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Illuminating the Consumer Viewpoint in Plans for Waste Electrical and Electronic Equipment Treatment: leveraging Twitter Data Analysis

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Abstract
Rapid advancements in technology have led to a significant rise in Waste Electrical and Electronic Equipment (WEEE), necessitating the development of effective strategies for managing this growing waste stream. This study explores consumer perspectives and preferences regarding End-of-Life (EOL) options for WEEE. By analyzing a substantial dataset of 2,905,579 Twitter tweets collected between May 2019 and April 2022, and utilizing the Fuzzy Analytic Hierarchy Process (FAHP) technique, we were able to identify the key factors influencing consumer decisions. These factors include accessibility of recycling centers, consumer awareness regarding EOL options, trust in government initiatives, potential economic incentives, involvement of charitable organizations in collection processes, and data security concerns during electronic waste disposal. FAHP was further employed to assess the suitability of each EOL option (reuse, remanufacturing, recycling, and disposal) based on these identified factors. The findings from this study offer valuable insights that can inform WEEE management practices, promote the development of efficient electronic waste disposal strategies, and contribute to the establishment of a circular economy for electronic waste.

Keywords: Waste of Electrical and Electronic Equipment (WEEE), End-of-Life (EOL), WEEE treatment, WEEE management

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Introduction

In recent years, a plethora of research has been carried out to explore supply chain waste and its effective management for enhancing product quality. Delving into this matter can facilitate the resolution of supply chain shortcomings, leading to improved performance, enhanced production efficiency, and heightened customer satisfaction (Ramezaninia et al, 2022). According to the American Reverse Logistics Executive Council, reverse logistics (RL) is described as the systematic process of strategically planning, efficiently implementing, and cost-effectively controlling the movement of materials, inventory, and used products from the point of consumption to the point of production. The primary objective of this process is to extract value from these materials or ensure their proper disposal (Rogers & Tibben Lembke, 1999). RL has gained acceptance and is used extensively in the global manufacturing sector through environmental legislation, recovering valuable material resources for the secondary market, and sustainable development principles (Islam & Huda, 2018). Supply chain management typically refers to the "forward supply chain" (FSC), which is not in charge of product EOL (Soleimani et al., 2017). Subsequently, the reverse supply chain, or RL, endeavors to manage EOL products in the most environmentally-friendly manner possible (Govindan & Soleimani, 2017). The rise in public awareness, heightened environmental concerns, a growing inclination towards sustainable business practices, and the recognition of the importance of recovering valuable and hazardous materials have led to the increasing adoption of the reverse supply chain (RSC) concept, both within industry and academia (Islam & Huda, 2018). This, in turn, has given rise to the notion of the "Closed-Loop Supply Chain" (CLSC), which encompasses not only the forward but also the reverse supply chain (Islam & Huda, 2018). RL and CLSC are fundamental components of a comprehensive waste management strategy, and all of these concepts are interconnected with the core principle of the circular economy (Corsini et al., 2020). One of the important EOL products considered in the RL/CLSC is Waste Electrical and Electronic Equipment/E-waste (Islam & Huda, 2018).

The proper disposal of waste electrical and electronic equipment is now crucial due to the population's rapid development and the growing use of electronic devices. All electrical and electronic equipment damaged or destroyed which has no utility for the user is referred to as WEEE (Awasthi et al., 2018). According to studies, environmental, social, political, and moral disciplines can all contribute to the solution of the electronic waste problem. The success of e-waste management has been demonstrated by experience: even with high technical expertise, without cooperation between stakeholders representing a social, ethical, political, and technical problem, it has failed e-waste management (Galante & Campos, 2012; Huisman, 2012). As a result, managers must clearly understand the factors that support their management performance (Nelson et al., 2021). Sorting waste is considered as a practical and efficient measure in overcoming issues related to solid waste production, including electronic waste, while simultaneously promoting a circular economy, public health, and environmental sustainability. To ensure widespread public acceptance and participation, it is essential to comprehend the factors that motivate and encourage consumers to separate waste (Adu-Gyamfi et al., 2023). The recent surge in interest in the circular economy highlights the unrealized potential for environmental and economic benefits in the manufacturing sector. A key element in implementing a circular economy approach is to focus on EOL strategies such as reuse, remanufacturing, and recycling (Lieder et al., 2017). This is particularly important when considering EOL electronic equipment, given the potential environmental hazards they pose. To empower interactions between various stakeholders, waste management firms adopt strategic policies for their waste management operations (Frempong et al., 2020). Enhancing the resilience of the energy generation and manufacturing industries is necessary to move towards sustainability while also updating current production, consumption, and waste management systems (Mele et al., 2011). It is possible to improve the urban environment and promote sustainable development by implementing standardized recycling of renewable resources (Qu et al., 2013). Consumers should be urged to consider environmentally friendly products to create sustainable development and protect the environment for future generations because customers can reduce their impact on the environment and appropriately dispose of garbage by purchasing and using greener items, using them properly, and maintaining them (Jafari et al., 2017). A number of studies have investigated the factors that influence WEEE consumer purchase (Joshi & Rahman, 2015; Barbu et al., 2022, sun el al., 2022). These studies have found that the following factors are important:

- Environmental awareness: Consumers who are more aware of the environmental impact of WEEE are more likely to purchase green products.
- Price: Green products are often more expensive than conventional products. This can be a barrier to purchase for some consumers.
- Performance: Consumers want products that perform well and meet their needs. Green products can be just as effective as conventional products, or even better in some cases.
- Convenience: Consumers want products that are easy to use. Green products can be just as convenient as conventional products.
- Implications for Companies: Companies can encourage consumers to purchase green products by addressing these factors. For example, companies can:
- increase environmental awareness: Companies can educate consumers about the environmental impact of WEEE and the benefits of green products.
- Reduce the price of green products: Companies can offer discounts or rebates on green products to make them more affordable.
- Improve the performance and convenience of green products: Companies can invest in research and development to improve the performance and convenience of green products.

The need to process WEEE properly has increased due to the rapid expansion of the electronics industry and rising consumer demand for new electronic items (Agrawal et al., 2018). E-waste is one of the fastest-growing streams of EOL products, and consumer attitudes toward its disposal are changing quickly (Nnorom & Osibanjo, 2008). E-waste also has a higher manufacturing volume than other EOL goods, such as end-of-life vehicles (ELV), which have an annual production of just 8–9 million tons (Islam & Huda, 2018). The production of WEEE is expected to increase dramatically over the next few years, from 53.6 Mt in 2019 to 74.7 Mt in 2030 (Forti et al., 2020). This problem highlights the need for increased implementation efforts, strong laws, and consumer encouragement to recycle and dispose of WEEE properly (Tansel, 2017). Consequently, the effectiveness of RL processes for WEEE will depend significantly on the design of an optimal network. Recycling WEEE has drawn much interest due to the rising global trend of WEEE usage (Guo et al., 2021). Increasing global consumption of electronic items and a reduction in their useful life due to ongoing technological advancements and changing consumer lifestyles have resulted in a significant rise in electronic trash (Kosai et al., 2020). WEEE comprises a variety of dangerous compounds that, if not disposed of properly, can lead to environmental degradation and health issues (Golev & Corder. 2017). China and other developing nations are focusing on creating sustainable WEEE recycling programs (Govindan et al., 2017). The Chinese government supports the electrical and electronic waste recycling market through subsidies and regulations (Fu et al., 2020). To reduce environmental pollution and increase the recycling rate, governments should support authorized recyclers (Liu et al., 2021). The manufacturing, recycling, and processing companies are the main links in the WEEE recycling industry. We should properly treat WEEE because it harms the environment and human health (Singh et al., 2018; Mintz et al., 2019). Social media can encourage garbage recycling and boost stakeholder participation by persuading locals to participate in the regulations (Knickmeyer, 2020). With the growth of the Internet of Things (IoT), social media platforms are being used creatively for household trash management, such as e-waste collection on WeChat and Weibo (Zuo et al., 2020). However, more research is needed to quantify the impact of social media advertising in trash management (Jiang et al., 2021). This study investigated the factors that influence the proper management of WEEE by utilizing social media data. The study also proposed the four best EOL options for WEEE: remanufacturing, reusing, recycling, and disposal.

- Remanufacturing is a process that involves the disassembly, cleaning, inspection, repair, and reassembly of a product to restore it to its original condition. Remanufactured products are often comparable in quality to new products, but they can be sold at a lower price.
- Reusing is the act of using a product again for its original or intended purpose. Reused electrical and electronic equipment can be donated to charities, schools, or other organizations, or it can be sold to individuals.
- Recycling is the process of converting waste materials into new materials and objects. Electrical and electronic equipment can be recycled to recover valuable materials such as metals, plastics, and glass.
- Disposal is the process of disposing of waste materials in a safe and environmentally sound manner. Electrical and electronic equipment should not be disposed of in landfills, as they can contain hazardous materials.

These four options were proposed as the best EOL options for WEEE based on their environmental, economic, and social benefits (Islam & Huda, 2018; Kumar & Chandrahasan, 2023; Ghanadpour et al., 2022). To ensure the validity of our results, we adopted a combination approach that involved analyzing social media data and employing the FAHP method. We chose Twitter as our primary source of data since it is one of the most widely used social networking sites, with 330 million active users and 500 million daily tweets in the first quarter of 2020 (Sun, 2022). Twitter was selected as the primary source of data for this study because it is one of the most widely used and rapidly expanding social media platforms (Chae, 2015). In order to address the critical issue of defining the factors that influence consumer behavior regarding the appropriate EOL option for electrical and electronic waste, we utilized Twitter to gather the necessary information for our study. Our aim was to provide an acceptable solution to this issue by answering the following questions:

- RQ1: What are the most influential elements on consumer behavior when it comes to participating in the recycling treatment process of electrical and electronic equipment, based on the analysis of Twitter data?
- RQ2: According to consumers, which EOL options for electrical and electronic equipment are more appropriate?
- RQ3: According to experts and academics, what are the best EOL options for electrical and electronic equipment based on the factors that affect consumer behavior at the EOL stage?

The remainder of the paper is organized as follows: The pertinent literature is reviewed in Section 2. The research methodology will next be explained in Section 3. We will discuss and analyze the findings in Section 4. Section 5 concludes by discussing the theoretical and practical results of this theory. Section 6 will also include findings, restrictions on the research, and ideas for additional research.

1. *Review of literature*

A comprehensive literature review is essential to scholarly research as it facilitates in-depth exploration and organization of a specific field of study (Brocke et al., 2009). A well-structured literature review serves as a foundation for generating new theories by identifying key concepts in the relevant domain (Paul & Criado, 2020). Despite significant advancements in waste management technologies, the management of WEEE remains a major challenge (Shahabuddin et al, 2023). Consumer engagement in WEEE recycling is essential for addressing this challenge and achieving environmental sustainability. However, the human aspect of recycling initiatives has received limited attention in the existing literature (Varotto & Spagnolli, 2017). Recycling and reuse are of paramount importance for environmental preservation and public health, as they account for a substantial portion of the growing waste stream (Garrido-Hidalgo et al., 2020). The literature review indicates that various interrelated factors influence waste management systems and people's recycling habits (Corsini et al., 2020). Consumers make EOL decisions for EEE, including whether to buy new or used EEE, fix or replace it if it fails, and replace or dispose of it early (Islam & Huda, 2018). EOL decisions for EEE are becoming increasingly important as the world becomes more reliant on electronic and electrical products. In order to protect the environment and conserve resources, it is important for consumers and manufacturers to make informed decisions about how to dispose of EOL EEE products (Zhang et al., 2000). Therefore, analyzing customer behavior regarding WEEE control is crucial (Hennies & Stamminger, 2016; Sabbaghi et al., 2016). In this regard, the critical elements persuading consumers to participate in suitable WEEE treatment programs are essential in determining the best EOL strategy. Recent research has focused on consumer opinions regarding recycling services, which is critical for effective policy planning and waste management (Adu-Gyamfi et al., 2023). Zhu et al. (2017) investigated consumer decision-making processes in offline and online recycling channels and found age to be a significant influencer of recycling channel choices. The WEEE offline recycling network structure comprises six key components: consumers, retail stores, separation and testing centers, remanufacturing centers, secondary markets, and processing centers (Guo et al., 2021). Similarly, WEEE online platform recycling channels also involve six essential components: consumers, online platforms, testing and separation facilities, re-production facilities, secondary markets, and processing facilities (Guo et al., 2021). Ylä-Mella et al. (2015) conducted a study on consumer attitudes towards recycling old mobile phones, highlighting the need for improved knowledge and awareness of mobile phone recycling practices. Bernstad et al. (2011) studied the impact of access to waste collection centers on families' willingness to separate hazardous waste and WEEE. They concluded that accessibility to waste collection facilities plays a vital role in recycling behavior. Wang and Wang conducted a study on the critical barriers and their causal relationships in China's WEEE recycling industry. They identified three key barriers to its development: insufficiently qualified and unqualified disassembly, and lack of effective policies and regulations. Shahabuddin et al. (2023) discuss the challenges of collecting and recycling e-waste in developing countries, where infrastructure and resources are often limited. The authors also highlight the need to develop more sustainable design practices for electronic products to reduce the amount of e-waste generated in the first place. Moyen Massa and Archodoulaki discuss the challenges of managing e-waste in Africa. The authors identify a number of deficits in the current e-waste management system in Africa, including lack of awareness, lack of infrastructure, informal sector dominance, and weak government policies and regulations. Jain et al. (2023) provide a comprehensive overview of e-waste management, including its definition, sources, composition, environmental and social impacts, management strategies, and challenges and opportunities. They conclude that effective e-waste management is essential to reduce the environmental and social impacts of e-waste. Cardamone et al. (2021) proposed a new management plan for WEEE plastic, which includes sorting treatments, catalytic pyrolysis, and plastic upgrading. Their research underscores the importance of strict restrictions on improper waste treatments. Knickmeyer's study in 2020 aimed to understand the societal influences on household waste separation behavior and highlighted the need to consider social elements in waste management programs (Knickmeyer, 2020). Shevchenko et al. (2019) investigated incentives for boosting customer collection rates of EOL electrical and electronic equipment, proposing the use of electronic reward card systems. Understanding the factors influencing waste recycling behaviors and the entire recycling network are essential to sustainable WEEE management. Recycling and reuse are of paramount importance for environmental preservation and public health, as they account for a substantial portion of the growing waste stream (Garrido-Hidalgo et al., 2020). The literature review indicates that various interrelated factors influence waste management systems and people's recycling habits (Corsini et al., 2020). In conclusion, the rapid increase in electrical and electronic waste highlights the need for effective management practices. This study aims to identify the factors influencing consumer engagement in the treatment of WEEE and their treatment behaviors. The findings will provide valuable insights for stakeholders to formulate policies and promote responsible treatment of WEEE. The findings provide valuable insights for stakeholders to formulate policies and promote responsible WEEE treatment, ultimately contributing to environmental sustainability.

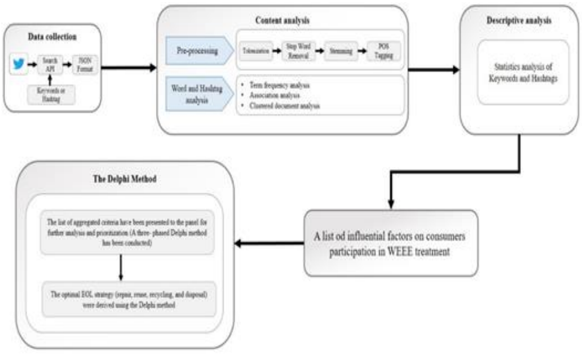
2. Research Methodology

The purpose of this research is to identify the factors that influence ordinary consumers to participate in the WEEE treatment process and suggest the best EOL options for WEEE by analyzing Twitter data. A combined method, including quantitative and qualitative techniques, was employed (Shokouhyar & Shahrasbi, 2021). The first section conducted a thorough investigation to compile a list of the variables affecting consumer participation in WEEE recycling. Twitter data was then examined using descriptive and content analysis techniques, and the results were then examined using the FAHP approach. The following EOL techniques will be considered since the proposed framework is employed by businesses whose main objective is waste management: remanufacturing, reusing, recycling, and disposal strategies can help advance waste management practices. Applying various research approaches and procedures to extract information from Twitter data is crucial, as social media data structures differ from traditional data (Radi & Shokouhyar, 2021). Using social media data to get client feedback could yield helpful information for business-related tasks and organizational decision-making (Pourabbasi & Shokouhyar, 2022). Given the ramifications of social media analysis, we require ways to extract valuable data from the Twitter database. As a result, this research recommends combining data mining techniques to examine social media data. This part describes the research process, gathers the data, and puts it into practice. The steps of the research approach created for this work are depicted in Fig. 1:

1. Collecting relevant tweets
2. Examining the tweets' content to determine what factors affect consumers' adherence to WEEE treatment programs

The FAHP technique determines the EOL choices for better WEEE management

Fig. 1. The research framework



The FAHP approach was used to identify appropriate EOL solutions for improved electrical and electronic product waste management. The content of each stage of the research procedure is as follows:

2.1. Data collection

Twitter was chosen as the primary data source for this study due to its significant global reach and impact on social media. With 330 million active users worldwide, it provides a rich source of data for collection and analysis. To ensure the relevance and reliability of Twitter data, we considered several factors. First, Twitter was selected as the primary data source because it is one of the most widely used social networking platforms globally. The platform's massive scale is evident in the daily posting of approximately 500 million tweets, amounting to about 6,000 tweets every second (source: InternetLiveStats). This vast amount of user-generated content provides a valuable opportunity to gauge consumer interests and identify trending research topics. To account for the diversity of Twitter's user base, we note that Twitter caters to a multilingual and multicultural audience. While our study does not exclude non-English users, we primarily focus on English-language content because of our research objectives and the authors' language proficiency. Twitter user demographics and language usage may vary significantly, but this study focuses on English-speaking segments to maintain consistency and allow for in-depth analysis. We collect data from Twitter using hashtags and keywords to identify and target specific domains and topics of interest. We accessed public tweets via the Application Programming Interface (API) using Python libraries. We used the search API to retrieve older tweets that met our predefined criteria, such as keywords, hashtags, senders, and location (Singh & Mishra, 2018). Finally, the data obtained from Twitter was downloaded in JavaScript Object Notation (.JSON) format, ensuring compatibility and ease of integration into our analysis process. The choice of Twitter as the primary data source was made considering both its global user base and its accessibility through the Twitter API for comprehensive data retrieval. Our study analyzed extensive data from English-language web evaluations. To ensure data relevance and consistency, we developed specific selection criteria for Twitter accounts, focusing on those with a minimum of 100 tweets, retweets, or replies per year. These criteria identified active users and ensured that our dataset included consistently engaged users. In other words, we considered accounts as "active users" if they had posted at least one tweet, retweet, or reply per week from the time of the account's creation. The rationale behind these criteria is to create a dataset that reflects a baseline level of user engagement. This ensures that the data we collected represents accounts with a consistent presence and activity on the platform. By setting this threshold, we aimed to filter out less active or dormant accounts, focusing on those that actively participate in discussions and interactions on Twitter. This approach aligns with the objectives of our study, as it allows us to investigate trends, consumer interests, and emerging topics within the context of actively engaged Twitter users. It also helps us maintain data quality and reliability throughout our analysis. These selection criteria were chosen to provide a meaningful and consistent dataset for our research.

2.2. Content analysis

The search API was used to retrieve 2,905,579 tweets from May 2019 to April 2022. The list of keywords and hashtags used to retrieve these tweets is shown in Table 1. Performing content analysis entails an entire arrangement of natural language processing (NLP) and text mining techniques, which are required for information extraction from unstructured social media data. By identifying its distinctive features, content analysis allows for drawing conclusions from a communication message or text research. Given that a tweet's content is informal and contains a shortlist of terms, Uniform Resource Locator (URL), hashtags, and other information, text cleaning and processing of the collected data should be done with caution (Chae, 2015). In order to use content analysis to acquire insights into unstructured data, the text must be coded or divided into manageable code segments.

2.1.1. Pre-processing

In order to extract relevant information from Twitter data, it is necessary to perform pre-processing. This is because the output from Twitter data can be complex and unstructured. Pre-processing involves removing unwanted segments such as emoticons and stop words, and extracting necessary sections such as URLs, hashtags, and retweet counts. By doing so, we can obtain the information that is most relevant to our needs. The primary objective of pre-processing in this case is to clean and prepare the data for more detailed analysis. To achieve this, non-English tweets were filtered out initially, and text cleaning was performed by removing punctuation and digits. All text was then converted to lowercase. Next, the texts were tokenized by separating them into individual terms. Stop words were removed, and the remaining words were stemmed. The focus then shifted to parts of speech (POS) tagging, feature extraction, and representation. To preserve the results of this stage, a comma-separated values (CSV) file was utilized (Radi & Shokouhyar, 2021).

2.1.2. Word and hashtag analysis

Various techniques can be employed to analyze words, including word clustering, term frequency analysis, and document summarization. Term frequency analysis is often utilized in detecting text data and recognizing word clusters. These techniques can aid in identifying important phrases and themes in the text (Mishra & Singh, 2018). Additionally, they can assist in identifying popular hashtags, which may provide insight into the characteristics and relevance of a tweet. Hashtags are a critical element in classifying Twitter posts. They can help uncover association rule mining and hashtag frequency (Chae, 2015). Different keywords are collected from a set of recurring items to distinguish new keywords for inclusion in the preliminary dictionary. Additionally, an online dictionary, WordNet, is used to discover synonyms of recognized keywords for inclusion. For example, a feature set like "recycling" includes "reuse" and "reprocess" (Abirami & Gayathri, 2016). In our study, we extracted several tweets related to #e-waste from the Twitter data.

2.3. Descriptive analysis

Twitter data contains a wealth of information on tweets and users. Descriptive analysis focuses on descriptive data, such as the number of tweets, the distribution of different tweet types, and the usage of hashtags. This type of analysis uses summary statistics to quantitatively describe or summarize the key characteristics of the data (Singh & Mishra, 2018). To further investigate the issue, this study includes studies on hashtags, age, and location. These studies aim to provide additional insight into the problem.

2.2. Fuzzy analytic hierarchy process (FAHP) method

To evaluate the descriptive framework based on specific criteria, the Fuzzy Analytic Hierarchy Process (FAHP) method was used to gather insights from experts and stakeholders in the field of WEEE management (De Jesus et al., 2019; Shoukohyar & Seddigh, 2020). This approach helped to improve the descriptive framework and collect expert perspectives. The FAHP process involved a three-stage survey of 39 prominent WEEE management experts. Participants were selected based on their significant contributions to waste management through academic publications, conference participation, or practical experience in waste management or related fields for a minimum of five years. Prior to commencing the FAHP process, the importance of participant engagement and commitment was emphasized, as this process could be time-consuming and potentially lead to reduced motivation among participants (Hardy et al., 2004). Therefore, comprehensive introductions and detailed explanations of the process were provided to participants, given that many university professors and experts may not be familiar with the concept. Experts were selected based on their required level of experience and expertise. They were assured that their responses would remain anonymous and confidential (Shoukohyar & Seddigh, 2020).

Interviews were carried out using an online questionnaire. All responses were collected within one month, in January 2023, the questionnaire is included in Appendix 1. Based on these interviews, we were able to discuss the various factors that influence consumers' engagement in WEEE treatment schemes. Furthermore, Cronbach's alpha was used to assess the questionnaire's validity, and its value was found to be 0.992. Cronbach's alpha is a coefficient that measures the internal consistency or reliability of a questionnaire (Sijtsma, 2009). We used IBM SPSS, a statistical software package, to calculate Cronbach's alpha following standard procedures. A higher Cronbach's alpha value indicates greater reliability and consistency. The obtained value of 0.992 indicates that the questionnaire has extremely high internal consistency, indicating that the items in our survey reliably measure the construct of interest. Of the 39 individuals who received invitations to review the descriptive framework, 20 accepted and agreed to participate. These 20 participants included 12 (75%) highly educated individuals at the master's level, program managers, and department heads, along with 8 (25%) professionals actively working in the industry. One participant had both academic and industrial experience. During the study, each participant had 5 to 25 years of professional or academic experience in WEEE management. Among the participants, 7 were female, and 13 were male. Experts from the United States, Canada, Germany, China, Turkey, Malaysia, Iran, Australia, France, and India participated in the survey. Additional information about the experts can be found in Appendix 2.

1. Results

Manufacturers have various options to consider for product recovery operations, including reusing, remanufacturing, recycling, and disposal when items reach their EOL phase. Each option comes with different costs and environmental impacts. Therefore, this paper proposes a multi-objective framework to reduce overall costs and environmental effects throughout the EOL phase. With the increasing amount of e-waste or WEEE, analyzing a product's EOL is essential to improve its recovery and minimize its environmental impact (Nowakowski et al., 2017). The FAHP approach was utilized in this study to determine the optimal EOL options that would promote WEEE recycling. The objective was to utilize the findings to establish regulations that would help reduce WEEE by selecting the best EOL alternatives. This section provides an illustration of how the proposed framework can assist in selecting the most suitable EOL solutions for the entire EOL phase. The suggested EOL decision-making process is divided into two stages: analyzing Twitter data to identify factors that influence consumer involvement in WEEE treatment programs and utilizing the FAHP technique to develop an EOL strategy for WEEE management based on the Twitter data.

1.1 Twitter data

To gather data on the factors influencing consumers' participation in WEEE treatment programs, we utilized Twitter as our data source. To analyze user comments on Twitter regarding the identified issues, we employed a recommended approach for analyzing Twitter data. Using Python programming language tools and APIs, we conducted keyword and hashtag searches, including terms such as "WEEE" and "e-waste," to collect tweets related to e-waste issues. Over the period from May 2019 to April 2022, we collected a total of 2,905,579 text tweets from Twitter, which provided valuable information for our study on WEEE treatment. We only considered tweets in English, and to ensure that we captured tweets relevant to the study's objective of identifying factors influencing consumer engagement in WEEE treatment programs. Table 1 displays the results of the keyword and hashtag extraction method related to electronic and electrical equipment waste, with the assistance of relevant literature and an online dictionary, considered in this study. This list can be expanded if necessary for future use. It was utilized to filter the complete set of tweets collected from Twitter during the study period (May 2019 to April 2022) and to investigate the WEEE-related issues raised by users.

Table 1: Keywords and hashtags used for extracting consumer tweets.

Keywords	Hashtags
e-waste day	#Refurbish
Mobile recycling	#Electronic Waste
e-waste junk	#Apple Renew
Cell phone buyback	#e-waste management
Mobile buy back	#Take Back Program
e-waste disposal	#Hazardous Waste
Mobile recycling	#Digital Clutter
Give-back program	#Circular Economy
Cell phone recycling	#iPhone Recycling
Electronic Recycling	#Data Destruction
	#WEEE
	#Samsung Recycling
	#EOL
	#Recovery
	#Take-back Program

4.2. Content analysis

4.2.1. Data pre-processing

To process the Twitter data and extract relevant information, pre-processing is necessary as the output appears unstructured and challenging to analyze. The following steps were taken to clean the data for the study:

1. Filtering: removing URL connections, emotions, rare Twitter words, and user names (e.g., @Ella, with the symbol @ indicating a user name).
2. Tokenization: a bag of words is formed by fragmenting the text into spaces and punctuation marks. However, we make sure that abbreviations like "doesn't," "I'm," and "she'd" are recognized as single words.
3. Stop word elimination –the articles ("a", "an" and "the") are eliminated from the bag of words.

Appendix 3 shows three examples of tweets checked with #e-waste. Tweets are text and need to be converted into processable units. According to the steps described in the pre-processing section, the following operations were applied to the tweets:

1. Lowercase
2. Remove usernames
3. Remove the website
4. Remove punctuation
5. Remove small words
6. Remove stop words
7. Stemming
8. Tokenization

The pre-processing of Twitter data is crucial to extract useful information since the output appears unstructured and difficult to process. The study's outcomes will be affected if the information is not cleaned properly. The pre-processing steps performed on the tweets are described in detail in Appendix 4, along with an example. As free-flowing text data is unstructured, pre-processing involves different steps depending on the context and goals of the study. The data preparation steps in this study include marking the text by converting each sentence into a series of words (for example: From #AI to #ewaste, a different ball game altogether. Secretary @Gol_MeitY inaugurated the 1000T PCB recycling equipment at #coe #ewaste, CMET, Hyderabad. Well, on a mission to save the planet #Earth! @jayesh_ranjan @Gol_MeitY @EmergingTechTS pic.https://pbs.twimg.com/media/FnfLQsKakAAEyWK.jpg).

Non-English words and characters are then removed, including HTML tags, punctuation marks, URLs, as well as stop words (these are words like "will", "if", "at", "but", "when" and ... are used abundantly in the text. The prepositions are grammatical, but in our analysis, they have little or no informational value.) In the next step, words (such as "recycle" and "recycling") are converted into the root form of "recycle" using Ports' (1997) root algorithm. After rooting each word, any word that appeared in less than 2% of the data is removed so that outliers do not influence the results. Passing through these preprocessing steps results in a collection where each tweet is treated as a single document.

4.2.2. Word and hashtag analysis

Environmental awareness, e-waste, mobile recycling, and electronic trash were among the terms most frequently used to describe problems, concerns, and potential obstacles to proper e-waste disposal. We grouped the themes from Twitter into six primary areas in the dataset by reading and analyzing the literature from earlier studies, and we then carried out word analysis:

- Accessibility to recycling facilities (Knickmeyer, 2020; Miliute-Plepiene et al., 2016)
- Raising consciousness of the negative effects of electronic waste (Shevchenko et al., 2019)
- Lack of confidence in the system due to consumers' dissatisfaction with government policies surrounding the recycling of electronic waste and exports to developing nations (Shevchenko et al., 2019; Knickmeyer, 2020)
- Financial incentives (such as electronic reward card systems) for the selling of electronic waste (Rompf 2014, Knickmeyer 2020, Shevchenko et al. 2019)
- Charitable donations of used electronics (Shokouhyar & Shahrasbi, 2021)
- Concerns around the disclosure of data (on hard drives, tablets, laptops, and other storage devices) (Shevchenko et al., 2019)

The detailed findings are shown in Table 2.

Table 2: Detailed word analyses

Accessibility to recycling facilities	**Raising consciousness and awareness**	**Lack of confidence**	**Financial incentives**	**Charitable donations**	**Concerns around data disclosure**
Limited number and remoteness of electronic recycling centers	Increasing awareness of the value of e-wastes	Doubts consumer's to the governments regarding proper disposal of waste	Lack of fair value recycling schemes	Refurbishing recycled products	Data bearing components
Electronic recycling centers	Increasing environmental knowledge	Consumers' negative attitudes e-waste recycling schemes regarding proper disposal of waste	Proper economic incentives	Reusing recycled products	Data stays safe
	Proper recycling and disposal of dangerous electronic	Lack suitable formal collection systems	free recycling	Redistribute	Safely and securely dispose
	Recycling program	harm to human health	Cashback	Electronic recycling	Secure data destruction services
		Harm to environment		New lease of life	Wipe the data
				Keeps out of landfills	
				Repurposing	

The tweets that were gathered had several hashtags. In total, 55681 hashtags were discovered in the cleaning reviews. The most commonly used hashtags are #e-waste, #WEEE, and #electronicwaste, among others. The data reveals that the top three overall hashtags for tweets are "Raising consciousness," "Financial incentives," and "Lack of confidence in the system."

4.3. Descriptive analysis

After examining each original tweet, a few retweets and replies were noted. As a result, at this stage, the authors concentrate on the topics that users have debated the most while also gaining essential insight from the data. Regarding this, Fig. 2 shows the most popular terms and hashtags, which are used more frequently than others. The most frequently used hashtags are #WEEE, #recycling, and #e-waste. To raise consumer awareness and engagement in e-waste treatment activities, most hashtags have been featured in commercials and announcements. They thus show that additional work is required to draw consumers' attention to the aforementioned problems.

Fig. 2. Frequency of top mentioned hashtags.

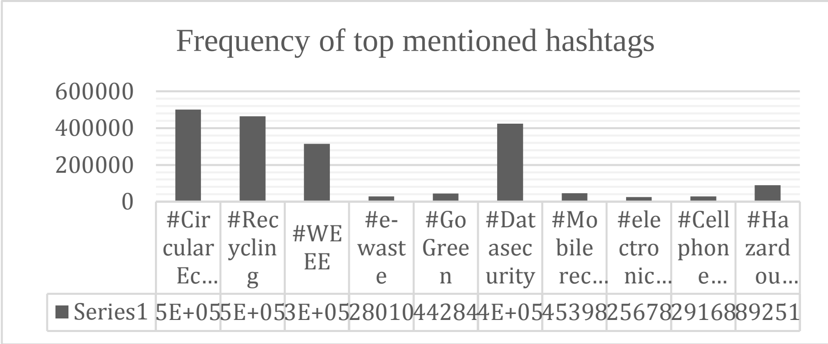


Figure 3 shows the age distribution of the most Twitter users in this field, but we should note that many people refuse to publicly share their personal information, such as age and location. Figure 4 shows the continents with the highest user participation in WEEE and e-waste concerns. As can be seen, most of the participants are in the age range of 25-35 years, and the most participation in the topics related to WEEE is related to the continent of Europe. The least is related to the continent of Asia, South America, and Africa. This issue indicates that experts in the field of electrical and electronic equipment recycling in these continents should do more to inform consumers due to their large population.

Fig. 3. Age distribution of people tweeting regarding WEEE.

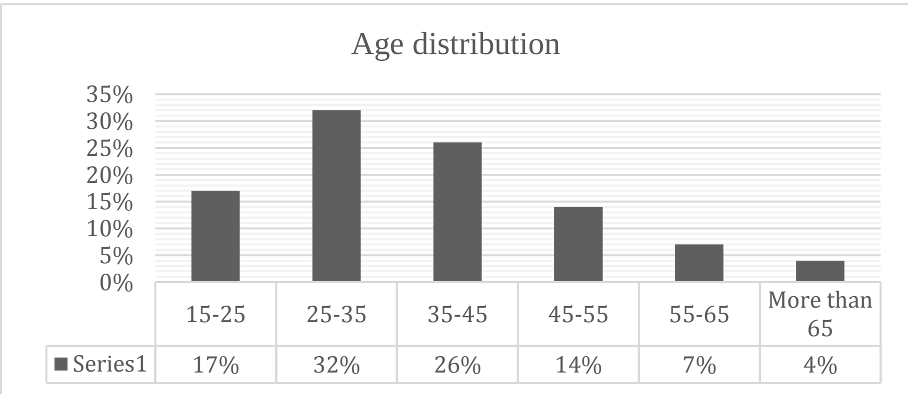
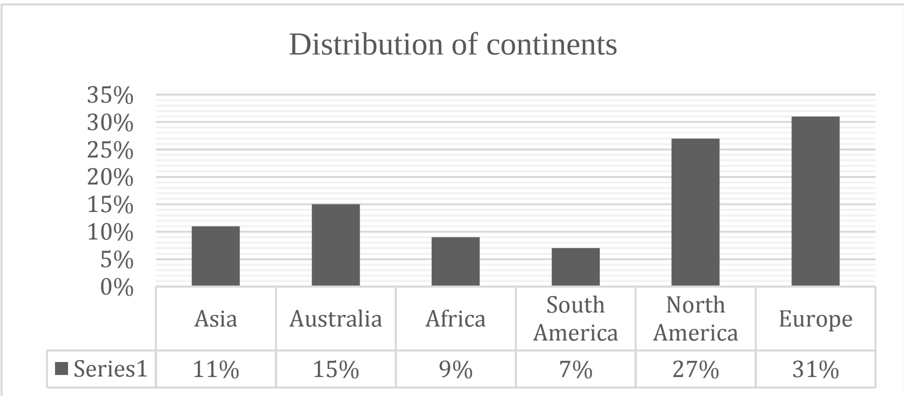


Fig. 4. Distribution of continents tweeting regarding WEEE.



4.4. The FAHP method results and related discussion

Using the FAHP approach, panels of experts in the field of WEEE recycling are presented with the findings from the Twitter data in this phase in order to decide on the best EOL solutions for WEEE based on consumer behavior with regard to the proper handling of WEEE. The method allowed us to compile expert opinions and improve the descriptive framework. After collecting the questionnaires from the experts, the geometric mean of the indices was calculated in pairs and is shown in Appendix 4. AHP method pairwise comparison questionnaire was analyzed with the help of EXPERT CHOICE 11" software. The indicators weight table was obtained by AHP method as follows in Table 3 and the final weight obtained for the indicators is shown in Table 4. The AHP method pairwise comparison questionnaire is shown in Appendix 5 and Appendix 6.

Table 3: The weight of the investigated indicators

	Accessibility to recycling facilities	*Raising consciousness and awareness*	*Lack of confidence*	*Financial incentives*	*Charitable donations*	*Concerns around data disclosure*
Remanufacturing	*0.383*	*1*	*0.187*	*0.423*	*0.470*	*0.459*
Reusing	*0.349*	*0.719*	*0.250*	*0.509*	*1*	*1*
Recycling	*1*	*0.156*	*0.084*	*0.247*	*0.178*	*0.745*
Disposal	*0.377*	*0.187*	*1*	*1*	*0.131*	*0.127*

Table 4: The final weight obtained for the indicators

	Accessibility to recycling facilities	***Raising consciousness and awareness***	***Lack of confidence***	***Financial incentives***	***Charitable donations***	***Concerns around data disclosure***
Remanufacturing	*0.355*	*0.234*	*0.270*	*0.264*	*0.236*	*0.283*
Reusing	*0.258*	*0.370*	*0.217*	*0.202*	*0.381*	*0.218*
Recycling	*0.221*	*0.201*	*0.192*	*0.167*	*0.131*	*0.313*
Disposal	*0.165*	*0.194*	*0.320*	*0.367*	*0.252*	*0.186*

The output from the analysis of the results in the EXPERT CHOICE 11 software is shown in Figure 5. Other outputs from the software for analyzing the results are shown in Appendix 7.

Fig. 5. Output from the results analysis

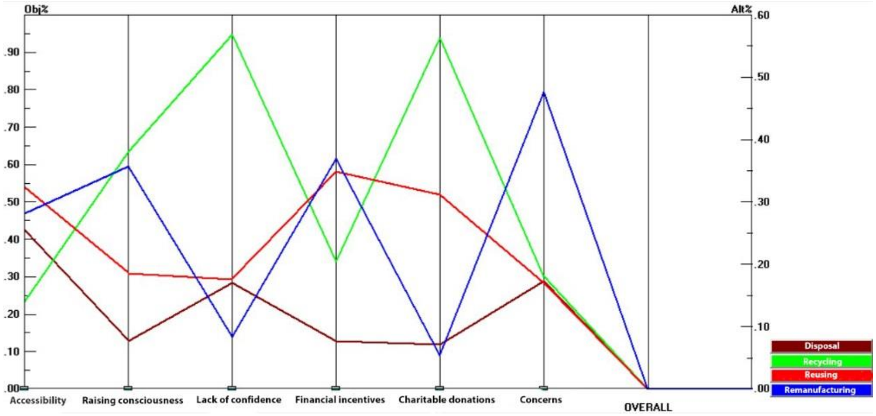


Fig. 6 displays the outcomes of the provided example to help with a more in-depth analysis of the FAHP implementation results. According to Fig. 6, it is possible to choose the optimum EOL alternatives depending on variables that affect consumer behavior.

Fig. 6. Results of the FAHP implementation

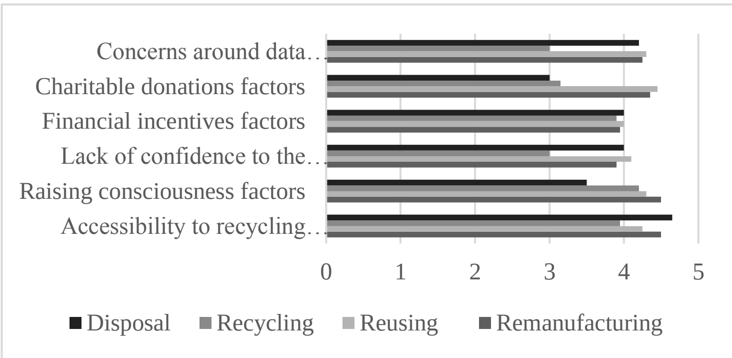
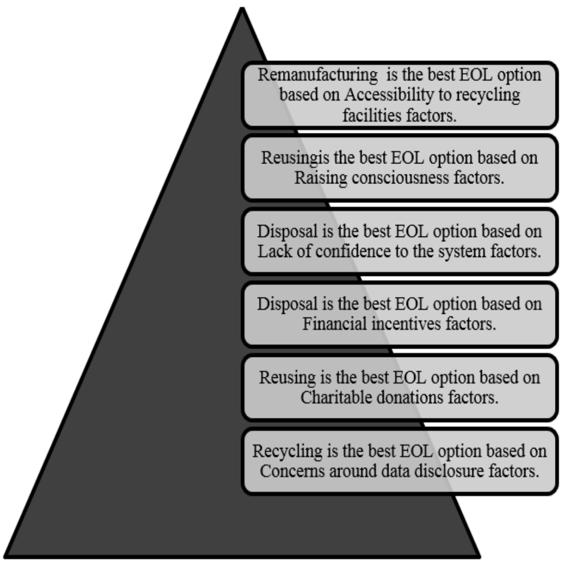


Fig. 7 illustrates the survey findings. The developed framework is a useful tool for selecting the appropriate EOL for electrical and electronic equipment based on the investigation findings.

Fig .7. Research results



5. Discussion

The primary focus of this research is to address three fundamental questions:

RQ1: What are the most influential elements on consumer behavior when it comes to participating in the recycling treatment process of electrical and electronic equipment, based on the analysis of Twitter data?

- RQ2: According to consumers, which EOL options for electrical and electronic equipment are more appropriate?
- RQ3: According to experts and academics, what are the best EOL options for electrical and electronic equipment based on the factors that affect consumer behavior at the EOL stage?

In our investigation, a comprehensive review of pertinent literature, combined with word and hashtag analysis of social media data, revealed several key factors influencing consumers' participation in the treatment of WEEE. Notably, these factors include accessibility to recycling facilities, levels of consciousness and awareness, consumer confidence (or the lack thereof), financial incentives, charitable contributions, and concerns regarding data disclosure. These findings significantly impact consumer behavior related to WEEE treatment. Our study proposed four distinct EOL options for these products: remanufacturing, reusing, recycling, and disposal. Leveraging social media data, particularly data from Twitter, and employing the FAHP technique, we analyzed the relationships between these EOL options and the identified influencing factors. This allowed us to determine the most suitable EOL option for each factor. From the research findings, as depicted in Figure 7, it is evident that remanufacturing emerges as the most suitable EOL option when considering accessibility to recycling facilities. On the other hand, recycling appears as the most appropriate choice when examining factors related to raising consciousness. Furthermore, disposal proves to be the most suitable EOL option in cases where a lack of confidence in the system and financial incentives are predominant factors. Reusing is identified as the most suitable EOL option when charitable donations and concerns about data disclosure hold sway.

5.1. Theoretical Implication

This study focuses on two primary theoretical concepts: the factors influencing consumer participation in WEEE treatment and the appropriate **EOL** options for WEEE. While numerous studies in various countries have explored consumer participation in WEEE treatment, there is a noticeable dearth of research examining the best EOL options from a consumer's standpoint. Our approach utilized social media data mining techniques to discern the factors affecting consumer participation in WEEE treatment by analyzing relevant Twitter posts. A review of prior research confirmed that our results align with existing studies, but the inclusion of a substantial number of consumers over a two-year period offered novel insights to the literature. This research aimed to pinpoint suitable EOL options for WEEE from the consumer's perspective through an efficient and scalable approach. It is imperative to recognize that these results are not set in stone and should undergo periodic monitoring and evaluation. The methodology employed in this research can be extended to ascertain appropriate EOL options for all types of electrical and electronic equipment, including but not limited to mobile phones, laptops, and televisions, thus contributing to academic research in this domain.

5.2. Managerial Implication

In today's world, the mounting **WEEE** is largely attributed to consumer behaviors and choices. Consequently, it is incumbent upon governments and companies to direct their attention toward consumers and their role in WEEE treatment and management programs. Such focus is vital for safeguarding the environment and mitigating the risks posed to environmental well-being by the burgeoning WEEE issue. Notably, the research findings have highlighted the disposal system as one of the most prominent systems in the hierarchy framework, particularly in the absence of financial incentives. This discovery holds significant implications for understanding consumer behavior in the context of WEEE treatment. The prominence of the disposal system underscores the fact that when financial incentives are lacking, consumers are more inclined to opt for disposal as an **EOL** option for their electrical and electronic equipment. This finding aligns with and adds depth to the existing literature, which has often emphasized the pivotal role of financial incentives in incentivizing recycling and environmentally responsible behavior. It underscores the critical role those economic considerations play in shaping consumer choices concerning the treatment of WEEE. Industry practices and policies should take cognizance of the strong influence of financial incentives on consumers' choices. Therefore, promoting sustainable recycling practices and the responsible treatment of WEEE should be coupled with strategies that address the financial aspects and motivations behind consumer behavior in this domain.

6. Conclusion

In today's digital world, EEE has become an essential part of daily life. However, the increase in usage and their short lifespan can lead to environmental hazards, making the proper management and treatment of waste recycling of electrical and electronic equipment critical. The findings of studies have shown that WEEE has significant implications for the environment. As such, governments should provide support for WEEE recovery and encourage manufacturers to recycle WEEE properly. Failure to do so may result in a sudden rise in WEEE, causing significant harm to the environment. Since consumers are among the primary users of electrical and electronic equipment and contribute significantly to the production of WEEE, analyzing the factors affecting their participation in recycling schemes to determine appropriate EOL options is necessary. The aim of this article is to enhance readers' understanding of consumer involvement in WEEE management. We conducted a study to determine the most effective WEEE recycling techniques by identifying and ranking the variables that have the greatest impact on customer engagement.

Our proposed framework was developed using Twitter data analysis, which has become a valuable source of information due to its widespread use. Through data mining, we extracted tweets related to electrical and electronic equipment recycling and used the FAHP technique to determine appropriate EOL options for EEE. Based on our research, we considered four strategies for EOL: reusing, remanufacturing, recycling, and disposal. These strategies can help improve the management of electrical and electronic waste. The findings obtained in this study contribute to the following issues: better management of electrical and electronic equipment waste, finding the appropriate treatment for WEEE at the EOL stage, reducing the damage of WEEE to the environment. As a result, companies producing electrical and electronic equipment can formulate a long-term strategy for better management of e-waste by using the decision-making strategies proposed in this research.

Future research

After conducting a thorough evaluation, we identified research gaps and suggest the following directions for future studies. Despite recent growth in research on WEEE, more effort is required to establish a recycling network for this equipment. Thus, further research is needed for each type of electrical and electronic equipment. In future studies, other approaches, such as software modeling, market theory, or other exploratory techniques, can be used to investigate customer engagement in recycling WEEE. This study only utilized English-language tweets, so future research should consider tweets in other languages. Additionally, our results were limited to Twitter, so it is recommended that future studies incorporate other social networks, such as Facebook and Instagram, to obtain a more comprehensive understanding of customer engagement in WEEE recycling.

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Appendix 1. Questionnaire Questions and Expert Responses

No.	Questions	Number of experts with rating				
		5	4	3	2	1
1	Based on accessibility to recycling facilities factors, repair can be a suitable EOL option for WEEE management	11	8	1	0	0
2	Based on accessibility to recycling facilities factors, reuse can be a suitable EOL option for WEEE management	8	9	3	0	0
3	Based on accessibility to recycling facilities factors, recycling can be a suitable EOL option for WEEE management	8	6	3	3	0
4	Based on accessibility to recycling facilities factors, disposal can be a suitable EOL option for WEEE management	13	7	0	0	0
5	Based on awareness factors, repair can be a suitable EOL option for WEEE management	10	10	0	0	0
6	Based on awareness factors, reuse can be a suitable EOL option for WEEE management	11	4	5	0	0
7	Based on awareness factors, recycling can be a suitable EOL option for WEEE management	9	6	5	0	0
8	Based on awareness factors, disposal can be a suitable EOL option for WEEE management	4	6	6	4	0
9	Based on lack of confidence factors, repair can be a suitable EOL option for WEEE management	5	10	3	2	0
10	Based on lack of confidence factors, reuse can be a suitable EOL option for WEEE management	7	8	5	0	0
11	Based on lack of confidence factors, recycling can be a suitable EOL option for WEEE management	0	7	8	3	2
12	Based on lack of confidence factors, disposal can be a suitable EOL option for management	7	6	7	0	0
13	Based on financial incentives factors, repair can be a suitable EOL option for WEEE management	6	7	4	3	0
14	Based on financial incentives factors, reuse can be a suitable EOL option for WEEE management	6	8	6	0	0
15	Based on financial incentives factors, recycling can be a suitable EOL option for WEEE management	7	7	3	3	0

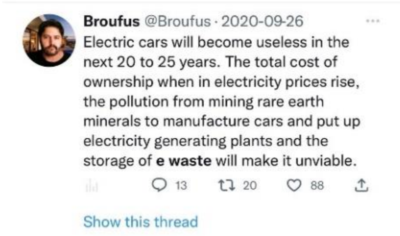
16	Based on financial incentives factors, disposal can be a suitable EOL option for WEEE management	7	6	5	2	0
17	Based on charitable donations factors, repair can be a suitable EOL option for WEEE management	10	7	3	0	0
18	Based on charitable donations factors, reuse can be a suitable EOL option for WEEE management	11	7	2	0	0
19	Based on charitable donations factors, recycling can be a suitable EOL option for WEEE management	0	7	9	2	2
20	Based on charitable donations factors, disposal can be a suitable EOL option for WEEE management	0	6	8	6	0
21	Based on concerns around data disclosure factors, repair can be a suitable EOL option for WEEE management	9	7	4	0	0
22	Based on concerns around data disclosure factors, reuse can be a suitable EOL option for WEEE management	9	8	3	0	0
23	Based on concerns around data disclosure factors, recycling can be a suitable EOL option for WEEE management	0	7	7	5	1
24	Based on concerns around data disclosure factors, disposal can be a suitable EOL option for WEEE management	8	8	4	0	0

Appendix 2: Composition of the expert panel

Years of work experience	Gender: F=Female M=Male	Countries: United states (US) Canada (Ca) Germany (Ge) China (Ch) Turkey (Tr) Malaysia (Ma) Iran (Ir) Australia (Au) France (Fr) India (In)	Industry experts with xperience working in WEEE treatment	rts in cademia and eoretical work rience in WEEE treatment
5-10	3 (F) 2(M)	2(Ir), 2(Au), 1(Fr)	2	4
10-15	3(F) 4(M)	2(Ca), 1(Ma), 2(In), 1(Us), 1(Tr)	1	5
15-20	1(F) 3(M)	2(Ge), 1(Fr), 1(Ch)	3	2
20-25	0(F) 3(M)	2(Us), 1(Ch),	1	1
>25	0(F) 1(M)	1(Us)	1	0

Total	7(F) 13(M)	2(Ir), 2(Au), 2(Fr), 2(Ca), 1(Ma), 2(In), 4(Us), 1(Tr), 2(Ge), 2(Ch) =20	8	12

Appendix 3: examples of collected tweets



Appendix 4: The pre-processing steps performed on a sample of tweets are fully described:

Method	Tweet
Tweet	From #AI to #ewaste, a different ball game altogether. Secretary @Gol_MeitY inaugurated the 1000T PCB recycling equipment at #coe #ewaste, CMET, Hyderabad. Well, on a mission to save the planet #Earth! @jayesh_ranjan @Gol_MeitY @EmergingTechTS pic.https://pbs.twimg.com/media/FnfLQsKakAAEyWK.jpg
Lowercase	from #ai to #ewaste, a different ball game altogether. secretary @gol_meity inaugurated the 1000t pcb recycling equipment at #coe #ewaste, cmet, hyderabad. well, on a mission to save the planet #earth! @jayesh_ranjan @gol_meity @emergingtechts pic.https://pbs.twimg.com/media/FnfLQsKakAAEyWK.jpg
Remove usernames	from #ai to #ewaste, a different ball game altogether. secretary inaugurated the 1000t pcb recycling equipment at #coe #ewaste, cmet, hyderabad. well, on a mission to save the planet #earth! pic.https://pbs.twimg.com/media/FnfLQsKakAAEyWK.jpg
Remove the website	from #ai to #ewaste , a different ball game altogether. secretary inaugurated the 1000t pcb recycling equipment at #coe #ewaste , cmet, hyderabad. well, on a mission to save the planet #earth!
Remove punctuation	from ai to ewaste a different ball game altogether secretary inaugurated the 1000t pcb recycling equipment at coe ewaste cmet hyderabad on a mission to save the planet earth
Remove small words	from ewaste different ball game altogether secretary inaugurated the recycling equipment ewaste hyderabad mission save planet earth
Remove stop words	ewaste different ball game secretary inaugurated recycling equipment ewaste hyderabad mission save planet earth
Stemming	ewaste differ ball game secret inaugurate recycle equip ewaste hyderabad mission save planet earth
Tokenization	‘ewaste’, u’differ’, u’ball’, u’game’, u’secret’, u’inaugurate’, u’recycle’, u’equip’, u’ewaste’, u’hyderabad’, u’mission’, u’save’ , u’planet’, u’earth’

Appendix 4: Geometric mean of indicators

Row	Pair indices	Geometric mean
1	Accessibility to recycling facilities	4.007600617
2	Raising consciousness and Awareness	4.127687941
3	Lack of confidence	5.171488673
4	Financial incentives	3.65008825
5	Charitable donations	3.500278245
6	Concerns around data disclosure	3.859633166
7	Remanufacturing	5.785092887
8	Reusing	4.393147265
9	Recycling	4.915730257
10	Disposal	4.079605376

Appendix 5: Guide to answering questions and scoring pattern

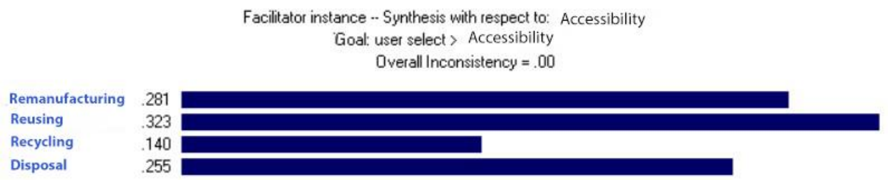
Value	Priority	Description
1	Same priority	Indicator i has equal importance to j or they are not preferred.
3	Slightly preferred	Indicator i is slightly more important than j.
5	Very preferred	Indicator i is more important than j.
7	Very much preferred	Indicator i is much more preferable than j.
9	Absolutely preferred	Indicator i is absolutely more important than j and is not comparable to j.
2, 4, 6, 8	Middling	The values between the preferred values show, for example, 8 is more important than 7 and less than 9 for i.

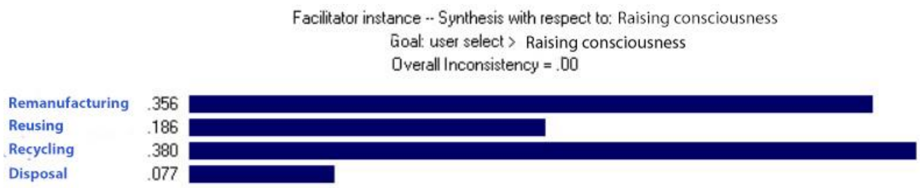
Appendix 6: Answers of the experts to the questionnaire

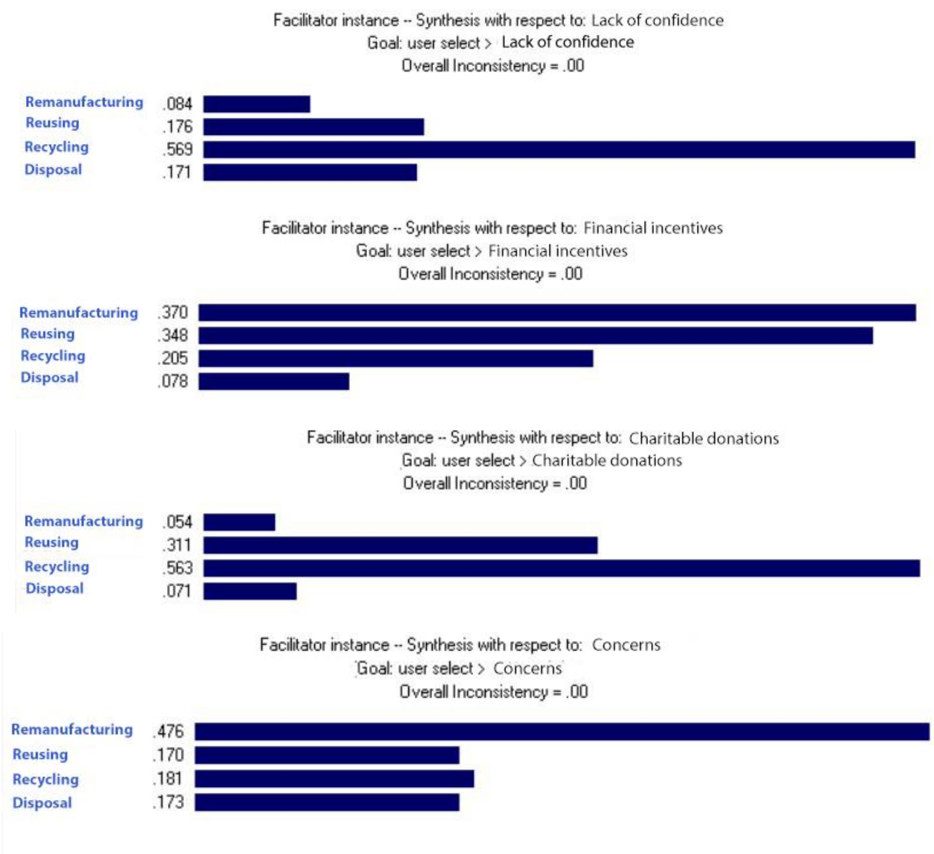
Indicators (j)	Priorities																	Indicators (i)
									Based on Accessibility to recycling facilities factors:									
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling
									Based on Raising consciousness and awareness factors									
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing

disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling
Based on Lack of confidence to the system factors:																		
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling
Based on Financial incentives factors:																		
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling
Based on Charitable donations factors:																		
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling
Based on Concerns around data disclosure factors:																		
reusing	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	remanufacturing
recycling	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	reusing
disposal	٩	٨	٧	٦	٥	٤	٣	٢	١	٢	٣	٤	٥	٦	٧	٨	٩	recycling

Appendix 7: Outputs from the software for analyzing the results






Facilitator instance -- Synthesis with respect to: Lack of confidence
Goal: user select > Lack of confidence
Overall Inconsistency = .00
Remanufacturing .084
Reusing .176
Recycling .569
Disposal .171
Facilitator instance -- Synthesis with respect to: Financial incentives
Goal: user select > Financial incentives
Overall Inconsistency = .00
Remanufacturing .370
Reusing .348
Recycling .205
Disposal .078
Facilitator instance -- Synthesis with respect to: Charitable donations
Goal: user select > Charitable donations
Overall Inconsistency = .00
Remanufacturing .054
Reusing .311
Recycling .563
Disposal .071
Facilitator instance -- Synthesis with respect to: Concerns
Goal: user select > Concerns
Overall Inconsistency = .00
Remanufacturing .476
Reusing .170
Recycling .181
Disposal .173