Craft workers	58 (47.9)	63 (52.1)	3.83 (0.65)		
	Agric /Fishery	96 (58.2)	69 (41.8)	3.62 (0.74)		
	Sales workers	250 (53.8)	215 (46.2)	3.86 (0.66)		
	Clerks	292 (49.7)	296 (50.3)	3.88 (0.70)		
	Technicians	147 (44.0)	187 (56.0)	3.93 (0.67)		
	Professionals	525 (33.5)	1,043 (66.5)	4.11 (0.56)		

Variable	Low Knowledge n (%)	Category	High Knowledge n (%)	Mean (SD)	χ^2 / F	Result
	Managers	115 (33.2)	231 (66.8)	4.09 (0.69)		
Income (INR)	≤ 6,767	173 (46.4)	200 (53.6)	3.76 (0.75)	χ^2 = 89.03, F = 15.06	***
	6,768–20,273	281 (46.8)	319 (53.2)	3.81 (0.69)		
	20,274–33,792	399 (60.3)	263 (39.7)	3.75 (0.68)		
	33,793–50,559	405 (44.7)	502 (55.3)	3.92 (0.68)		
	50,560–67,586	422 (39.7)	641 (60.3)	4.02 (0.61)		
	67,587–1,35,168	383 (41.0)	552 (59.0)	3.97 (0.63)		
	≥ 1,35,169	471 (41.0)	679 (59.0)	3.99 (0.65)		

Source: Authors' compilation

Socio-demographic variations were also identified. Male respondents (56.3%) had a slightly higher proportion of high knowledge compared to females (54.4%), though the difference was not statistically significant. Younger respondents in the 18–30 years (58.0%) and 31–40 years (58.5%) age groups had higher knowledge levels compared to those aged 60 years and above (34.7%), with differences reaching statistical significance ($p < 0.001$).

Education was significantly associated with knowledge; graduates (62.4%) and those with professional degrees (62.7%) reported the highest levels, whereas illiterate (23.4%) and primary-level respondents (15.2%) reported the lowest ($p < 0.001$).

As per the results, occupational status and income also influenced knowledge. Professionals (66.5%) and managers (66.8%) had the highest proportions of high knowledge, while plant and machine operators (18.0%) and elementary workers (42.2%) had the lowest.

Respondents in higher income groups (≥ Rs.1,35,169: 59.0%) reported better knowledge, whereas those in the Rs.20,274–33,792 bracket reported the lowest (39.7%).

While marital status and family type showed smaller differences, with married respondents (58.7%) scoring higher than unmarried respondents (52.1%), and nuclear families (56.9%) scoring higher than joint families (53.7%). Whereas SES, measured by the Kuppuswamy scale (2024), was significantly associated with knowledge levels, with higher SES groups reporting higher proportions of high knowledge.

Respondents in the upper category reported the highest knowledge (66.1%), followed by the upper-middle category (59.3%), while those in the lower and lower-middle categories had substantially lower levels (40–49%) (Table 7).

Overall, knowledge of EWM was associated with several socio-demographic and socio-economic characteristics. Higher education, professional occupations, younger age groups, higher income, and upper SES were consistently linked with higher knowledge.

Table 7: Knowledge Levels and Mean Scores by Marital Status, Family Type and Socio-Economic Status (SES) (N = 5,690)

Variable	Low Knowledge n (%)	Category	High Knowledge n (%)	Mean (SD)	χ^2 / F	Result
Marital Status	Single	1,320 (47.9)	1,436 (52.1)	3.89 (0.68)	χ^2 = 24.83, F = 8.31	***
	Married	1,186 (41.3)	1,686 (58.7)	3.94 (0.65)		
	Divorced	16 (44.4)	20 (55.6)	4.01 (0.61)		
	Separated	12 (46.2)	14 (53.8)	3.84 (0.65)		
Family Type	Nuclear	1,376 (43.1)	1,814 (56.9)	3.93 (0.67)	χ^2 = 5.76, F = 5.76	*
	Joint	1,158 (46.3)	1,342 (53.7)	3.90 (0.66)		
SES	Lower (V)	48 (60.0)	32 (40.0)	3.63 (0.75)	χ^2 = 153.94, F = 39.52	***
	Upper-Lower (IV)	413 (50.1)	411 (49.9)	3.74 (0.70)		
	Lower-Middle (III)	628 (57.8)	458 (42.2)	3.73 (0.70)		
	Upper-Middle (II)	1,136 (40.7)	1,652 (59.3)	3.99 (0.64)		
	Upper (I)	309 (33.9)	603 (66.1)	4.10 (0.56)		

Source: Authors' compilation;
*Note: *** $p < 0.001$, * $p < 0.05$*

Awareness of E-waste among Study Participants

Table 8 presents the distribution of responses across six awareness items. Mean awareness scores ranged from 3.49 to 3.82 on the five-point Likert scale, indicating variability across different aspects of awareness. A total of 57.0% of respondents agreed or strongly agreed that they were aware of e-waste collection sites, while 23.2% disagreed and 19.8% were neutral. For reuse, repair, refurbishing, exchange, and recycling, 67.7% reported agreement, 21.5% were neutral, and 10.8% disagreed. Awareness that mixing e-waste with regular waste is inappropriate was reported by 64.2% of respondents, with 24.3% neutral and 11.5% in disagreement.

Table 8: Consumer Awareness on E-Waste (N = 5690)

Aw.Stat.	Mean	SD	St.Dis.	Dis.	Neutral	Agree	St. Ag.
Awareness of e-waste collection sites	3.49	1.29	614 (10.8%)	706 (12.4%)	1126 (19.8%)	1774 (31.2%)	1470 (25.8%)
Awareness of reuse, repair, refurbish, exchange, recycling	3.77	1.01	224 (3.9%)	392 (6.9%)	1222 (21.5%)	2506 (44.0%)	1346 (23.7%)
Awareness that mixing e-waste with regular waste is wrong	3.76	1.05	212 (3.7%)	444 (7.8%)	1382 (24.3%)	2104 (37.0%)	1548 (27.2%)
Awareness of valuable components in e-waste	3.57	1.12	401 (7.0%)	468 (8.2%)	1517 (26.7%)	2121 (37.3%)	1183 (20.8%)
Awareness that e-waste management is economically rewarding	3.82	1.03	178 (3.1%)	462 (8.1%)	1162 (20.4%)	2306 (40.5%)	1582 (27.8%)
Awareness that e-waste management provides affordable products	3.63	1.03	315 (5.5%)	315 (5.5%)	315 (5.5%)	315 (5.5%)	315 (5.5%)

Source: Authors' compilation;
Awareness Statement:Aw.Stat.; Strongly Disagree: St.Dis.; Disagree:Dis; Strongly Agree: St. Ag.

Awareness of valuable components within e-waste was noted by 58.1%, with 26.7% neutral and 15.2% in disagreement. Financial aspects of EWM were relatively better recognised: 68.3% agreed that EWM can be economically rewarding, and 58.7% acknowledged that it can provide affordable products.

For further analysis, a composite awareness score was created by summing responses across the six Likert-scale items. Respondents were then categorised into low awareness and high awareness groups based on their total scores. This classification enabled the examination of associations between awareness and socio-demographic characteristics. Chi-square analyses indicated significant associations between

awareness and several socio-demographic factors. Awareness varied significantly by socioeconomic status (χ^2 = 91.97, df = 8, p < 0.001), education (χ^2 = 261.93, df = 12, p < 0.001), occupation (χ^2 = 272.60, df = 18, p < 0.001), and family type (χ^2 = 8.76, df = 2, p = 0.013). No significant associations were observed with gender (p = 0.930) or marital status (p = 0.575). These findings suggest that education, occupation, and socioeconomic position were key determinants of awareness regarding EWM.

Socio-demographic Factors and EWM Behaviour

Table 9 shows that several socio-demographic factors were significantly associated with EWM behaviour. Age displayed a clear declining trend, with the highest mean EWM score observed among respondents aged 18–30 years (M = 3.75) and the lowest among those aged 60 years and above (M = 3.32). Both ANOVA (F = 36.10, p < 0.001) and regression (β = –0.133, p < 0.001) confirmed age as a significant predictor. Education also showed strong effects, with graduates reporting the highest mean score (M = 3.76), and education remained significant in both bivariate (β = .184, p < 0.001) and multivariate models (β = 0.128, p < 0.001).

Table 9: Socio-Demographic Factors and E-Waste Management (EWM)Behaviour (N = 5,690)

Socio-Demographic Variable	Mean Differences (ANOVA)	Regression Effect
Age	F(4,5685) = 36.10, p < .001	β = –0.133, p< .001
Gender	F(2,5687) = 0.95, p = .389	β = –0.044, p = .001 (multivariate only)
Education	F(6,5683) = 43.867, p < .001	β = .184 (bivariate), β = .128 (multivariate), both p < .001
Occupation	F(9,5680) = 16.905, p < .001	β = .081 (p < .001 bivariate), ns in multivariate
Income	F(6,5683) = 18.616, p < .001	β = .083 (p< .001 bivariate), β = –.061 (p = .002 multivariate)
Marital Status	F(1,5688) = 6.29, p = .012	β = –.033 (p =.012 bivariate), ns multivariate
Family Type	F(1,5688) = 0.070, p = .792	β = .002, p = .906
State	F(7,5682) = 100.36, p < .001	β = .019, p =.084 (ns multivariate)
Socio-Economic Status (SES)	F(4,5685) = 31.688, p < .001	β = .134 (bivariate), β = .112 (multivariate), p <.001

ns: Non-Significant

Income demonstrated significant differences across categories (F = 18.62, p < 0.001), with the lowest income group (M = 3.43) scoring notably lower than others; however, its multivariate effect was small. Occupation showed significant variation (F = 16.91, p < 0.001), with skilled and professional groups reporting higher scores than elementary and machine-operator groups, although occupation lost significance

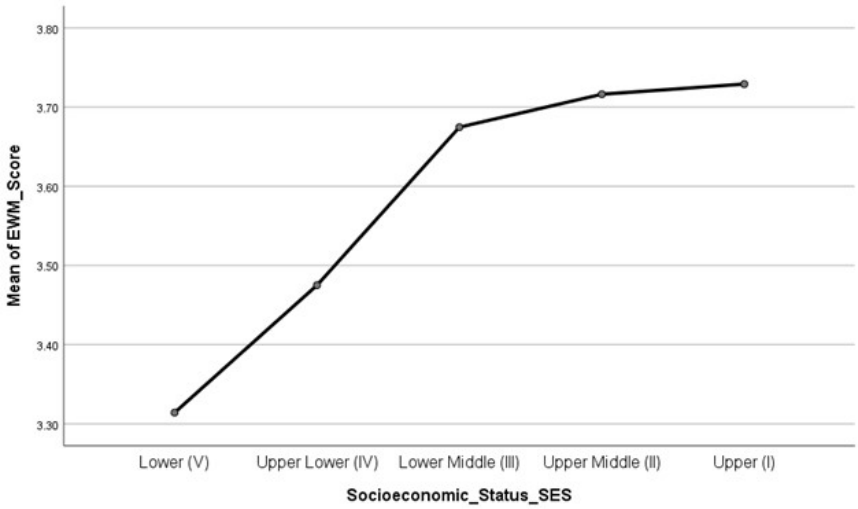

Figure 2: E-Waste Management (EWM) across Socioeconomic Status (SES) groups.
The plot shows EWM scores steadily increase from the 'Lower' to the 'Upper Middle' SES group but level off slightly from 'Upper Middle' to 'Upper,' indicating a plateau at higher SES levels.

when controls were applied. Gender, marital status, and family type showed minimal or no meaningful influence on EWM behaviour in adjusted models. State-level differences were statistically significant in ANOVA ($F = 100.36$, $p < 0.001$), but state did not independently predict EWM in the multivariate analysis.

SES and EWM

Table 10 shows that SES was a significant predictor of EWM behaviour ($B = 0.075$, $\beta = 0.134$, $t = 10.185$, $p < 0.001$), accounting for 1.8% of the variance in EWM scores. ANOVA confirmed significant differences in mean EWM scores across SES groups, $F(4, 5685) = 31.688$, $p < 0.001$. Mean scores indicated a positive gradient, with the Upper ($M = 3.73$, $SD = 0.68$) and Upper Middle ($M = 3.72$, $SD = 0.67$) groups reporting the highest levels of EWM, while the Lower ($M = 3.43$, $SD = 0.62$) and Upper Lower ($M = 3.56$, $SD = 0.60$) groups scored lowest. No significant difference was observed between the Upper and Upper Middle categories, suggesting stabilisation of EWM behaviour beyond a certain SES threshold. Multivariate regression analyses confirmed SES as a significant positive predictor ($B = 0.079$, $\beta = 0.112$, $t = 5.432$, $p < 0.001$), independent of demographic controls. Overall, EWM behaviour was most strongly influenced by age, education, income, occupation, and SES, whereas gender, marital status, and family type showed limited or no meaningful effects. These findings indicate that higher socioeconomic status is associated with greater engagement in EWM, likely supported by better access to resources, information, and relevant infrastructure. However, Figure 2 depicts the distribution of mean EWM scores across SES categories. The trend line illustrates a steady increase in EWM from the Lower to the Upper Middle SES groups. Beyond this point, the scores plateau between the Upper Middle and Upper categories, reflecting a convergence of behaviour at higher SES levels.

Table 10: Socioeconomic Status and E-Waste Management (N = 5690)

SES Group	N	Mean EWM Score	SD	B (SE)	β	t	F(4,5685)	p-Value	R^2
Lower (V)	80	3.43	0.62	0.075	0.134[a]	10.185[a]	31.688	<.001[a]	0.018
Upper Lower (IV)	824	3.56	0.60	(0.007)[a]					
Lower Middle (III)	1086	3.68	0.64	0.079[b]	0.112[b]	5.432[b]		0.001[b]	
Upper Middle (II)	2788	3.72	0.67						
Upper (I)	912	3.73	0.68						
Total	5690	3.67	0.68						

a: Bivariate regression, b: Multivariate regression

Discussion

The present study examined the socio-demographic determinants of consumer practices in EWM across eight north-western states of India. The findings indicated that knowledge, awareness and practices related to e-waste varied significantly by education, occupation, income, and socioeconomic status, but were less influenced by gender and marital status. These patterns align with earlier evidence showing that socio-demographic characteristics shape consumer behaviour towards e-waste recycling and disposal (Saphores, Nixon & Ogunseitan, 2006; Dwivedy & Mittal, 2013; Aboelmaged, 2021).

Building on this, the results demonstrated that younger age groups, respondents with higher education and those employed in professional occupations reported greater knowledge of e-waste hazards, policies, and recycling mechanisms. Similar associations have been reported in prior studies, where educational attainment and professional background enhanced environmental literacy and increased willingness to engage in sustainable disposal (Wang et al., 2019; Song et al., 2012; Parajuly et al., 2020). Conversely, it has been reported in the present study that lower knowledge among respondents with limited schooling or those engaged in manual occupations reflected structural inequities in access to information. This is consistent with findings from other developing contexts reported in studies done by Borthakur and Govind (2018). Thus, the evidence suggests that consumer practices are strongly conditioned by educational and occupational opportunities, which influence both informational access and the capacity to act on knowledge.

Furthermore, in the present study, awareness of EWM was significantly influenced by socioeconomic status, education and occupation, whereas no differences emerged by gender. This suggests that awareness

is primarily determined by structural and informational factors rather than demographic attributes alone. Socioeconomic status also emerged as a strong predictor of behaviour, with respondents from upper and upper-middle categories reporting greater engagement in reuse, exchange, and recycling. However, the plateauing of behaviour at higher socioeconomic levels indicates that once basic informational and resource thresholds are met, further improvements depend on systemic supports such as infrastructure, regulation, and incentives.

These results are consistent with the observations of Dwivedy (2013), who reported that Indian consumers with higher education and occupational status demonstrated stronger awareness and willingness to adopt formal recycling channels. Yet actual participation was constrained by the dominance of informal recycling systems, which offered higher returns to households compared to formal recyclers bound by environmental standards. The present findings therefore reinforce that even the most aware consumer groups face structural barriers that limit the translation of knowledge into practice.

Comparative evidence from other contexts further supports this interpretation. Li et al. (2012) reported that although urban residents in China were aware of e-waste risks, disposal choices were still driven by the monetary value of discarded devices, a pattern similar to the Indian context. Similarly, Momoh and Oladebeye (2010) observed low willingness to participate in household recycling programmes, with income and awareness acting as major barriers. These parallels echo the present study's finding that lower socioeconomic groups display weaker engagement in EWM.

By contrast, Martin et al. (2006) showed that strong kerbside collection schemes and clear communication strategies boosted household recycling compliance, while Mee et al. (2004) demonstrated that effective marketing campaigns significantly improved participation. These examples from developed nations highlight how infrastructure and communication systems transform awareness into practice.

Financing models further shape consumer participation. Nixon and Saphores (2007) found significant willingness among Californian households to pay advanced recycling fees when transparency and fairness were ensured, while Nixon et al. (2009) confirmed that pro-environmental attitudes were positively associated with willingness to fund recycling systems. In the Indian context, Dwivedy (2013) observed that consumers preferred 'pay-afterward' or deposit-refund models and were reluctant to accept upfront recycling charges. The present study complements this finding by showing that respondents demonstrated higher recognition of the financial and economic aspects of EWM than of technical issues such as recovery of valuable components. A larger proportion of respondents viewed EWM as economically rewarding (68.3%) or a source of affordable products (72.3%) than those who were aware of valuable material recovery (58.1%). This suggests that economic incentives resonate more strongly with consumers than technical or environmental arguments.

Beyond individual patterns, the present study also reveals meaningful differences across states. Knowledge disparities reflected uneven levels of awareness and policy communication, with Uttar Pradesh and Uttarakhand demonstrating comparatively higher knowledge, while Rajasthan and Delhi showed lower levels. Although the study did not directly examine the causes of these variations, earlier research suggests that factors such as organized collection systems and NGO-led awareness drives may contribute to higher recognition of e-waste hazards, whereas weaker communication and limited facilities may produce lower

awareness (Dutta, 2021; Kumar, 2019). These patterns indicate that tailored, state-level interventions may be needed to strengthen formal collection networks and public education (Tansel, 2017; Dave et al., 2025).

Overall, the present study found that awareness and practices of EWM were strongly shaped by socio-demographic factors such as education, occupation, and socioeconomic status, with respondents from upper and upper-middle groups reporting greater engagement in reuse, exchange, and recycling. State-level differences also showed uneven patterns of knowledge, with respondents in Uttar Pradesh and Uttarakhand reporting comparatively higher awareness than those in Rajasthan and Delhi. These findings underline that while socio-demographic advantages improve awareness, they do not automatically lead to sustainable practices unless supported by strong systems and enabling conditions. Consistent with wider literature, the results point to the need for integrated approaches that combine consumer education with systemic reforms. Awareness initiatives must be adapted to socio-economic and regional contexts, while policies should strengthen collection infrastructure, enforce compliance, and create incentives for formal recycling (Dave K et al., 2025). Addressing both informational gaps and structural barriers is therefore essential for advancing circular economy practices and reducing the health and environmental risks associated with informal recycling (Parajuly et al., 2020).

Conclusion

The study demonstrated that consumer knowledge, awareness, and EWM practices are significantly shaped by socio-demographic and socio-economic characteristics. Education, occupation, income, and socioeconomic status emerged as the strongest determinants, while gender, marital status and family type showed minimal influence. Younger respondents, those with higher educational qualifications, and individuals employed in professional occupations reported greater knowledge and more consistent engagement in reuse, repair, exchange and recycling practices. Respondents from lower educational and occupational categories reported weaker engagement, highlighting persistent structural inequities in access to information and formal recycling channels.

State-level variations further underscored the uneven distribution of awareness and policy communication, with certain states showing considerably lower knowledge and engagement despite similar socio-demographic profiles. In particular, Rajasthan and Delhi reported the lowest levels of knowledge and awareness, while groups with low education, manual occupations, lower income, older age, and lower SES showed the most pronounced gaps. Identifying these specific states and vulnerable population groups provides a concrete basis for designing targeted awareness interventions and strengthening state-level collection systems.

These findings indicate that strengthening responsible EWM in India will require interventions that address both socio-demographic disparities and region-specific gaps in communication, infrastructure, and service delivery. Tailored awareness programmes, improved access to formal collection systems, and incentives for sustainable disposal are essential to support behavioural change across population groups.

Limitations

This study had some limitations. The sample was limited to eight north-western states and may not represent practices across the entire country. Being cross-sectional, data were collected at a single point in

time without follow-up or open-ended discussions, which restricts deeper insights. As this work forms part of a larger study, future research will expand to examine rural-urban differences, track changes over time and incorporate the perspectives of informal workers and other key stakeholders.

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Conflict of Interest

The authors declare no conflict of interest.

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