# Analyzing Factors Influencing E-waste Sustainable Management System

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# Analyzing Factors Influencing E-waste Sustainable Management System

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**Abstract:** The research focuses on consumers sustainable approaches for controlling electronic waste. The aim of this study is to analyse the factors that influence how consumers manage electronic waste in a particular geographical location. A thorough literature review identified the variables, which were then analyzed using the Theory of Planned Behavior (TPB). The data was gathered using a self-administered questionnaire from 207 respondents, using snowball sampling method in districts of Udupi, Karnataka, India. The data was analyzed with SMARTPLS 4.0, and the framework was validated with partial least squares structural equation modeling. The study indicates that factors like public awareness, publicity, and convenience significantly influence consumer behaviour regarding managing electronic waste, ultimately contributing to the establishment of a sustainable e-waste system.

Keywords: Willingness to Pay; Awareness; TPB; e-waste disposal intention and e-waste management

## 1. Introduction

The progression of innovative technology and models has resulted in a growing inclination among individuals to replace or discard their obsolete appliances and equipment to acquire the latest versions. E-waste or electronic waste is the general expression referring to electronic devices that have been discarded[1)]. The abandoned material might be utilized for refurbishment, resale, reuse, material recovery, or properly disposed away. Nevertheless, the process of discarding them has significant negative consequences for the ecosystem and the health of people[2)].

The Extended Producer Responsibility (EPR) was implemented in accordance with the E-Waste (Management) Rules, 2016, which sought to establish a sustainable framework for electronic waste management[3)]. Extended Producer Responsibility must be implemented by electronic makers to ensure that electronic waste is only transported to approved recyclers or dismantlers. The e-waste management regulations establish precise obligations for the manufacturing, disposal, and control of electronic waste for all parties concerned. Specific obligations are assigned to manufacturers, producers, collection centers, dealers, refurbishers, consumers or bulk consumers, recyclers, and the state government.

The change to the 2016 E-Waste Regulations, which came into effect in 2018, eased the certain stringent features of the regulations. The purpose of the amendments was to better legitimize the recycling industry by directing the nation's e-waste toward approved recyclers and dismantlers (E-waste Management Amendment Rules, 2018)[4)]. Toxic metals are commonly discovered in e-waste, and insufficient disposal of these metals or inappropriate management of electronic waste will represent a risk to the environment and society[5,6)]. A considerable quantity of obsolete devices is kept, moved, or discarded at home, yet the volume of electronic waste reaching certified e-waste collectors remains quite limited[7)]. A significant number of consumers demonstrate insufficient understanding of the proper methods for disposing of electronic waste, highlighting the need for an extensive awareness campaign to educate them on appropriate disposal techniques[8)]. The community exhibits a constrained comprehension of e-waste disposal, with only two to three percent of households participating in e-waste recycling[9)]. The main elements leading to inadequate e-waste management systems include a deficiency in knowledge and governmental limitations[10)].

The e-waste collected is increasing globally and nationally, but there are still issues because formal treatment facilities are expensive and there is insufficient infrastructure to handle e-waste collection[11,12)]. Furthermore, the government would reap benefits by giving a practical and well-managed infrastructure near the neighbourhood, thereby ensuring simple accessibility

for residential consumers[13]. To promote recycling in the official recycling sector, stakeholders such as the government and private parties should collaborate to create a robust advertising campaign aimed at increasing awareness and encouraging the recycling of electronic wastes[14]. It is recommended that the government should emphasize the authorized recyclers to increase their advertising efforts for e-waste recycling to improve public awareness of how to manage e-waste[15,16].

In recent years, a major emphasis has been placed on sustainable development in both research and policymaking[17]. The concept of 'Sustainability' has been adopted globally to address the issues of climate change and global warming[18]. Consumers should give priority to electronic components that provide leasing or take-back alternatives, have reduced amounts of harmful ingredients, are intended for convenient upgrading and dismantling for recycling purposes, and are energy efficient with higher Energy Star ratings[19]. Consumers should also ensure that electronic devices are packaged with fewer materials to encourage cleaner production and environmental sustainability[20]. Sustainability entails the creation of a society and culture where individuals and businesses actively reduce the adverse consequences resulting from their worldwide economic and non-economic activity[21]. Sustainability is a guiding principle that aims to generate favourable outcomes for society, the economy, and the environment[22]. Promoting environmental education from an early age is vital since it greatly enhances understanding and awareness of the environment. Ultimately, individuals will develop behaviours that encourage future sustainable practices in the management of electronic trash[23]. To attain sustainable growth in a nation, it is imperative to enforce efficient management strategies for e-waste. The rationale behind this is the tremendous threat that e-waste poses to ecosystems and human well-being[24].

Many households often overlook the proper disposal of small electronic devices, primarily due to insufficient awareness regarding the issue of electronic waste[25]. The majority of participants exhibit a constrained comprehension of the appropriate methods for e-waste disposal. To address this issue, it is essential to launch a comprehensive awareness campaign focused on informing individuals about the proper methods for waste disposal[8]. Studies found that the majority of residents possess a limited understanding of proper e-waste disposal methods[9,26]. The presence of a well-developed infrastructure facility in proximity to the community will significantly streamline the process for individuals to recycle electronic waste. Previous studies have demonstrated that convenience significantly influences the tendency to recycle electronic waste (e-waste)[27,28]. Moreover, households are required to incur costs for recycling, resulting in a decrease in their income[29,30]. Saphores and Nixon, (2007)[31], established a notable positive correlation between individuals' environmental opinions and their inclination to financially contribute towards electronic processing costs[31].

Considering the current body of knowledge, it is clear that specific constructions necessitate validation through the application of TPB as the theoretical framework. This study is grounded in two fundamental gaps: the theoretical gap and the empirical gap.

To address the e-waste concerns, the objectives of the study are defined below as

1. To identify the factors influencing e-waste recycling intention.
2. To analyze the effect of intent to recycling of e-waste on sustainable e-waste management systems.

The article is structured as follows: Part 2 offers a brief summary of the theoretical foundation, while part 3 presents the justifications for the formulation of the hypothesis. The specifics of the conceptual framework are presented in Section 4. Analysis of the research methodologies is presented in Section 5. The data analysis and interpretation of the results are discussed in section 6. Section 7 examines the possible outcomes and practical uses of the research, both by theoretical analysis and real-world implementation. In section 8, the study concludes by highlighting the boundaries of the work and suggests potential directions for future research.

## 2. Theoretical Background

The Theory of Planned Behavior (TPB), developed by Ajzen in 1991, is a well-known social psychological paradigm that researchers have extensively used to explore a variety of environmentally conscious behaviors displayed by individuals[32]. This theory has significant application in many areas of behavioral study[33,34]. According to the Theory of Planned Behaviour (TPB), three essential aspects determine an individual's behavioural intention: attitudes (ATT) toward the behavior, subjective norms (SN), and perceived behavioural control (PBC)[32]. The TPB is a systematic framework for studying the different aspects that influence an individual's behavior and subsequent decision-making processes. A direct and positive correlation exists between behavioural intention and three factors: ATT, SN, and PBC[35]. Previous studies found that there was a positive link between SN, ATT, and PBC and increased involvement in household rubbish recycling[36]. Researchers from various countries, both developed and developing, commonly employ the TPB model in their research. Previous research has looked into recycling of e-waste through the various aspects of the TPB among young people. These factors include ATT, SN, PBC, and intentions[23,37,38]. Prior investigations have shown that elements like environmental knowledge and willingness to pay correlate with ATT, public awareness, and publicity relating to SN, in addition to convenience related to PBC, all of which affect the ease of recycling[32,39,40].

## 3. Hypotheses Development

According to the TPB model, an individual's willingness to perform an activity can be reliably anticipated if they have positive attitudes towards the behavior, a favorable SN, and a strong PBC.

### 3.1 Environmental Knowledge (ENK)

Environmental knowledge regarding E-waste refers to hazardous materials that are improperly stored, thereby posing risks to both the environment and human health[41]. A significant number of people do not recognise the dangers associated with e-waste, particularly the harmful impact of heavy metals such as lead, mercury, and cadmium, which can seep into soil and water if not disposed off correctly. The lack of understanding diminishes the chances of participating in responsible e-waste disposal methods, including recycling or returning devices to appropriate collection locations[29,42]. Environmental knowledge and recycling experience had a moderating effect on the behavioural intentions of e-waste recycling[43]. The studies found that there is a direct link between environmental understanding and consumers' willingness to recycle e-waste[13,44]. Given the contradicting findings of the previous studies, environmental knowledge is an important aspect in e-waste recycling.

Hypothesis 1: There is a positive influence of Environmental knowledge towards recycling intention of e-waste

### 3.2 Public Awareness (PAW)

Consumers lack of awareness regarding the recycling of electronic waste (e-waste) and its negative ecological consequences has been identified as a significant concern[45]. Based on previous research, it has been observed that the extent to which consumers are willing to pay for a particular product is significantly influenced by their level of awareness regarding its environmental implications[46]. According to Garg et al. (2023)[47], the study revealed that an individual's awareness of e-waste recycling had a detrimental effect on their intention to engage in recycling activities. Consumers who are aware about the consequences of e-waste disposal engage in responsible practices, promote awareness of its dangers, and advocate for alternative disposal methods[42]. A study conducted by Afroz et al. (2013)[9] discovered that although many families were educated about the environmental repercussions of e-waste, just a minority of them engaged in e-waste recycling. Thus, the following hypothesis was formulated considering the significance of public awareness in determining the recycling intention towards e-waste.

Hypothesis 2: Public Awareness has a positive influence towards recycling intention of e-waste

### 3.3 Willingness to Pay (WTP)

Willingness to pay refers to the additional cost associated with recycling e-waste at an appropriate recycling unit/infrastructure[8]. From the previous studies, it was found that a small proportion of people agreed to contribute to e-waste recycling[48,49]. In India it was found that people are willing to come forward and pay more for e-waste recycling if there is the prospect of cost sharing between users and manufacturers[8,41]. Studies found respondents from both low- and high-income groups were willing to pay for an effective management of e-waste[50]. A significant proportion of customers are ready to pay for formal recycling, but their actual readiness to do so is quite minimal. To overcome challenges and enhance both motivation and participation in official recycling initiatives, tailored regulations, financial incentives, and heightened awareness campaigns may be employed[12]. As a result, the preceding investigations show that WTP plays an important role in e-waste recycling.

Hypothesis 3: There is a positive influence on individuals who are willing to pay for recycling of electronic waste.

### 3.4 Publicity (PUB)

Increasing public awareness and willingness to recycle e-waste can be achieved through effective publicity efforts[6]. Hicks et al., (2005)[51] found that publicity positively influenced residents' intentions to recycle e-waste. Recent studies found it is important to recommend and endorse the recycling of electronic waste[16,52]. The lack of comprehensive conservation and education initiatives in China has resulted in an overall lack of environmental awareness among consumers[53]. According to Park et al. (2019)[54], respondents believed that the publicity campaign was insufficient, and that regular advertising is required to increase e-waste collection rates. Utilizing an innovative study methodology in South Korea that integrates the Theory of Planned Behaviour (TPB) and the Norm Activation model (NAM), the results indicated that information publicity (IP) did not directly influence an individual's tendency to recycle e-waste[55].

Thus, publicity is designated as a crucial aspect of e-waste recycling.

Hypothesis 4: There is a positive influence of publicity towards recycling intention of e-waste

### 3.5 Convenience (CON)

Convenience is dropping off e-waste at a nearby or a suitable location[56]. A study done in Malaysia[57] found that, in addition to being aware, the ease of recycling infrastructure has a good link with people's intentions to recycle. Ensuring the presence and quality of recycling facilities and services is essential for enabling residents to efficiently recycle their electronic waste[26,48]. Laeequddin et al., (2022)[58] state that consumers prefer to be involved in sustainable practices when using products that are easy

to operate, easy to dispose of, and have ample supporting infrastructure. This finding suggests that while convenience is an essential factor, it alone is insufficient to drive changes in behaviour. Consequently, effective recycling initiatives must be supported by accessible infrastructure and enhanced public awareness to achieve better recycling objectives[55]. Saphores et al. (2006)[59] evaluated the impact of drop-off points for e-waste collection on individuals recycling willingness. Their findings indicated that convenience factors, including proximity to recycling centres and the availability of curbside recycling programs, significantly enhanced recycling rates. This led to the following hypothesis being proposed.

Hypothesis 5: There is a positive influence of convenience towards recycling intention of e-waste.

### 3.6 Sustainable E-waste Management (SEM)

The TPB says that people's intentions are what drive their actions and show how much work they are willing to put into the behaviour[32]. The motivation behind a person's actions is a powerful indicator of their future behaviour. The sustainability of a waste management system relies heavily on how households perceive and engage with sustainable waste management practices. Access to facilities and individual intentions both had a significant impact on waste-sorting behaviours[60]. Recent studies also revealed a strong and significant link between environmentally sensitive goals and the sustainable management of e-waste[61]. Given the above, it is proposed that

Hypothesis 6: There is a positive influence of people's intentions of disposing e-waste towards sustainable e-waste management systems.

## 4. Conceptual Framework

The theoretical framework is derived from the established Theory of Planned Behaviour (TPB). The study lists the factors shown in the conceptual model leading to influence the e-waste recycling intention. Consequently, the study also measures the influence of recycling intention of e-waste leading to sustainable e-waste management systems.

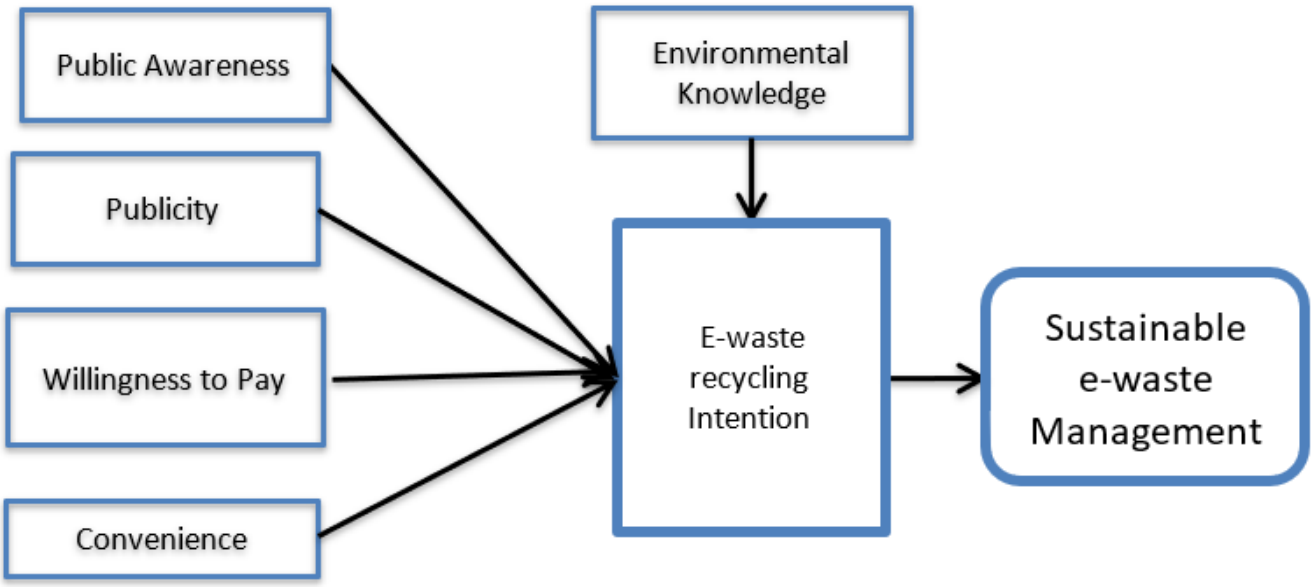


**Fig. 1:** The conceptual model

## 5. Research Method

The research employs a quantitative methodology and utilizes a cross-sectional study design.

### 5.1 Questionnaire design

The questionnaire was validated by subject matter experts prior to being distributed to the respondents. The panel of experts that was given the instrument was made up of two industry personals and three academicians. The set of questions for each construct was based on previous studies[30,62]. The questionnaire underwent a thorough evaluation process, and the researcher received minimal feedback from professionals regarding areas that needed further clarification. The questionnaire consists of two components: one for collecting demographic data and another for assessing the intention and management of e-waste. A five-point Likert scale with a range from one to five was used to measure the questionnaire items[63]. A high degree of agreement is indicated by a score of five, whereas a score of one indicates a considerable difference in opinion. Appendix 1 shows the questionnaire considered for this study.

### 5.2 Data Collection

In the absence of a sampling frame, respondents were picked using the snowballing method, and the created framework was evaluated using Structural Equation Modelling (SEM). The snowball sampling strategy was

selected due to its effectiveness in reaching populations that are challenging to access or identify through conventional sampling methods. This approach facilitated access to a substantial and pertinent sample size while maintaining a clear focus on the study's intended population. Moreover, snowball sampling was suitable considering the exploratory nature of the study, aimed at revealing insights rather than attaining precise representativeness. The study includes participants of all genders over the age of 18. Consumers who wish to engage in the survey must either possess or routinely have access to technological devices, including smartphones, tablets, and computers. The research survey form was administered via Google Forms. The study was exclusively conducted in Udupi district, located in the Karnataka area of India. A total of 207 replies were gathered for the purpose of data analysis. The instrument's validity and reliability were assessed by collecting data from around 60 participants. The input and recommendations provided by the participants were used to enhance the interpretability of the questionnaire. Ultimately, the data collection questionnaire was effectively developed. The study utilized Smart PLS as the chosen research instrument. The data distributions of the respondents are shown in Table 1.

## 6. Results and Analysis

### 6.1 Demographic profile of the respondents

The demographic profile of the respondents is tabulated in Table 1. The survey revealed that 62% of the respondents were male, and most fell within the age range of 18-24 years (64%), followed by 25-40 years (22%). It was also noted that the respondents were pursuing undergraduate and postgraduate degrees or had completed them.

Table 1. Demographic characteristics

| No. | Characteristics | Frequency | Percentage |
|---|---|---|---|
| 1 | **Gender** | | |
| | Male | 129 | 62 |
| | Female | 78 | 38 |
| 2 | **Age** | | |
| | 18-24 | 132 | 64 |
| | 25-40 | 46 | 22 |
| | 41-60 | 29 | 14 |
| 3 | **Number of electronic gadgets held (portable devices)** | | |
| | 1 | 23 | 11 |
| | 2 | 72 | 35 |
| | More than 2 | 112 | 54 |
| 4 | **Highest Degree of education completed** | | |
| | Under graduate degree | 123 | 59 |
| | Post graduate degree | 51 | 25 |
| | Doctorate | 15 | 7 |
| | Others (Certificate Program) | 18 | 9 |

### 6.2 Validity and Reliability of the scale:

The instrument is tested for reliability and convergent validity. The results are indicated in Table 2. It is clear that the research instrument is reliable and upholds convergent validity[62]. All AVEs for the constructs exceed 0.5, demonstrating that the research instrument possesses measurable reliability and robustness. Additionally, given are the various Cronbach's alpha characteristics for the standards used in the methodology. The reliability of the factors is high, as every factor exceeds an acceptable value of 0.7. Content validity is assessed by a panel consisting of academic professionals and industry experts. The instrument is thought to be dependable, in accordance with the experts' opinion.

### 6.3 Construct Reliability and Convergent Validity

The reliability of constructs in SmartPLS is assessed using Cronbach's alpha, while the internal correlation within each construct is ascertained using the Composite Reliability measure[44]. The metric quantifies the degree of resemblance among the elements inside each construct (mentioned in Table 2). It is important for the composite reliability to be above the threshold limit of 0.7. A study by Hair et al. (2016)[63] demonstrates a direct correlation between the value of a measurement and its dependability.

Furthermore, the AVE is employed to measure the degree of similarity or dissimilarity among the elements of a construct[44,63]. In this particular scenario, it is crucial for the value to surpass 0.5 in order to establish its validity. Subsequently, an analysis is conducted to evaluate the external loadings of each individual component, which indicate the component's impact on the construct. The results indicate a significant degree of internal consistency among the measures.

Table 2. Reliability and Validity Results.

| Construct | Factor Loadings | Cronbach's alpha | Composite reliability | Average variance extracted (AVE) |
|---|---|---|---|---|
| CON1 | 0.833 | 0.767 | 0.810 | 0.589 |
| CON2 | 0.773 | | | |
| CON3 | 0.836 | | | |
| CON4 | 0.606 | | | |
| ENK2 | 0.675 | 0.705 | 0.740 | 0.525 |
| ENK3 | 0.805 | | | |
| ENK4 | 0.722 | | | |
| ENK7 | 0.688 | | | |
| INT 1 | 0.752 | 0.881 | 0.887 | 0.629 |
| INT 2 | 0.744 | | | |
| INT 3 | 0.866 | | | |
| INT 4 | 0.843 | | | |
| INT 5 | 0.787 | | | |
| INT 6 | 0.758 | | | |
| PAW1 | 0.760 | 0.778 | 0.792 | 0.599 |
| PAW2 | 0.711 | | | |
| PAW3 | 0.845 | | | |
| PAW4 | 0.773 | | | |
| PUB1 | 0.767 | 0.815 | 0.828 | 0.523 |
| PUB2 | 0.795 | | | |
| PUB3 | 0.706 | | | |
| PUB4 | 0.636 | | | |
| PUB5 | 0.805 | | | |
| PUB6 | 0.607 | | | |
| SEW1 | 0.684 | 0.840 | 0.846 | 0.558 |
| SEW2 | 0.815 | | | |
| SEW3 | 0.821 | | | |
| SEW4 | 0.678 | | | |
| SEW5 | 0.775 | | | |
| SEW6 | 0.695 | | | |
| WTP1 | 0.781 | 0.718 | 0.725 | 0.634 |
| WTP2 | 0.793 | | | |
| WTP3 | 0.814 | | | |

The factor loadings for CON5, ENK1, ENK5, ENK 6, PAW5, SEW7, WTP4 and WTP 5 were excluded as the values were less than 0.5.

**6.4 Evaluation of Measurement Model**

The PLS-SEM technique offers benefits by not imposing limitations on measurement scales or demographic variables[64]. The model accommodates the integration of both reflective and formative indicators, positioning it as a more favorable option compared to

AMOS and LISREL[44,65]. The study favours the use of PLS-SEM as the preferred method. PLS-SEM is better suited for data sets that do not follow a normal distribution[63]. A detailed explanation of the PLS-SEM approach is presented in two distinct parts. In the initial phase, the focus is on assessing the accuracy and dependability of the measuring model, followed by the examination of the structural model in the subsequent phase[63].

### 6.4.1 The measurement model

The assessment of discriminant validity was performed utilising the Fornell-Larcker Criterion, with the findings displayed in Table 4. The statistical analysis indicated that the square root of the average variance extracted (AVE) for each construct exceeded the inter-correlations among the constructs, suggesting that the constructs effectively differentiated from one another[63]. The results of the discriminant validity assessment are detailed in Tables 3 and 4. The alignment of the diagonal elements indicates that discriminant validity has been successfully established.

Table 3. Discriminant validity

| Construct | CON | ENK | INT | PAW | PUB | SEW | WTP |
|---|---|---|---|---|---|---|---|
| CON | 0.768 | | | | | | |
| ENK | 0.150 | 0.724 | | | | | |
| INT | 0.388 | 0.434 | 0.793 | | | | |
| PAW | 0.295 | 0.572 | 0.562 | 0.774 | | | |
| PUB | 0.370 | 0.570 | 0.594 | 0.559 | 0.723 | | |
| SEW | 0.307 | 0.475 | 0.745 | 0.507 | 0.549 | 0.747 | |
| WTP | 0.382 | 0.368 | 0.471 | 0.571 | 0.513 | 0.341 | 0.796 |

The discriminant validity of the instrument is tested using Fornell and Larcker, (1981)[65] criterion. Accordingly, the diagonal values should be higher than its corresponding row and column values. Table 3 demonstrates the discriminant validity values.

Table 4. HTMT values

| Construct | CON | ENK | INT | PAW | PUB | SEW | WTP |
|---|---|---|---|---|---|---|---|
| CON | | | | | | | |
| ENK | 0.209 | | | | | | |
| INT | 0.451 | 0.519 | | | | | |
| PAW | 0.354 | 0.754 | 0.663 | | | | |
| PUB | 0.469 | 0.720 | 0.693 | 0.686 | | | |
| SEW | 0.373 | 0.606 | 0.861 | 0.631 | 0.661 | | |
| WTP | 0.489 | 0.471 | 0.570 | 0.724 | 0.639 | 0.419 | |

Evaluating the variation inflation factor (VIF) among the components is necessary to identify any possible multi-collinearity used by the data[44]. The values recorded in Table 5 is used to find correlations between latent variables. It is recommended that VIF values remain below 5[62]. According to the findings, the VIF values were substantially below the maximum threshold of 3.3[66], falling between 1.00 and 1.997. Given that the numbers in Table 5 are within acceptable limits, the existence of multicollinearity is not cause for concern. When Common Method Bias (CMB) is present, using PLS-SEM, presents a significant problem[44,67]. A comprehensive collinearity examination is necessary to locate the CMB. Our results show that the model has no CMB since the VIF values are less than 3.3.

Table 5. Inner VIF Values

| | **CON** | **ENK** | **INT** | **PAW** | **PUB** | **SEW** | **WTP** |
|---|---|---|---|---|---|---|---|
| **CON** | | | **1.250** | | | | |
| **ENK** | | | **1.751** | | | | |
| **INT** | | | | | | **1.000** | |

| | |
|---|---|
| **PAW** | **1.997** |
| **PUB** | **1.927** |
| **SEW** | |
| **WTP** | **1.692** |

Table 6. PLS predict using $Q^2$ and model fit using $R^2$ values.

| Construct | Q-square Predict | R-square | Effect |
|---|---|---|---|
| **INT** | 0.407 | 0.457 | Moderate |
| **SEW** | 0.330 | 0.555 | High |

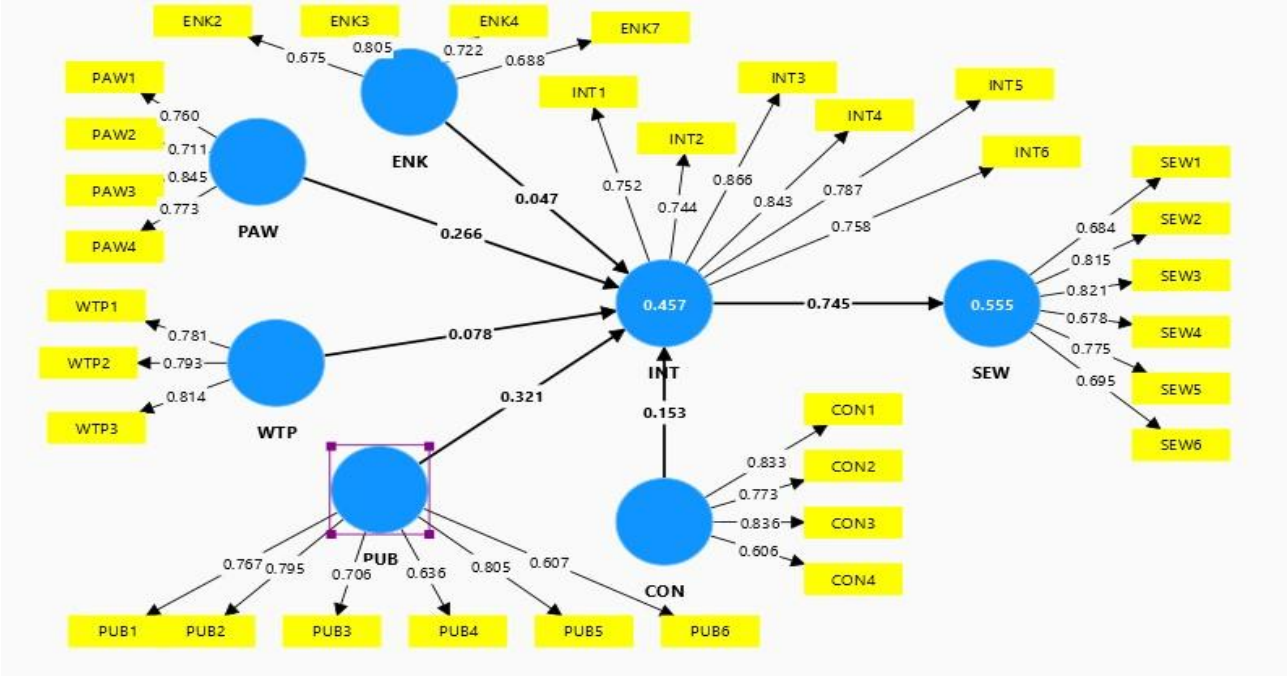


**Fig. 2:** Results of the structural model.

### 6.5 Evaluation of SEM - Testing

Figure 1 depicts an assessment of the suggested theoretical framework for the study using SEM and the SmartPLS tool. SEM is a technique that examines the correlations between underlying factors and questionnaire items. The T-statistic value of 1.9661 suggests a statistically significant positive effect. Higher T-statistic statements or indications have a greater influence on latent variables than lower T-statistic statements or indications[68].

In Figure 2 the structural model's coefficients and findings suggest that model constructs are significantly influenced. Out of the six constructs, only four were accepted. The study found that public understanding, convenience, and publicity have significant effects on individuals' willingness to be part of e-waste disposal activities. The bserved effects were as follows: H2: _2 had an effect size of 0.266 with a p-value of 0.001; H4: _4 had an effect size of 0.321 with a p-value of 0.001; H5: _5 had an effect size of 0.153 with a p-value of 0.003; H6: _6 had an effect size of 0.745 with a p-value of 0.000. Thus, H2, H4, H5, and H6 are accepted. The effects of H1: _1=0.047, p = 0.486 and H3: _3 = 0.078, p = 0.339. This means that the factors of environmental knowledge and Willingness to pay are rejected.

Table 7 summarizes the path coefficient results. The results show that the hypotheses H1 and H3 are not statistically significant at the 95% level. The study's findings show that public knowledge, publicity, and convenience all have an impact on people's intentions to dispose of electronic waste. Furthermore, this aim has a direct impact on how consumers interact with a sustainable e-waste disposal system.

Table 7. Path coefficients

| | β | T statistics | P values | Hypothesis |
|---|---|---|---|---|
| **H1: ENK -> INT** | 0.047 | 0.696 | 0.486 | **Rejected** |
| **H2: PAW -> INT** | 0.266 | 3.297 | 0.001 | **Accepted** |
| **H3: WTP -> INT** | 0.078 | 0.957 | 0.339 | **Rejected** |
| **H4: PUB -> INT** | 0.321 | 3.273 | 0.001 | **Accepted** |
| **H5: CON -> INT** | 0.153 | 2.996 | 0.003 | **Accepted** |
| **H6: INT -> SEW** | 0.745 | 23.458 | 0.000 | **Accepted** |

Note: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

## 7. Discussion

The objective of this study was to investigate the determinants that inspire intentions toward environmental conservation and the implementation of sustainable strategies for managing electronic waste. The survey evaluates the proximity of nearby e-waste disposal facilities, the level of consumer awareness regarding e-waste, and their willingness to financially contribute to its proper disposal. The data collection was done in Karnataka, India where there are no proper e-waste collection centres. The e-waste collected is mostly sent to the informal recycling centre where the electronic devices are dismantled manually in an open area. Data was collected from 207 individuals with the use of structured questionnaires in a quantitative survey methodology. A conceptual framework was developed to illustrate hypothesized links based on sustainability and the model of the Theory of Planned Behaviour[15].

The study found a clear link between intentions and sustainable e-waste management, with intentions playing a major role in determining the outcome. Furthermore, research has revealed the existence of several characteristics that have a beneficial impact on consumers' willingness to discard electronic waste. According to the study, public awareness had a positive impact on individuals' intentions to appropriately dispose of electronic waste. The studies support the work done by Afroz at al. (2013)[9] in Malaysia, but contradict the results of the studies done by Garg et al. (2023)[47] which was done in India.

While there may not be a plethora of PR campaigns, the majority of homes are conscious of the environmental consequences of e-waste. The study's conclusions on publicity are supported by prior research studies[6,52]. Publicity will also generate consumer awareness during the purchase of electronic goods, prompting many consumers to return worn or non-functional electronic items. The analysis's conclusions were in direct opposition to the outcomes of prior studies[48] but were in line with the awareness documented in the research conducted by Afroz et al. (2013)[9]. Furthermore, the results indicated that ease positively impacted the effective handling of electronic waste[41]. The results of the study were in line with the previous studies which was carried out by Laeequddin et al. (2022)[58] and Afroz et al. (2020)[57].

The study indicated that individuals had a limited comprehension of the adverse effects of e-waste, leading to environmental knowledge having little impact on their intentions to dispose of e-waste. The investigation produced results that were inconsistent with those of the earlier study [13]. Similar to the previous studies consumers of electronic and electrical products possessed insufficient knowledge about the toxic effects of e-waste and its disposal[29,42]. The level of awareness greatly influences the willingness of buyers to pay for electronic waste disposal. However, the findings of this study differed from earlier research, likely due to consumers' reluctance to incur extra costs for e-waste disposal[46,47].

### 7.1 Theoretical Implication

TPB suggests that recycling intention has a positive relationship with the independent variables like public awareness, publicity, and convenience [44]. The desire to recycling, ultimately is related to sustainable e-waste management. Our research findings are consistent with previous investigations, producing comparable results.

The TPB framework has traditionally been employed to examine individuals' intentions to recycle. This study investigates the integration of the TPB model with an evaluation of the aspects covered in the research. The goal is to investigate how these factors influence people's recycling habits, particularly in relation to e-waste.

Integrating the construct of sustainable e-waste management systems into the TPB model, rather than emphasising solely on individual behaviour, introduces a new dimension. This new model enhances our awareness of the comprehensive behaviour of TPB in relation to sustainable e-waste management, while also enlightening individuals about the significance of e-waste recycling. The study reveals that recycling intention is an important determinant in developing a sustainable e-waste management system.

As a result, the results of this study may serve as a valuable addition to the findings of other studies and may require a greater emphasis on environmental issues. The R2 value for recycling intention in this study was 0.457, whereas for sustainable e-waste management systems it was 0.555. Strydom, (2018)[69] in his study found that had

R2 values of 46.4% and 26.4%, the current R2 value is closer and falls within the moderate range. Undoubtedly, the model used in this study was well-suited and suitable.

**7.2 Managerial Implications:**

The study revealed that many individuals had little knowledge of the specific guidelines used to ascertain the recyclability of products. Lack of proper education in India related to waste separation results in incorrect segregation of e-waste in households, impeding the government's efforts to regulate waste management in metropolitan areas.

Based on these findings, it is advised that lawmakers continue to enforce legislation that promotes citizen participation in the separation of solid waste and e-waste [42]. The impact of publicity on an individual's willingness to recycle electronic waste is significant, leading to positive consequences in the promotion of sustainability[26].

Policymakers and stakeholders should implement impactful advertising campaigns and ensure the availability of convenient facilities for citizens. In addition, it is important for individuals to actively promote the separation of domestic solid waste and e-waste. Based on these findings, policymakers should focus on improving advertisements and implementing government policies to encourage the separation of e-waste in households[16]. The level of public awareness significantly influenced individuals' inclination to recycle waste positively. Policymakers should take advantage of this opportunity to educate individuals on proper electronic waste disposal. This can be done by promoting the use of formal recycling centres or setting up convenient collection locations nearby. Currently, private households lack information when disposing of electronic garbage, but manufacturers have created systems for returning such material through authorized dealerships.

Research has shown that when consumers have a stronger intention to recycle e-waste, it directly and positively impacts their willingness to do so. The government measures and convenience received relatively lower, yet still positive scores, suggesting that there is potential for improvement in these influential variables. The role of convenience is crucial when it comes to disposing of electronic waste. It is the responsibility of the local authorities, in collaboration with the municipality, to guarantee the availability of e-waste bins/collection boxes in residential areas or designated e-waste collection stations. These bins should be collected on a weekly basis to ensure proper disposal of electronic waste. Understanding the environment is essential for responsibly disposing of electronic waste. The research conducted revealed that the presence of environmental information has a detrimental impact on individuals' intentions to recycle. It is imperative for the government to utilize official channels to inform individuals about the harmful substances found in electronic waste, as they can potentially lead to health complications in the future. Having a strong understanding of environmental issues and concerns helps individuals in society appreciate the importance of environmental conservation. The willingness to pay has a negative effect on individuals' intentions to recycle electronic waste. When assessing the Willingness to Pay (WTP) element, only a small portion of individuals opt to utilize this particular service. The issue of WTP is complex, requiring individuals to make thoughtful decisions regarding the payment for e-waste disposal, which is commonly discarded alongside regular household waste in many areas. Having proper recycling facilities for electronic waste is crucial to support waste-to-product initiatives. The recycling facility nearest to the study location is situated quite a distance away. From this research it is found that there is a positive intention towards e-waste disposal on the implementation of sustainable e-waste management[26]. Governments play an important role in ensuring the efficient management of electronic waste. They must prioritize infrastructure development, ensure adequate funding, and encourage public participation.

Ensuring producer responsibility is essential in driving waste reduction, reuse, and recycling in both households and industries. The active involvement of the industry is crucial in successfully attaining this objective.

## 8. Conclusion

The issue of waste generation caused by the use of technology and electronic devices poses a serious concern for the sustainable availability of resources across multiple sectors and the general welfare of society. Every individual has a duty to manage e-waste in an effective and responsible manner. Upon examining the issue of electronic waste disposal through the lenses of sustainable development and behavioural theories, it is evident that the existing intentions surrounding waste disposal fall short in fostering sustainable practices for waste management. The primary element is the degree of public awareness, publicity in the press, and convenience, largely influenced by the dissemination of information regarding electronic waste. A carefully crafted public relations campaign highlighting the adverse effects of electronic waste can significantly enhance consumer awareness regarding the persistent challenges associated with e-waste. The volume of electronic waste produced, and the methods employed for its management have considerable implications for environmental health, social welfare, and economic development. At the consumer level, it is essential to introduce initiatives focused on changing viewpoints and informing individuals about the environment. Business organisations are required to adopt waste management strategies to showcase their dedication to social responsibility and environmental sustainability. The government should play a vital role in building

necessary infrastructure and enforcing waste management laws.

The scope is essentially confined to the factors that were considered in this study. The study comprised a total of 207 individuals, all of whom were exclusively from Udupi district, in Karnataka, India and the nearby areas. Although the findings are intriguing, they cannot be applied to the entire state of Karnataka, situated in India. Future research should be performed to explore the effects of electronic waste disposal on sustainable e-waste management by analysing different societal demographics. The data gathered primarily originates from Tier 2/3 cities in Karnataka, and the outcomes would notably differ when compared to those from a metropolitan city. As this is a continuing study, an expanded dataset with more constructs may enhance the knowledge within the research domain.

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**Appendix 1**

Table 1: Constructs with their items and questions

| Constructs | Items | Questions | References |
|---|---|---|---|
| **Public Awareness** | PA1 | I am often concerned about environmental issues | Wang et al., 2016; Nguyen et al., 2018 |
| | PA2 | I think everyone should contribute to environmental protection | |
| | PA3 | It's wrong to dispose electronic waste and regular waste together | |
| | PA4 | Disposing e-waste in a proper manner is my responsibility. | |
| | PA5 | I feel very satisfied when recycling e-waste. | |
| **Environmental Knowledge** | ENK1 | I know that e-waste contains heavy metals that can harm our health if it is not recycled or processed appropriately. | Islam et al., 2016; Afroz et al., 2013; Nduneseokwu et al., 2017 |
| | ENK2 | I know that recycling of e-waste preserves natural resources for the benefit of future generations. | |
| | ENK3 | I believe recycling my old electrical or electronic devices is good for the environment. | |
| | ENK4 | I know that e-waste is rich in recyclable components. | |
| | ENK5 | I know that proper management of e-waste reduces the use of landfills and emissions of greenhouse gases. | |
| | ENK6 | I know that e-wastes should be disposed separately from general household wastes. | |
| | ENK7 | E-waste can be a resource if properly managed. | |
| **Willingness to Pay** | WTP1 | I am Willing to share a part of recycling cost, only if there is recycling facility/collection center nearby | Kwatra et al., 2014; Shaikh 2020 |
| | WTP2 | Willing to share a part of recycling cost, is not consumer's responsibility alone | |
| | WTP3 | Willingness to take responsibility for recycling of E-waste | |
| | WTP4 | Willingness to pay a charge for disposal of e-waste | |
| | WTP5 | I want the government to pay for the disposal and recycling of e-waste | |
| **Publicity** | Pub1 | Publicity will help me to know that, e-waste is the reason to pollute the environment or endanger human health. | Wang et al., 2018 |
| | Pub2 | Publicity will help me to know there are still many recyclable components available in e-waste | |
| | Pub3 | I think the relevant information about e-waste recycling publicity is important. | |
| | **Pub4** | Because of publicity I know the shortcomings of the informal e-waste disposal. | |
| | Pub5 | Publicity will help me to know what household e-waste can be recycled. | |
| | Pub6 | Because of publicity, I know where to dispose my household e-waste for recycling. | |
| **Convenience** | Conv 1 | It is easy for me to go to an E-waste recycling centre | Sidique et al. (2010); Saphores et al. (2012) |
| | Conv 2 | It is easy for me to find information on E-waste recycling | |
| | Conv 3 | It is easy for me to find time to recycle E-waste | |
| | Conv 4 | I have no convenient transport to send E-waste to the collection point. | |
| | Conv 5 | I think surrounding E-waste recycling channels are incomplete. | |
| **Intention** | Int1 | In the future when dealing with e-waste, I would like to try to contact the factory or professional recycling agencies. | Zhang et al., 2020 |

| | | | |
|---|---|---|---|
| | Int2 | When I buy electronic products in the future, I tend to choose products that promise to be recycled or disposed of in a proper manner | |
| | Int3 | I intend to put extra effort into recycling of e-waste | |
| | Int4 | In the future, I intend to recycle my e-waste by formal channels. | |
| | Int5 | In the future, I will actively participate in e-waste recycling programs | |
| | Int6 | In the future, I will tell people around me about the e-waste recovery experience. | |
| **Sustainable e-waste Management systems** | SEW1 | I separate my electronic waste from ordinary garbage so that I can sell them | Ofori and Opoku, 2022; Author, 2024 |
| | SEW2 | I should not waste anything if it can be used again | |
| | SEW3 | I consider the device that is easy to repair and reuse before purchase | |
| | SEW4 | I will buy products from manufacturer's who design products for reuse, recycle, recovery of material, component parts etc.. | |
| | SEW5 | I only buy electronic equipment when there is an immediate need | |
| | SEW6 | I prefer to buy products from companies that will reuse the recycling materials(Eg: Raw materials) in their products. | |
| | SEW7 | To sustain in the competitive market, manufacturers need to introduce sustainable e-waste management practices | |