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A STUDY ON PUBLIC PERSPECTIVES OF E-WASTE COLLECTION IN KOCHI

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ABSTRACT

Digital revolution and advancement in technology has created a mammoth challenge in the form of electronic waste or e-waste. Severe environmental and health impacts have resulted from toxic hazards of e-waste. The role of public in e-waste management is essential in establishing a sustainable system in the society. The paper proposes an e-waste collection model for households through which easy disposal of e-waste can be ensured. The paper further analyzes the acceptance of the proposed model among households in Kochi city by the theoretical lens of Technology Acceptance Model.

Introduction

Electronic waste or e-waste consists of broken or unwanted electrical and electronic devices [1]. These are highly complex with toxic substances [Wang] and hence pose challenges in treatment or recycling [2]. E-waste at the household includes a large variety of equipments including television, refrigerator, computer, washing machine, mobile phone, etc. [3]. The rapid growth of technology has exponentially increased the discarded electronics or e-waste dumps across the world [4].

Health [6] and environmental [7] challenges created by the e-waste toxins are enormous. Health hazards of e-waste affect reproductive system, neuro-system, immunity, skin, kidney, liver, and can also lead to cancer [8, 9, 10, 11, and 12]. Environmental impacts of e-waste include contaminated soil, air, and water bodies in traditional backyard recycling locations, leaching of chemicals and toxins to atmosphere, climatic changes etc. [13, 14, and 15] and even administrative challenges leading to illegal trafficking [16] in poor and developing countries. Management of e-waste involves activities covering collection, transportation or logistics, segregation and dismantling, and recycling [17] to ensure resources and materials are utilized optimally [18]. This brings us to think of the source of e-waste generation, the households. Although bulk users generate majority of e-waste, they were not included in the scope of this study. The objective of this paper was to propose a model to encourage households to return or dispose e-waste through a systematic network that would lead to environmentally safe practices of e-waste treatment. The intention to use the proposed model was pilot tested among households in Kochi city. The paper used the theoretical background of the Technology Acceptance Model [19]. The study would benefit the stakeholders in e-waste scenario and research community in e-waste management.

Background

E-waste disposal is challenging for households and therefore selling to informal collectors is preferred commonly [20 and 21]. The treatment and recycling processes of the informal sector are harmful to life and environment [22]. In advanced countries, collection systems are provided through municipality sites, retailer or producer take back schemes, where further treatments are conducted as per best-available technologies [23]. However, e-waste dumps from many countries are sent to developing countries and less-developed countries [23] for end-processing. These countries face the challenges not just of e-waste generation internally but also as exports and illegal dumps from many other countries [24]. The E-waste (Management and Handling) Rules 2011, 2016 mandates channelization of e-waste [25]. However, the existing infrastructure and mechanism of e-waste collection and handling in the country is not sufficient. This is the phase where technological advancement can be a turning point for the e-waste industry by creating a proper mechanism for e-waste collection and further, environmentally safe processing. Block chain digital paradigm is an innovative concept applied in the area of e-waste management by integrating stakeholders on a common platform and enabling targeted collection through careful monitoring [26]. A study in China proposed a cloud-based information sharing platform to connect stakeholders for efficient e-waste management system enabled with Enterprise Resource Planning (ERP) [27]. Another study proposed an Internet-of-Things (IoT) and Big Data Technologies enabled e-waste management system that covers the information flow throughout the life of electronic equipment enabling total control of the product movement and processes [28]. Hence, it is important to understand and adopt technology as possible solutions for e-waste management in the future.

E-Waste Collection Model

E-waste collection or disposal from households is the starting point for a successful e-waste management system. Modern technology, e-commerce and infrastructure have evolved to facilitate convenience and easy access to almost all spheres of life. A study found that trust in a website, perceived usefulness and perceived ease of use influences the intention to use the commercial website again [29]. IoT enabled machine-to-machine communication has transformed e-waste and environmental management scenarios [30]. An Internet-of-Things (IoT) enabled smart solid waste collection model was proposed in Siliguri city in West Bengal that functions on cloud and mobile-monitoring systems [31]. In Malaysia, a sensor based e-waste collection box was designed that monitors collection levels and generates pick-up [32]. The application of IoT technology [33], sensors or Wireless Sensor Network (WSN) with digital information of devices [34], and radio-frequency identification (RFID) enabling tagging of devices [35], transforms the traditional methods of reaching to consumers.

We propose an IoT enabled e-waste collection model (Fig.1) that would ensure return of household e-waste to the manufacturer (E-waste Management and Handling Rules, 2011). This would further enhance application of Extended Producer Responsibility (EPR) Principle (E-waste Management and Handling Rules, 2011) by facilitating periodic returns of electronic waste from households. At the time of purchase, consumer information is integrated with an e-waste portal of the product marketer. A unique identification number for the device enables easy access of information throughout the life of the electronic device [35]. Therefore, at the end-of-life of the device, the information enabled on mobile application can be made use of by the consumer to schedule collection with the press of a button. The traditional informal e-waste collection can be avoided by introducing a Deposit-Refund Scheme [36]. This is a fee collected from the consumers during purchase for end-of-life management which is refunded during e-waste return [36]. Informal unit workers made part of the modern collection system can provide collection from the households to the Producer Responsibility Organizations (PRO) responsible for managing e-waste (E-waste Management and Handling Rules, 2016). The recyclers and the original manufacturers are links in the network. Government authority and the financial intermediaries such as banks are included in the network for transparency and monitoring of the system. The dotted arrows in the model indicate the communication flow between the stakeholders over the e-waste information portal.

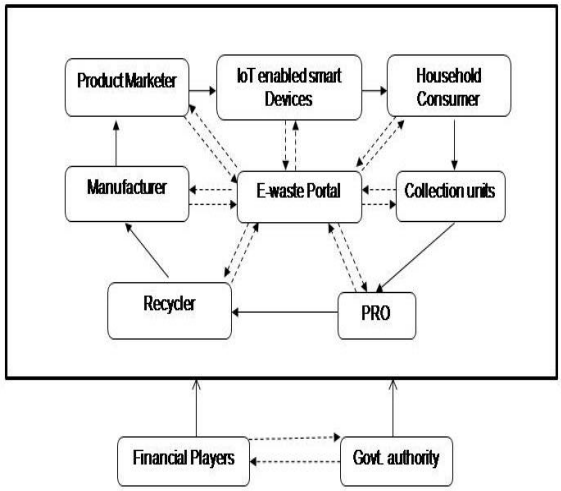

Fig.1. E-waste Collection Model

The implementation of the model will ensure a systematic return of obsolete household e-waste and thereby ensure smooth functioning of e-waste management system.

Technology Acceptance Model (Tam)

The Technology Acceptance Model (TAM) [19] (Fig 2) is considered powerful in identifying household preferences towards acceptance of information systems [38, 39 and 40]. Originally [37] the theory was adapted from the Theory of Reasoned Action [41] to measure the individual intentions to accept information technology [42]. According to [19], the pre-implementation model of TAM is considered before implementing a technology [42]. The variables used for this model are perceptions of usefulness and ease of use [42] and have direct effect on intentions; however, after implementation of a technology, perceived ease of use has an indirect effect on intentions through perceived usefulness [42]. An individual's perspective of a technology is considered as perception of usefulness [43]. Perceived ease of use results in perceived usefulness as it measures the individual's perspective of the ease in using a technology [43]. Intention to use measures the individual intention in using a technology and usage behavior measures the actual usage.

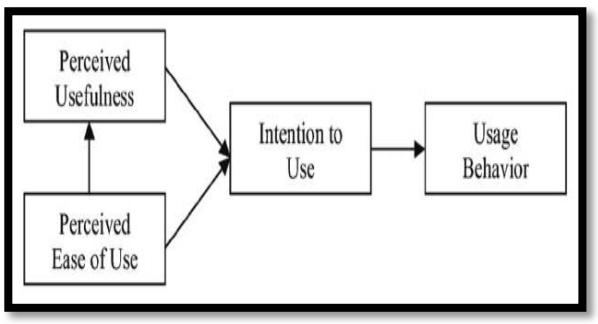

Fig.2. Technology Acceptance Model (Davis et al., 1989)

The Theory of Reasoned Action [41] and the Theory of Planned Behavior [44 and 45] model explain how attitudes predict intentions and actual behaviors [46]. Specific, environmental attitude is a construct of environmental psychology [47], ecological behavior [48] or pro-environmental behavior [49]. Literature showed prediction of subsequent behavior through environmental attitude [50and 51]. Habit or behavior sequences to a situation and occurs automatically [52] predicts future behavior [53].

For, the current study, measuring the acceptance of the proposed e-waste collection model (Fig.3) integrated with IOT was the technological development, in the existing scenario of e-waste management. The conceptual model was based on TAM [37], TRA [41], TPB Behavior [44 and 45], Environmental Attitude [54] and Habit [52].

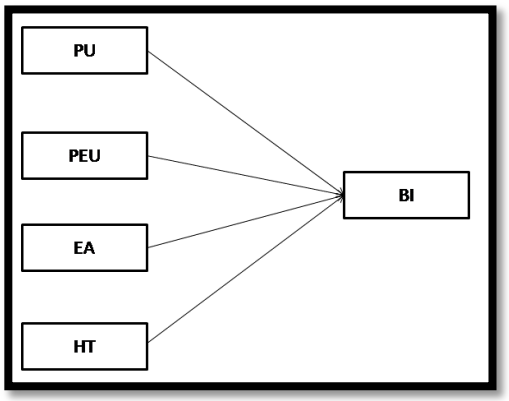

Fig.3. Conceptual Research Model

The research model included the following constructs, perceived usefulness (PU), perceived ease of use (PEU), environmental attitude (EA), habit (HT) of using technology and behavioral intention (BI) of returning e-waste using the proposed collection model [19, 41, 44, 45, 52 and 54].

Public Perspective

The proposed e-waste collection model in the study was analyzed through the perspectives of the households. This was included in the study to prove the acceptance of the collection model from the point-of-view of the households.

A. Study Area

The household survey was conducted in Kochi city of the southern coastal state of Kerala. The metropolis city is presently the largest urban agglomeration in Kerala. For this study, a total of 500 samples (100 samples from each location) were collected randomly from the five directions which were Pachalam in the north, Thevara in the south, Kakkanad in the east, Thoppumpady in the west and Thammanam in the central location. Out of these, 326 samples were complete and valid.

B. Methodology

The objective of the survey was to analyze the intention to return e-waste using the proposed e-waste collection model. A structured questionnaire schedule was framed through behavioral scales in literature.

C. Hypothesis development

Perceived Usefulness has found to influence behavioral intention in prior studies [55, 56 and 57]. Hence, the hypothesis H_1 PU strongly influence BI was proposed.

Perceived ease of use was found to have direct influence on intention [58, 59 and 60] in prior studies. Therefore, the hypothesis H_2 PEU strongly influence BI was proposed.

Environmental attitude was found to influence behavioral intention, although not strong [61, 62 and 63]. The hypothesis was thus proposed

H_3 EA strongly influences BI.

Habit was found to influence behavioral intention in prior studies [64, 65, 66 and 67]. The hypothesis H_4 HT strongly influences BI was proposed.

D. Measurement Scale

The primary data for the study was collected with a schedule. The constructs, measurement items and references based on which the questions were framed is given below:

Perceived Usefulness [68, 69, and 70]

PU1 Improve e-waste collection

PU2 Enhance e-waste scenario in state

PU3 Improve household participation

Perceived Ease of Use [68, 69, and 70]

PEU1 Easy to practice

PEU2 Easy to use

Environmental Attitude [71, 72 and 73]

EA1 Concern on environmental problems from e-waste

EA2 It is good to use technology for safe disposal of e-waste

Habit of using Technology [74, 75]

HT1 Frequent technology use

HT2 Comfortable in using technology

HT3 Addicted to technology

Behavioral Intention of e-waste collection technology [76 and 77]

BI1 Intention towards commitment to act

BI2 Intention towards e-waste returns using technology

BI3 Intention to behave environment friendly

The above described 5 constructs with total 13 items were included in the study. The respondents in the study were asked to rate the statements on a five-point Likert scale with the ratings as 1 –strongly disagree, 2- disagree, 3 – neutral, 4 – agree, 5 – strongly agree. The socio-demographic information of the respondents was also collected.

Results and Discussion

The results of the analysis are presented in this section. The tests conducted were simple percentage analysis, factor analysis and structural equation modeling (SEM) using IBM SPSS software and IBM AMOS software.

Respondent Demographic Profile

The study included a total of 326 valid responses. Table 1 presents the frequencies and percentages of the respondents and their demographic information.

The female respondents in the study were 170 (52.1%) and the male respondents were 156 (47.9%). Majority of the respondents belonged to the age group 35 to 45 years (30.1%). Aged persons above 65 years were least in the study (4.3%). The educational qualification of majority respondents was graduation with 114 numbers (35.0%). 105 respondents (34.2%) were employed in the private sector. The monthly household income was in the bracket of Rs 25000 to Rs 50000 (32.5%).

Table 1: Profile of the Respondents

Variable	Frequency	Valid Percentage
Gender		
Male	156	47.9
Female	170	52.1
Age		
Below 25	40	12.3
25 – 35	86	26.4
35 – 45	98	30.1
45 – 55	46	14.1
55 – 65	42	12.9

Above 65	14	4.3
Educational Qualification		
High School	27	8.3
Senior School	62	19.0
Graduate	114	35.0
Post Graduate	36	11.0
Professional Degree	34	10.4
Diploma	26	8.0
Nil	27	8.3
Employment		
Business	74	18.6
Government Employment	38	16.1
Private Employment	105	34.2
Homemaker	37	12.6
Retired	16	3.7
Student	26	5.4
Not employed	30	9.5
Monthly Household Income		
Less than Rs 25000	25	7.7
Rs 25000 - 50000	106	32.5
Rs 50000 - 75000	91	27.9
Rs 75000 - 100000	70	21.5
Above Rs 100000	34	10.4

Source: Primary Data

Reliability and Validity

The reliability was verified using the Cronbach's Alpha. An alpha value of 0.7 or above is considered acceptable [78]. The convergent validity was verified through composite reliability [79] and the average variance extracted [80] which has acceptable values of 0.7 to 0.9 [81] and 0.6 to 0.8 [82] respectively. Table 2 present the details of the reliability and validity and are within the threshold limits.

Table 2: Reliability and Validity

C	I	M	FL	CR	AVE	CA

Perceived Usefulness (PU)	PE1	3.36	0.873	0.883	0.7171	0.741
	PE2	3.06	0.869			
	PE3	3.19	0.797			
Perceived Ease of Use (PEU)	PEU1	2.95	0.836	0.811	0.682	0.823
	PEU2	2.65	0.816			
Environmental Attitude (EA)	EA1	3.94	0.869	0.858	0.751	0.742
	EA2	3.92	0.865			
Habit of using Technology (HT)	HT1	3.56	0.838	0.808	0.585	0.706
	HT2	3.67	0.731			
	HT3	3.87	0.721			
Behaviroral Intention of using e-waste collection technology (BI)	BI1	3.97	0.834	0.834	0.626	0.771
	BI2	3.88	0.789			
	BI3	3.86	0.750			

Note C-construct, I – items, M-mean, FL – factor loading, CR – composite reliability, AVE – average variance extracted, CA – Cronbach's alpha

The hypotheses were tested using SEM. Table 3 shows the hypothesis standardized regression values. Fig. 4 provides the structural model.

Table 3: Results of Hypothesis

Hypothesis	Path	Result
H_1 PU influence BI	$.140^{**}$	s
H_2 PEU influence BI	$.414^{***}$	s
H_3 EA influences BI	$-.048^{ns}$	ns
H_4 HT influences BI	$.548^{***}$	s

Note: **p<0.01, ***p<.001, s – supported, ns – not supported

H_1 Perceived usefulness influenced behavioral intention of e-waste collection technology. The hypotheses was significant at p<0.01 level of significance and hence supported. The results were in congruence with prior studies [55, 56 and 57].

H_2 Perceived ease of use influenced behavioral intention of e-waste collection technology. The hypotheses was significant at p<.001 level of significance and hence supported. The results were similar to prior studies [58, 59 and 60].

H_3 Environmental attitude did not influence behavioral intention of e-waste collection technology. The hypotheses was not significant (p = -0.048) and negative. Therefore the hypothesis was not supported [83].

H_4 Habit of using technology influenced behavioral intention of e-waste collection technology. The hypotheses was significant at p<0.001 level of significance and hence supported. The results were in congruence with prior studies [64, 65, 66 and67].

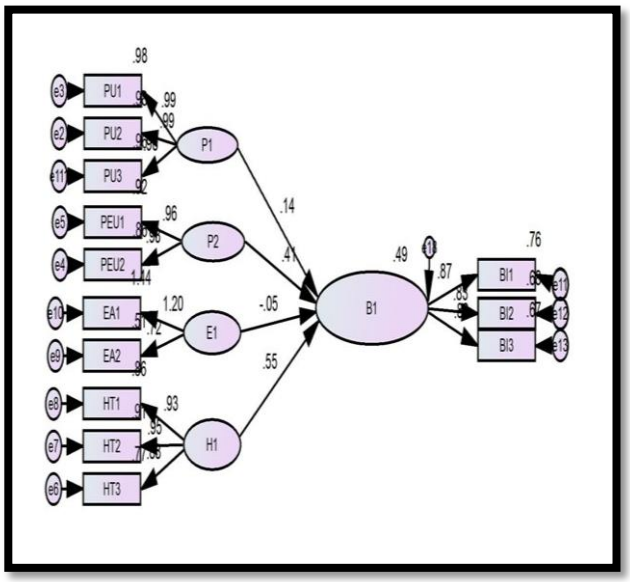

Fig. 4. Structural Model

Note: P1 – perceived usefulness, P2 – perceived ease of use, E1 – environmental attitude, H1- habits of using technology, B1 – behavioral intention of using proposed collection model

E. Implications

The analysis proved that the respondents in the study intended to make use of the proposed model for e-waste collection at the household level. The intention was determined by the factors perceived usefulness, perceived ease of use, and habits of using technology. The role of environmental attitude was not significant and did not influence the intention towards proposed e-waste collection technology. This showed that although respondents were concerned of the environmental conditions that did not result in their practices towards disposal of e-waste efficiently.

Conclusion

The study attempted to present a major problem in e-waste management which is the disposal from households. The use of communication technology and applications in modern times has resulted in solving many prevalent challenges. Here, too an integrated model was proposed to encourage e-waste collection at the household level. Further, Technology Acceptance Model (TAM) was used to develop a conceptual model to test the acceptance of the proposed collection model among households in Kochi city. The analysis showed that respondents intended to use the IoT enabled e-waste disposal technology which was influenced by perceived usefulness, perceived ease of use and habits of using technology. Environmental attitude however, did not influence the intention.

Future Scope

The study addressed a small part in the very big challenge of e-waste management. Future studies could be undertaken by focusing on other aspects such as role of different stakeholders in the industry, transportation models for e-waste, addressing illegal dumping of e-waste globally, etc.

Conflict of Interest:

The authors have no conflict of interest to disclose.

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