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ASSESSING THE VALUE OF DIFFERENT UTILIZED ATTRIBUTES ON RESIDENTS' BEHAVIOR AND PREFERENCES FOR PROPOSED E-WASTE RECYCLING SERVICES

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ABSTRACT

Inappropriate e-waste management is a matter of deep concern that requires an urgent and international response involving stakeholders at different levels. As each resident is a key link in a chain associated with e-waste recycling strategies, it is crucial to understand the utmost important attributes affecting residents' behavior and preferences for proposed e-waste recycling services. This study attempts to identify the level of the importance of different utilized attributes using a Vietnamese sample. Data collected from 538 residents were subjected to descriptive analysis and factor analysis to assess the level of importance and factorial structure of the selected attributes. It is found that attributes pertaining to law compliance and the trust in the effectiveness of e-waste recycling organizations, environmental conservation, and recycling consulting services are the most important aspects, followed by the convenience of the collection services and economic benefits. Factor analysis suggests a two-factor model, in which the first one relates to the environmental consciousness and responsibility while the second one concerns the utility. These findings support the scientific community and environmental managers with a valid and reliable reference for determining priority levels when designing an effective e-waste recycling scheme, aiming at accelerating the goal of sustainable development and circular economy.

Contribution/Originality: This research contributes to the existing literature by providing empirical insights about the importance of different utilized attributes on residents' behavior and preferences for proposed e-waste recycling services, which are a useful reference for achieving the goal of environmentally sound management of hazardous waste.

1. INTRODUCTION

An ever-alarming amount of waste from electrical and electronic equipment (e-waste) is a matter of deep concern that requires an urgent response involving proper management. According to the latest data, it is recorded that there were approximately 53.6 million metric tonnes generated globally in 2019 with its estimation to reach 74.7 million metric tonnes by 2030 (Forti, Balde, Kuehr, & Bel, 2020). With the rapidly growing rates of e-waste disposal, concerns about negative consequences including the loss of precious materials and threats to human health and the environment have raised great challenges to solve the issue of e-waste management (Qu, Wang, Liu, & Zhu, 2019; Xu & Yeh, 2017). In fact, e-waste contains valuable substances that can be recycled and reused as input resources, which are later used in the next steps of the manufacturing cycle. On the other side, toxic compounds in

e-waste are associated with dangerous potential for human health and the ecological system (Araújo, Magrini, Mahler, & Bilitewski, 2012; Saumya & Vaish, 2015). Therefore, to maintain sustainable development that aims at waste reduction and natural resources conservation, the appropriate e-waste treatments should be put on the top priority. Of the current waste management strategies, recycling is proved to be one of the most effective methods that focus on pollution reduction and resources and energy conservation, which is aligned with the target of "responsible consumption and production" presented in Sustainable Development Goals 12 (Echegaray & Hansstein, 2017; ECOSOC, 2019; Nazatul, Sidique, & Radam, 2017; Shevchenko, Laitala, & Danko, 2019). Numerous earlier studies indicated that the emphasis on improving the collection rate is considered a fundamental step, contributing to the success of the e-waste recycling approach (Golev, Werner, Zhu, & Matsubae, 2016; Islam & Huda, 2018). However, the rate of e-waste recycling is still near the bottom line, which implies that there is a big problem with collection activities. For example, while there are nearly 40.7% of e-waste generated in Asia, only 15% of them was collected properly, raising the question of where is the rest of this huge amount of e-waste and its fate (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017).

To improve the collection rate of e-waste, and in turn, gain the success of the recycling target, one of the key measures that should be taken is to enhance the level of resident participation (Tan, Duan, Liu, Yang, & Li, 2018). Realizing the important role of the community involvement in e-waste recycling collection and recycling approaches, several studies have been conducted to explore the fundamental factors affecting residents' behaviors and preferences for e-waste recycling services (Nduneseokwu, Qu, & Appolloni, 2017; Qu et al., 2019). For example, in the investigations of Sidique, Lupi, and Joshi (2010) and Qu et al. (2019) collection method and collection fees were found to be significant attributes influencing citizens' decision to engage in e-waste recycling, respectively. Other crucial factors were also reported, such as legislation and regulation (Pandebesie, Indrihastuti, Wilujeng, & Warmadewanthi, 2019; Wang, Guo, & Wang, 2016) convenience (Chi, Wang, & Reuter, 2014; Miliute-Plepiene, Hage, Plepys, & Reipas, 2016) compensation mode (Qu et al., 2019) residents' environmental awareness (Tanskanen, 2013; Wang et al., 2016). However, the evaluation of the effect of these above-mentioned factors appeared separately in different studies, which makes it difficult to compare which attributes are the most important. Therefore, it is urgent to have a clearer and more comprehensive understanding of the main factors affecting residents' behaviors and preferences for e-waste recycling services, which in turn guides the managers and decision-makers to determine the priority approach aimed to improve collection and recycling rate. The objective of this study is to explore the level of importance of different utilized attributes on residents' behavior and preferences for proposed e-waste recycling services, which is ranked based on a mean value of each attribute. In addition to this, it also is of great importance to assess whether the underlying dimensions are related among selected attributes; therefore, the factor analysis technique is used to group attributes into descriptive categories with similar characteristics.

2. METHODOLOGY

2.1. Research Design

To fulfill the research goal, based on the literature review and experts' opinions through in-depth interviews, attributes affecting residents' behaviors and preferences for e-waste recycling services were selected. The research targets five large common e-waste originating from refrigerators, air conditioners, washing machines, desktop computers, and television sets. The questionnaire was then designed and included three sections. The introductory part provides respondents with general pictures about e-waste, the importance of its proper collection and treatment, and an introduction to a proposed e-waste recycling program. The second section is about the attributes affecting residents' behaviors and preferences for e-waste recycling services. A five-point Likert scale was used to weigh the level of the importance of each attribute, which ranges from 1 for "not very important" to 5 for "very important". The last section of the questionnaire is to collect the personal information of respondents, including

gender, age, level of education, average income, household size, and living area. Before conducting the official interview, the questionnaire was sent to two experts and twenty residents for doing a pre-test survey. According to the comments and feedback collected through this trial, revisions and corrections were made to ensure the feasibility of the questionnaire. Data obtained from the interview was then analyzed and the level of importance of different utilized attributes on residents' preference for proposed e-waste recycling services was evaluated by ranking mean value of each attribute. A factor analysis technique was employed to classify attributes into descriptive categories with common characteristics. Factor analysis is a multivariate technique, aiming to identify underlying variables, in turn, explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance that is observed in a much larger number of manifest variables. The research process is illustrated in Figure 1.

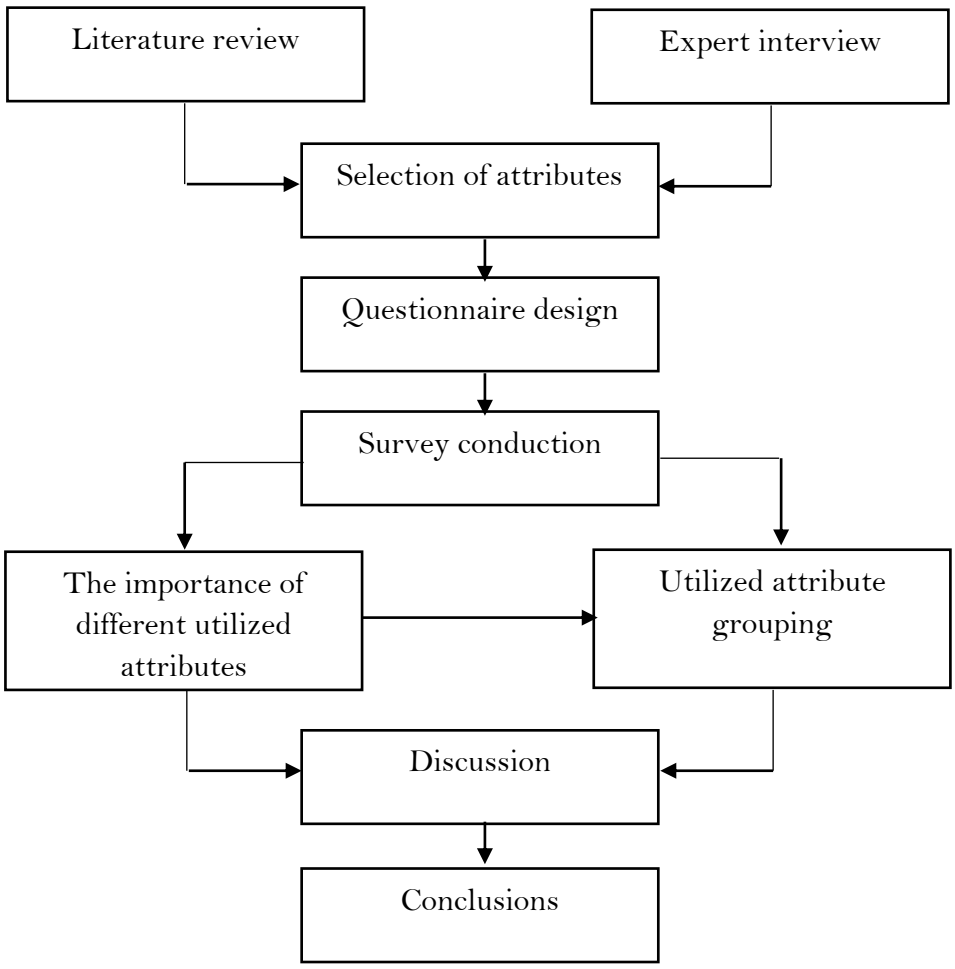

Figure 1. Research framework of this study.

2.2. Attribute Selection

As earlier discussed, the selection of attributes is a key step of the current investigation. On the basis of the literature review and in-depth interviews with waste management experts, eleven key attributes were included in this research, namely, (A1) e-waste legislation and regulation; (A2) e-waste recycling consultancy; (A3) e-waste collection mode; (A4) e-waste collection frequency; (A5) e-waste collection distance; (A6) e-waste collection fees; (A7) e-waste recycling companies and organizations; (A8) incentives or compensation; (A9) environmental benefits of e-waste recycling; (A10) data security; (A11) self-awareness on environmental protection.

E-waste legislation and regulation (A1): Several studies reported that legislative policy is a key attribute that drives residents' recycling intention (Hicks, Dietmar, & Eugster, 2005). Findings from recent investigations

conducted in China also confirmed that government laws and regulations had a positive effect on the willingness of residents to recycle e-waste (Wang et al., 2016; Yu, He, Li, Huang, & Zhu, 2014). However, the importance of legislation attributes in explaining residents' participation in the e-waste recycling scheme is inconsistent. (Pandebesie et al., 2019) found that regulation was a positive influence on recycling involvement, while Wang, Zhang, Yin, and Zhang (2011) and Saphores, Ogunseitan, and Shapiro (2012) revealed a non-significant correlation between knowledge of e-waste laws and residents' engagement.

E-waste recycling consultancy (A2): Consulting services aimed to equip people with the knowledge and skills to gain a better understanding of how to discard used electronic devices in an environmentally friendly way have been introduced to be a crucial factor associated with residents' involvement in recycling (Cooper & Mayers, 2000; Siringo, Herdiansyah, & Kusumastuti, 2020; Tanskanen, 2013).

E-waste collection mode (A3): Previous studies revealed that the collection method had a significant effect on recycling participation (Chi et al., 2014; Nazatul et al., 2017; Sidique et al., 2010; Tan et al., 2018). There are two main modes of e-waste collection, namely, drop-off and pick-up (Chowdhury, 2009; Sidique et al., 2010). While a drop-off service is welcomed in several studies (Le, Tran, & Pham, 2012; Nixon, Saphores, Ogunseitan, & Shapiro, 2009; Sidique et al., 2010) a pick-up collection service is preferred by a huge of residents (Bai, Wang, & Zeng, 2018; Chi et al., 2014; Karousakis & Birol, 2008).

E-waste collection frequency (A4): The collection frequency for recycling is one of the key determinants of residents' disposal preference, which was indicated in earlier studies (Eddy & Finigan, 2014; Hornik, Cherian, Madansky, & Narayana, 1995). This attribute presents the conditions and convenience that the collection service offers, for example, the number of times per week or per month recycling vehicles pick-up.

E-waste collection distance (A5): Published papers pointed out the importance of the collecting distance for the decision towards different e-waste collection services (Miliute-Plepiene et al., 2016; Tan et al., 2018). As reported by Saphores et al. (2012) the farther the collection distance caused the lower number of collected e-waste.

E-waste collection fees (A6): The collection fee is the monetary attribute, which refers to the amount of money that residents have to pay for using the collection service. It is believed that the higher the expenditure on e-waste recycling is, the weaker likelihood of residents' intention is. According to (Wang et al. 2016), the residents' intention toward recycling e-waste decreased when the cost of recycling increased, even residents may refuse to participate in formal recycling programs if they have to pay more. However, other researchers also concluded that recycling cost is not statistically significant (Saphores et al., 2012).

E-waste recycling companies and organizations (A7): This attribute refers to the organizations that are in charge of collecting and recycling e-waste, including self-employed collectors, private companies, governmental collectors, and non-government organizations. It is reported that Chinese residents preferred to send their discarded electronic devices to the formal e-waste collection channels (Qu et al., 2019; Tan et al., 2018). In line with this idea, recent studies conducted in Vietnam also emphasized the role of formal organizations in the-waste recycling program (Hai, Hung, & Quang, 2017; Tran & Salhofer, 2018).

Incentives or compensation (A8): This attribute refers to the benefit a resident receives when sending e-waste to collectors. The benefits are not only cash but also vouchers, award points, coupons, or certificates. It is found that incentives have been proved a key antecedent of residents' willingness and behavior toward e-waste recycling (Wang et al., 2011). Nnorom and Osibanjo (2008) and Jafari, Heydari, and Keramati (2017) confirmed that offering economic incentives increased resident participation in the recycling program. However, Nduneseokwu et al. (2017) argued that there was no correlation between incentives and recycling commitment.

Environmental benefits of e-waste recycling (A9): Opposite to tangible benefits that can be received from incentives or compensation, intangible beneficial attribute so-called environmental benefits that residents can gain is the quality of environment presented through levels of waste reduction and resource conservation (Nazatul et al.,

2017; Sophie, Christophe, & Jeff, 2009). It was found that the higher the recovery rate, the more preferred for e-waste recycling services made by residents (Sophie et al., 2009).

Data security (A10): This is an important and ongoing concern when consumers discarded their electronic devices such as mobile phones, computers, etc. It was found that 63.7% of respondents refuse to involve in e-waste recycling because of the data safety reason (Tan et al., 2018). Therefore, data security is listed to be the most important factor affecting residents' decision to participate in the e-waste recycling program (Bai et al., 2018).

Self-awareness on environmental protection (A11): Residents' environmental protection consciousness has been proved a significant attribute that effectively motivates recycling behavioral intention (Kochan, Pourreza, Tran, & Prybutok, 2016; Nixon & Saphores, 2007; Tanskanen, 2013; Tonglet, Phillips, & Read, 2004; Wang et al., 2016).

2.3. Sample and Data Collection

The research survey was conducted in December 2021 in Danang, a coastal city in the central part of Vietnam. The research questionnaire was distributed to households located in six urban districts, namely Thanh Khe, Hai Chau, Cam Le, Lien Chieu, Son Tra, and Ngu Hanh Son, by using a multi-stage sampling technique. Here, a combination of stratified sampling and simple random sampling was usually applied. The first step involves proportionally dividing the population into six groups based on the residential area (district). The second step was the selection of households that were invited to be interviewed by the random sampling method. Interviews were conducted in 600 houses sheltering in six districts. After screening to check the quality of the collected questionnaires, 538 answers were valid for further analysis, which yields a valid response rate of 89.67%.

2.4. Analytical Methods

The collected data were analyzed using TIBCO Statistica 14.0.0 (TIBCO Software Inc.). Firstly, residents' demographic data and the mean value of each attribute were calculated by using a descriptive statistics tool. In the next stage of the analysis process, factor analysis was applied to learn more about the number of factors "behind" the utilized attributes and their meaning. For factor analysis, the following criteria were set: principal components were selected as an extraction method, Eigenvalue is higher than 1 or percentage of variance explained is larger than 50%; factor loadings are greater than 0. 500 (Hair, 2010) and varimax raw was selected to perform a varimax rotation.

3. RESULTS AND DISCUSSION

3.1. Characteristics of the Sample

The demographic profile of respondents is demonstrated in Table 1. It can be seen that the number of males participated in this study is nearly doubled that of females, 62.45% compared to 36.80%, respectively. It is reasonable because the study aimed to invite the head of each household (mostly men in Vietnamese culture) to answer the questionnaire. Most of the participants are in the age groups of (18-30) years old, while the middle age respondents in two groups of (31-40) and (41-50) are almost equal, making the seniors aged over 50 the least. Regarding education level, more than half of respondents finished tertiary or graduate level, 59.85% in total. Among 538 investigated households in this study, most of them have four members (45.54%), while the number of households with less than four numbers is small (15.06%), being less than a half of that with more than four members (39.40%). In terms of average income, a majority of respondents (54.65%) revealed that their earnings were less than 6 million Vietnamese Dong (VND), while 26.58% and 18.78% of them get the average (6-10) and more than 10 million VND per month, respectively.

Table 1. Respondents' demographic profile (sample size N = 538).

Demographic Variables		Frequency	Percentage (%)
Gender	Female	198	36.80
	Male	336	62.45
Age (years old)	<=20	140	26.02
	21-30	170	31.60
	31-40	83	15.43
	41-50	85	15.80
	51-60	42	7.81
	>60	18	3.35
Educational level	Lower secondary	69	12.83
	Upper secondary	108	20.07
	College/ Vocational education	39	7.25
	University	264	49.07
	Master's degree or above	58	10.78
Family size (number of members)	1	3	0.56
	2	15	2.79
	3	63	11.71
	4	245	45.54
	5	125	23.23
	>5	87	16.17
Income (million Vietnamese Dong)	< 6	294	54.65
	6-10	143	26.58
	10-15	46	8.55
	15-20	20	3.72
	> 20	35	6.51
Residential Area	Thanh Khe	104	19.33
	Son Tra	86	15.99
	Hai Chau	142	26.39
	Ngu Hanh Son	39	7.25
	Lien Chieu	100	18.59
	Cam Le	67	12.45

Note: Vietnamese Dong equals to approximately 0.000044 US Dollar.

3.2. The Importance of Utilized Attributes

To explore how much each of the utilized attributes would affect residents' behavior and preference for proposed e-waste recycling services. The level of importance of eleven selected attributes was ranked, shown in Table 2, calculated by the mean value of each attribute from all respondents. It can be seen that law compliance (A1) and environmental awareness (A11) play the most important role in residents' decision to participate in the recycling program, followed by the trust in the effectiveness of e-waste recycling organizations (A7), environmental conservation (A9), and recycling consulting services (A2). The convenience of the collection services, including mode (A3), frequency (A4), and distance (A5) are the moderately important attributes, making the concern of data security (A10), incentives (A8), and collection fee are the least important factors.

Findings indicate that residents considered "e-waste legislation and regulation" the most important factor that affects their decision whether to participate in the recycling program, which is in agreement with previous studies performed by Nduneseokwu et al. (2017) and Wang et al. (2016). In fact, it is apparent that the power of laws and regulations is one of the strongest factors affecting residents' behavior. From this point of view, the introduction of enforced legislation specified in e-waste recycling is necessary, which also clearly specifies the responsibility of residents in e-waste recycling. Along with force motivation by the laws, the voluntary of residents is another vital key of recycling involvement (Nnorom, Ohakwe, & Osibanjo, 2009; Ramayah, Lee, & Lim, 2012) which explains why "Self-awareness on environmental protection" comes in the second place, which its mean value is 4.032.

Table 2. The importance of the attributes related to e-waste recycling schemes.

Attributes	Importance	Standard Deviation	Rank
E-waste legislation and regulation (A1)	4.102	0.983	1
Self-awareness on environmental protection (A11)	4.032	1.084	2
E-waste recycling companies and organizations (A7)	3.944	0.977	3
Environmental benefits of e-waste recycling (A9)	3.903	1.077	4
E-waste recycling consultancy (A2)	3.894	0.936	5
E-waste collection mode (A3)	3.844	1.015	6
E-waste collection frequency (A4)	3.745	0.975	7
E-waste collection distance (A5)	3.706	1.012	8
Data security (A10)	3.699	1.144	9
Incentives or compensation (A8)	3.500	1.027	10
E-waste collection fees (A6)	3.444	1.155	11

The quality of the organizations being responsible for e-waste collection and treatment is also among the concern of residents, followed by the commitment to environmental benefits gained through recycling activities (Hornik et al., 1995; Sophie et al., 2009). Regarding collection services, the method of e-waste collection (drop-off or pick-up), the frequency of e-waste collection, and the distance required for traveling to collection sites are influential attributes, which affect residents' determination to be involved in e-waste recycling. As indicated in earlier investigations, pick-up services are preferred over the drop-off method, especially for large types of e-waste (Bai et al., 2018; Chi et al., 2014; Sophie et al., 2009). In addition, the proximity of collection sites was proved to bring more convenience for those who preferred to discard their obsolete electronic devices by the drop-off method (Saphores et al., 2012). It is interesting from the research's findings that the financial benefits are ranked as the least important attributes. To be specific, incentives or compensation and collection fees are not the top concern of residents when considering doing recycle. It can be explained by the fact that residents realized that the importance of environmental protection is higher than the economic benefits.

3.3. Factor Analysis

Factor analysis was employed to explore the relationships between eleven chosen attributes discussed above. Principal components extraction method with the varimax rotation was performed on the 11 attributes and suggested the two factors. However, there were two attributes with factor loading lower than 0.500 (A4 and A10) and thus, excluded from the model. With a model of the 9 attributes left, there were also 2 factors extracted from this second run of factor analysis, in which Factor 1 contains 5 attributes (A1, A2, A7, A 9, A11) and Factor 2 includes 4 attributes (A3, A5, A6, A8). To check the reliability, or internal consistency, of a set of attributes in each factor, Cronbach's alpha was adopted, with a widely accepted value of greater than 0.6 (Hair, 2010). The research's results show that while Cronbach's alpha of Factor 2 satisfies the desired value, that of Factor 1 cannot pass the test. The reason is that Cronbach's alpha if item deleted of A11 in Factor 1 is higher than the overall Cronbach's alpha of Factor 1 (0.709 compared to 0.687, respectively). Therefore, to ensure the internal consistency of all attributes in Factor 1, A11 was removed, and there were four attributes left in Factor 1. The subsequent factor analysis of eight remaining attributes suggests a two-factor model, together explaining 53.088% of the total variation, with the Eigenvalues of Factor 1 and Factor 2 being 3.173 and 1.075, respectively. Figure 2 illustrates the line graph of the Eigenvalues in order to perform Cattell's scree test. It can be seen that the point could be at Factor 2 where the continuous drop in Eigenvalues levels off suggests the cutoff (>1).

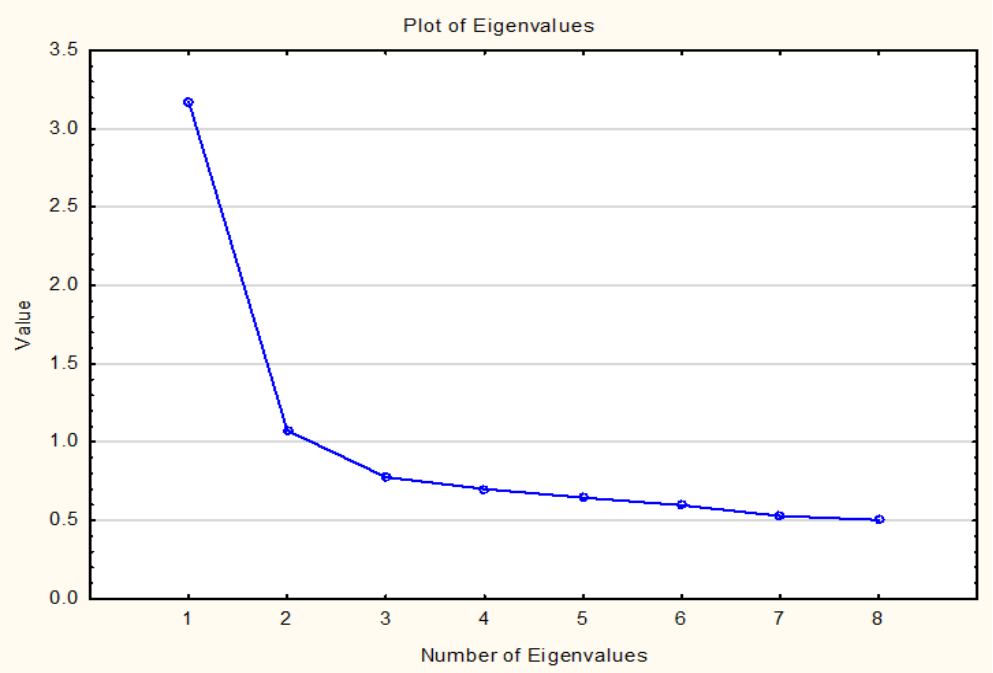

Figure 2. Scree plot.

Factor loadings of the remaining eight items are presented in Table 3. Two factors are best identified for the mental state variable and the useful, profitable, or beneficial state variables, in which Factor 1 accounts for 39.657% of the variance (α = 0.709) and shows the highest loadings for the items pertaining to the environmental consciousness and responsibility. Factor 2 that accounted for 13.432% of the variance (α = 0.672) shows the highest loadings for the utility, which is presented in Figure 3.

Factor 1, the "environmental consciousness and responsibility" consists of "e-waste legislation and regulation", "e-waste recycling companies and organizations", "e-waste recycling consultancy", and "environmental benefits of e-waste recycling". This factor mainly delineates the individuals' concerns about the importance of the e-waste legislative system, the expectation of the e-waste recycling system and its benefits, and the recycling consulting services. "Environmental consciousness and responsibility" was proved to have a significant relationship with the recycling behavioral outcomes (Sharma & Bansal, 2013).

Factor 2, the "utility", involves the convenience and incentives that residents expected to gain through recycling activities. This factor includes "e-waste collection distance", "e-waste collection mode", "e-waste collection fees", and "incentives or compensation". The "utility" was considered an important factor in predicting residents' behavior and preferences for e-waste recycling programs (Bai et al., 2018; Jafari et al., 2017; Sidique et al., 2010).

Table 3. Factor loadings.

Attributes	Factor 1	Factor 2
E-waste legislation and regulation	0.778	
E-waste recycling companies and organizations	0.718	
E-waste recycling consultancy	0.700	
Environmental benefits of e-waste recycling	0.582	
E-waste collection distance		0.788
E-waste collection fees		0.657
Incentives or compensation		0.612
E-waste collection mode		0.574

Note: Extraction Method: Principal Component Analysis.
Rotation Method: Varimax raw.

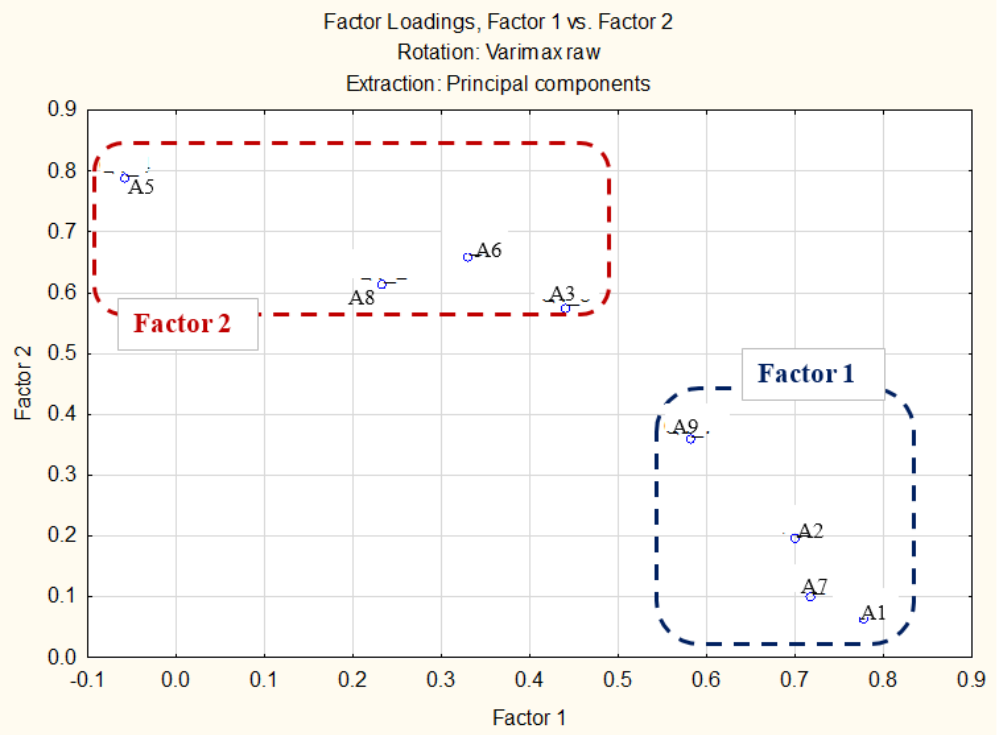

Figure 3. Component plot and rotated space of the exploratory two- factor solution.

4. CONCLUSIONS

This research delves into the importance of different utilized attributes on residents' behavior and preferences for proposed e-waste recycling services. Attributes referring to law and regulations and trust in the effectiveness of e-waste recycling organizations, environmental conservation, and recycling consulting services play a fundamental role in residents' decision-making regarding whether participate in recycling or not. Therefore, in order to contribute to a successful e-waste recycling and management system, the introduction and propaganda of legislative policy and environmental conservation strategy specified on e-waste recycling should be put on a top priority. The convenience of the collection services and economic benefits are also found to be influential factors, but the level of their importance is lower than that of the above mentioned attributes. Results obtained from factor analysis reveal that there are two factors extracted, the former one pertains to the environmental consciousness and responsibility while the latter delineates the utility. These findings support the scientific community and environmental managers a valid and reliable reference in stipulating an appropriate e-waste management approach, aiming to ensure environmentally sound management of hazardous waste and circular economy.

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