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E-waste Management in Egypt: Analyzing the Impact of Households' E-Waste Awareness and E-waste Disposal Behavior on Customer Participation

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Abstract

Electric and Electronic market is growing rapidly. Thus, there is a huge amount of electronic waste (e-waste) due to technological advancements. These products include mobile phones, music players, televisions, refrigerators, computers, printers, and even medical equipment. Although e-waste Management system implementation enhances social, environmental, and economic sustainability, e-waste management in Egypt suffers from lack of systematic approaches and improper technologies, and on top of all, the lack of collection and sorting process of e-waste. The study aims to investigate Egyptian household awareness concerning the e-waste collection and treatment proposes, it proposes strategies that act as a roadmap for effective e-waste management, including raising awareness, establishing e-waste legislation, and promoting collaboration between stakeholders. Moreover, the current research provides a recommendation for developing a comprehensive e-waste estimation framework. Finally, the investigation highlights the calling need for improved e-waste awareness, legislation, and recycling practices in Egypt.

Keywords

Egypt, E-waste, Electrical/Electronic equipment, Awarness, Behavior, and Households

1. Introduction

The business world is facing high competition in the electronic market due to the rapid evolution of electronic devices which leads to the rapid generation of e-waste (Doan et al. , 2019), E-waste includes electrical components or circuits with either battery or power supply, such as TVs, computers, mobile phones, white goods, home entertainment and appliances generated by household, industrial, and institutional sectors (Shaikh, 2021). Egypt has the highest e-waste generation among African countries, it generates more than 20% of e-waste generated in the whole continent (Sakr et al., 2021) However, The Egyptian government has not yet developed a legislative framework for e-waste in Egypt (G. Iattoni, 2021).

Accordingly, this study aims to investigate Egyptian household awareness concerning the e-waste collection and treatment, while highlighting the hazardous effect of untreated e-waste and the importance of recycling the WEEE (Waste from Electrical and Electronic Equipment) and identifying the key variables associated with the households' awareness, consumption of electronic devices, and the disposal of e-waste behavior, through a random sample.
This research seeks to achieve the following objectives:

- Define Electronic Waste

- Analyze the Consumers' awareness and behavior towards e-waste management practices.
- Determine the impact of E-Waste Awareness and E-waste Disposal Behavior on Customer Participation
- Conclude the applied Recommendations.

2. Literature Review

1.1 Overview on the Electronic Industry

The electronic sector involves several industries which are telecommunications, networking, electronic components, industrial electronics, and consumer electronics (Beers, 2022). The electronic industry faced a dual impact from the COVID-19 pandemic as the sector grew fast due to the high usage of electronic equipment because of the layoff, it also suffered from slowdown due to supply chain disruptions and the decreased production because of the limited working hours as a part of the layoff (Statistica, 2023). Sustainability in electronics is achieved through minimizing the use of raw materials, establishing raw materials recovery programs, and improved energy efficiency (McCulley & Sahle-Demessie, 2013). B (2023) stated that the circular economy implementation means achieving sustainable development goals that are identified by the UN. The circular economy is a solution for the disposal of waste through informal sector in developing countries. The sustainable development goals aim to eliminate waste, end poverty, and protect the plan which will contribute in economic growth. Circular economy can contribute to SDGs by eliminating wastes and reducing pollution, these goals are SDG 11 and SDG 12. Circular economy can contribute to SDG 8 by creating new job and business opportunities which results in significant economic growth. Also, it can contribute to SDG 9 through offering innovative and technological development and building a strong infrastructure (Figure 1).

Figure 1. Sustainable Development Goals

The major problems of e-waste management in Africa are the lack of awareness, lack of governmental legislations and regulations, lack of effective collection system, lack of specialized recycling facilities, and the poor financing for e-waste management practices as most of the components are hazardous materials (Forti et al. ,2020). Egypt produces 90,00 tons of e-waste yearly (Shoukry, 2022). Egypt has initiated innovation practices to the electronic industry, increase the domestic production, create job opportunities, and reduce the import reliance (Pivnenko, 2021).

1.2 Electronic Waste

The electronic sector involves all electronic equipment and the electrical components for a variety of products. The electronic sector involves several industries which are telecommunications, networking, electronic components, industrial electronics, and consumer electronics. The industry is growing very rapidly because of the increasing demand for buying new electronic equipment due to the fast evolution of technology. The most profitable sector within the electronics is semi-conductors because they are used is most electronic products and it supports almost every industry (Beers, 2022). E-waste refers to all types of electrical and electronic products and their components that are no longer useful to the product's owner (Doan et al., 2019).

The e-waste comprises substances like copper, zinc, plastic, gold, silver, and even platinum which are valuable and can be used after the recycling process as a new raw material. These metals can be reused and can be used as a secondary source of raw materials as well (Table 1). Recycling and reusing these metals is a challenge due to the complexity of the process as a huge amount of dangerous substances can be found in e-wastes such as lead, mercury, flammable retardants, and cadmium which can affect the environment and health in a negative way (Banu. A et al., 2021)

Table 1. Hazardous substances and their impact on health (Shaikh & Khandare, 2019)

Hazardous substance	Its impact on health
Lead	Affects Kidney, reproductive system and mental development of children
Plastic	Harms immune system, burning plastic generates dioxins BFR
Mercury	Affects central nervous system and impairs fetus growth
Acid	Cause respiratory problems, corrosive to eye and skin
Beryllium oxide	Causes lung diseases
Cadmium	Severe pain in joints & spine, affects kidney & bones
Chromium	Can damage the liver & kidney or lungs cancer

It is predestined that 75% of the EEE is stored due to the uncertainty of how to manage it and that the consumer is not aware of the disposal and recycling process. Management practices should be implemented so consumers can dispose of e-waste in the right place. These practices can be put into some tips which are: (Rao, 2014)

a. Don't throw the electronic waste in landfills but deliver it to organizations where recycling process is executed.
b. Buy electronic products from vendors who provide return back End-of-life products.
c. Use the product till the end of its lifetime so the e-wastes can be decreased due to the efficient use of products.
d. Citizens should accept the concept of buying recycled products.
e. Citizens should support the circular economy.

Yuan et al. (2019) used conceptual framework that shows the relationship between the variables which are: lack of knowledge, awareness, cooperation, and facilities and the barriers for practicing e-waste management. The model shows that the lack of knowledge, its hazardous effect on human health and the environment, lack of cooperation from the government, and the facilities to collect, recycle and assemble the e-waste. It highlights that the barriers will result in ineffective implementation of e-waste management and harder to implement recycling process among households (Figure 2).

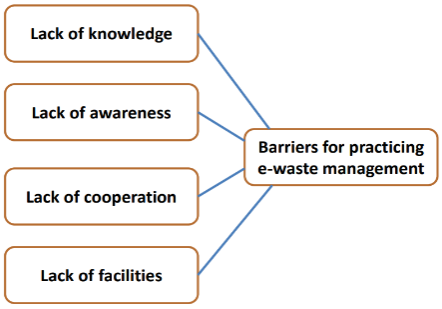

Figure 2. Conceptual model of barriers for practicing e-waste management

1.3 Current Situation of e-waste management in Egypt

Egypt is a country of around 106,963,058 people (EGYPT Population (2024) - Worldometer, n.d.) which represents a significant market share for electronic equipment and makes Egypt has the largest e-waste generation (Sakr et al., 2021). Egypt has an advanced infrastructure compared to other countries in the Arab region but, no updated quantative and qualitative data are available to measure its performance. The Egyptian government has not yet developed a legislative framework for e-waste in Egypt (G. Iattoni, 2021). The recovering of E-wastes in Egypt is through the selling of collected devices and equipment in five main markets around Egypt which are Shoubra El-Khema, El-Warrak, El-Kollaly, El-Emam El-Shafie and El-Matareya (Mohamed, A. 2019).

The Egyptian e-waste management system was unregulated till 2020. In 2020, Egypt encountered its current law (#202/2020) to ensure the proper e-waste disposal through authorized factories under the control of the Ministry of Environment, these factories are authorized to recycle, reuse, and recover (Shoukry,2022). The global environmental facility has supported Egypt with $8 million through the African development bank to implement effective e-waste and medical waste management (Magoum, 2022). Also, the ministry made an initiative in cooperation with the UNDP by implementing the E-Tadweer Application which allows the return of e-wastes and gain incentives in return (Sakr

et al., 2021). The Egyptian e-waste management initiative is limited to computers, telephones, display devices, cellular devices, and video gaming devices (Etadweer, n.d.)

There is a lack of consumer awareness concerning the importance of recycling electronics which can lead to unsafe e-waste treatment (Shoukry,2022). The unsafe recycling practices can increase the exposure of hazardous substances, harmful to human health and the environment. The Release of hazardous materials into the environment can lead to food pollution, ecological exposure, and bioaccumulation (Perkins et al., 2014). Hazardous materials involved in Electric and Electronic Equipment production can be minimized at the product design stage through usage of safer renewable materials such as bio-based plastic made with plant-based chemicals or plant-produced polymers instead of petrochemicals, ensure that the non-renewable materials used can reused, repaired, or upgraded in the future, and start reducing the use of materials while manufacturing and think of making thinner and lighter products (Rao, 2014).

3. Research Design

This research follows predictive research design (PRD) which is applied to analyze the effect of IV (independent variables) on the DV (dependent variable). It aims to develop statistical tools that can be used for scientific prediction of the most likely value of a continuous measure, or the probability of the occurrence (or recurrence) of an event on the short or long terms (González-Díaz & Bustamante-Cabrera, 2021).

This type of research aims to make predictions about untested or unproposed ideas by examining and analyzing existing phenomena, policies, or other entities. Predictive research is mostly hypothetical, theoretical, or experimental. It is concerned with ideas that haven't been tried yet, might not be testable, or didn't previously exist (Field: 2009). This study aims to understand the consumer's awareness and behavior towards e-waste management by gathering insights from a random sample using a questionnaire to anticipate future scenarios, awareness, behaviors, and consumer participation towards e-waste management.

4. Research Model

This research used quantitative method and conducted a conceptual framework to study the connection between the consumer awareness and behavior towards e-waste which are the independent variables and their impact on the customer's participation which is the dependent variables. Figure 3 shows the studied variables and its impact on Customer's participation. Lack of knowledge and awareness makes in harder to implement recycling process among households. Customer's participation can be significantly increased by positive behavior towards e-waste treatment and increased awareness will contribute to the establishment of proper e-waste management system in Egypt.

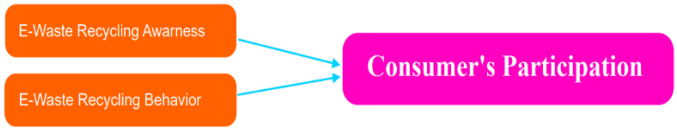

Figure 3. Research Model

Based on the previous model, the following hypothesis have been considered:
H_1: The E-Waste Recycling Awareness has a significant impact of the Consumer's E-Waste Participation.
H_2: The E-Waste Recycling Behavior has a significant impact of the Consumer's E-Waste Participation.

5. Data Collection

This study seeks to understand the Egyptian context by designing, developing, and conducting structured questionnaires, that were distributed over 392 Egyptians. The questionnaire aims to analyze consumer behavior, knowledge, and awareness regarding e-waste collection and treatment, as well as factors associated with household e-waste behavior. Collected questionnaires that were considered valid, were modelled, and statistically analyzed using SPSS and EViews software. it focuses on the household's who are living in Egypt and uses the electronic equipment. The questionnaire consists of 15 multiple choice questions and was designed to be divided into 4 main sections as shown in Table 2.

Table 2. Questionnaire Sections General Description

Questionnaire Section	Section Description
1	It includes questions from 1-4 which involves questions about demographics which are age, gender, number of persons, and educational level
2	It includes questions from 5 – 9 which involves questions about consumer's awareness and the negative impacts of e-waste
3	It includes questions from 10 – 12 which involves questions about the consumer's behavior towards e-waste disposal
4	It includes questions from 13 – 15 which involves questions about the customer's participation and their opinion towards e-waste management programs

6. Sampling

In this study, the unit of analysis was individuals; those individuals include customers who uses electronics. Specifically, the target population of the current research are involved in e-waste recycling practices in Egypt. A total of 392 customers of both genders, over the age of 18 who are responsible for taking sustainable decisions and that were most easily accessible and willing to participate in this study.

5. Results and Discussion

5.1 Questionnaire results

According to the sociodemographic findings, 392 people were surveyed and the results showed that 58.9% were females and 41.1% were males. The highest percentage of respondents are in the age group of 18-24 which represents 46.9%. Moreover, 67.6% hold bachelor's degree. And most of the households are between 3-4 members which represents 43.6%. Figure 2 shows a brief description of the respondents regarding Age group, Gender, Education, and household size. Figure 4 shows the sociodemographic findings of the respondents.

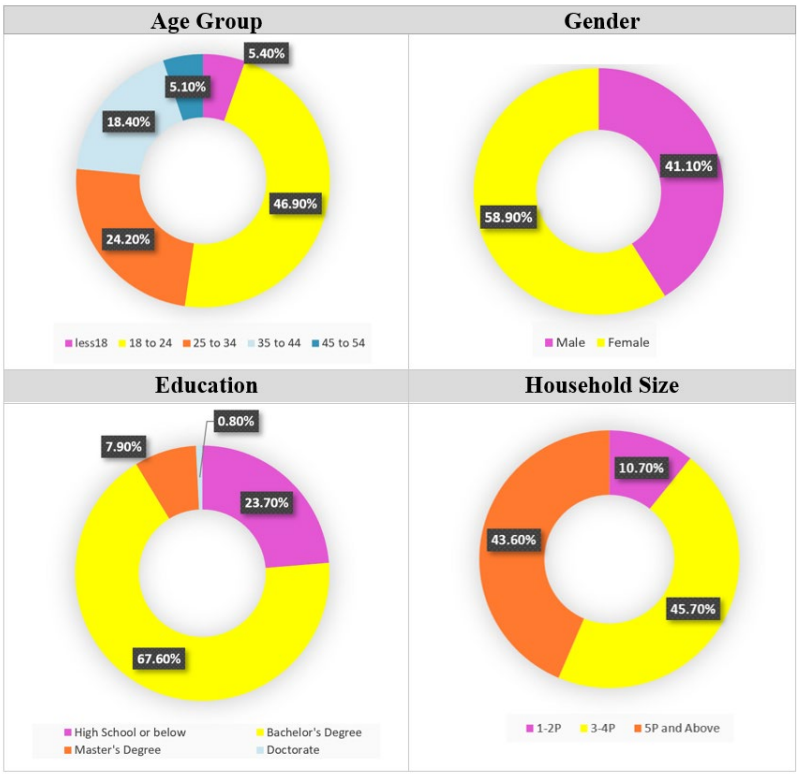

Figure 4. Sociodemographic Results

To investigate the consumer's perspective towards their electronic products, it was important to determine the frequency of electronic device replacements and the rate of recycling among households. The results show that 37.5% of consumers replace their electronic devices annually while 29.3% recycle their electronic products more than once a year. However, 18.1% rarely replace their electronic devices and 15.1% never recycle their electronic products. These statistics offer insights into consumer behavior and attitudes towards managing electronic products, which shows that there are high levels of electronic waste which pose environmental and health concerns as electronic devices contains hazardous materials that can affect the human health and environment negatively if not treated safely. E-waste recycling awareness will help to include the section that never recycled their electronic products to participate in e-waste recycling programs and increase the levels of recycled electronic devices. A detailed description of all the above results is illustrated in Figure 5.

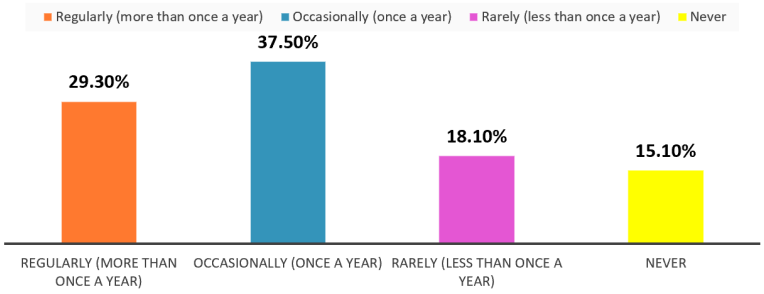

Figure 5. Rate of Recycled Electronic Devices

Respondents were asked about the methods of disposing their discarded electronic products to understand the disposal behavior of the Egyptian context as they contribute significantly to e-waste generation. The results show that most of the respondents (29.8%) used to dispose their discarded electronic devices by selling them, 26.5% used to give them away to friends or family, 19.6% give them for donation while 16.8% store them at home. However, only 7.1% used to recycle their discarded products through the authorized collection points. These results explains that only 7.1% of the respondents are aware of the significance of proper e-waste management therefore, increased awareness about e-waste management and its tremendous impact on human health and environment is needed to increase the volume of recycled e-waste. Figure 6 shows the behavior of the respondents towards disposing of their discarded electronic products.

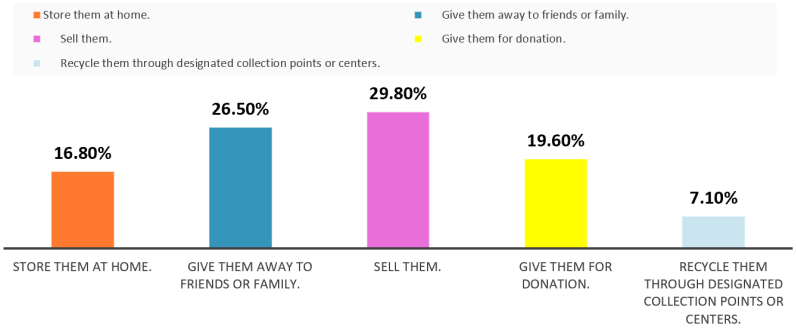

Figure 6. Methods of Disposing discarded electronic products

Consumer's opinion is very important as they are a main stakeholder in e-waste management system. The respondents were asked about the preferred programs for safe e-waste disposal. 43% recommended tax collected program and handled by the government, 29.3% preferred advanced disposal fee that is refunded, while 27.3% suggested the non-refundable disposal fees. These preferences highlight the different opinions of several communities so, the unique needs of each community need to be analyzed and understood to promote safe and sustainable e-waste management practices and encourage the customers to participate in a suitable e-waste management program (Figure 7).

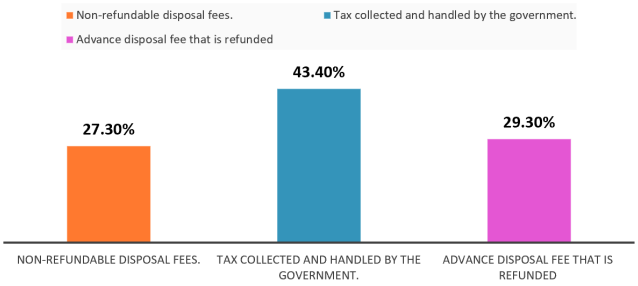

Figure 7. Preferred Programs for safe e-waste disposal

5.2 Descriptive Statistics

Descriptive statistics are used to provide fundamental data about variables in a dataset and highlighting the potential relationship between the used variables. In this research, one dependent variable and two independent variables are determined. In Table 3, The dependent variable is Consumer Participation, its Mean value is 3.44 with standard deviation 0.632 and standard error of mean 0.032. The first independent variable is Awareness, its Mean value is 9.25 with standard deviation 1.339 and standard error of mean 0.068. The second independent variable is Behavior, its Mean value is 4.14 with standard deviation 1.134 and standard error of mean 0.057.

Table 3. Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistics	Statistics	Statistics	Statistics	Std. Error	Statistics	Statistics
Awareness	392	5	12	9.25	.068	1.339	1.793
Behavior	392	2	6	4.14	.057	1.134	1.285
Participation	392	2	5	3.44	.032	.632	.400
Valid N (listwise)	392						

5.1 Numerical Results

A stepwise multiple regression was conducted to evaluate the impact of the independent variables (Awareness and Behavior) on the Consumer Participation as dependent variable, and to signify the unique contribution of studied predictors. For the ANOVA outcomes, the F value represents the significance of the studied equation, and the results indicate that F is (72.528) and is significant at 0.01.

Table 4 shows that the B value of the first predictor (Awareness) was (.378), Beta value = (.509) and the t-value was (11.720), with significant level at 0.01. This indicates that the (Awareness) has a positive and significant effect on the Consumer Participation as dependent variable. The B value of the second predictor (Behavior) was (.174), Beta value = (.162) and the t-value was (3.734), with significant level at 0.01. This indicates that the second predictor (Behavior) has a positive and significant effect on the Consumer Participation as dependent variable.

Table 4. Stepwise Multiple Linear Regression

Independent Variables	B	Std. Error	BETA	t	Significant	R	R square	R square Change
Constant	.743	.373		1.991	.047			
Awareness	.378	.032	.509	11.720	.000	.495	.246	.246
Behavior	.174	.047	.162	3.734	.000	.521	.272	.026

F value = 72.528 (*P< 0.01)*
Std. Error of the Estimate= 1.040
N=392

Table 4 shows that the two studied hypotheses were accepted, the *Awareness* represents 26.6% of the variance of the dependent variable (Consumer Participation), while the *Behavior* represents 2.6% of the variance of the dependent variable (Consumer Participation) as the total variance is 27.2%. it highlights that the awareness is the main predictor for customer participation, if the citizens are aware of the e-waste sustainable practice, the behavior will change to be

positive towards electronic waste treatment. Mohamad et al. (2022) stated that the consumers show willingness to invest more to buy green electronic equipment when they are aware of the environmental considerations.

These results confirm that awareness is the most significant factor influencing participation in electronic waste recycling. It refers to the individual's perception of all changes that surround him and his reaction to these changes. This confirms that developing the level of the individual's participation in recycling electronic waste requires increased level of awareness according to on two basics: first, individual awareness of the hazardous effect of e-waste. Second, the benefits that can be accrued from its value.

5.3 Testing Hypothesis

The coefficient of determination (R Square) which refers to the explained variance of the predictors. For the first predictor (Awareness) R Square value was (.246) and this indicates that the awareness explains alone about 24.6% from the variance in the (Consumer Participation) as dependent variable. Accordingly, the first hypothesis is statistically accepted.

For the second predictor (Behavior) R Square value was (.026) and this indicates that the behavior explains alone about 2.6% from the variance in the (Consumer Participation) as dependent variable. Accordingly, the second hypothesis is statistically accepted.

6. Conclusion and recommendation

Egypt generates high level of e-waste and it's the highest e-waste generation among African countries, it generates more than 20% of e-waste generated in the whole continent. This study highlights the importance of e-waste management system in Egypt. It identified 2 independent variables that will affect consumer's participation which are the consumer's awareness and the consumer's behavior. The consumer's awareness has the strongest connection with the customer's participation, and it is stated that the consumer's behavior relies on their awareness towards e-waste management systems. A structured questionnaire was conduct among households in Egypt to address the consumer's awareness and behavior, and its impact on the consumer's participation.

This study recommends developing comprehensive legislation framework to define electronic waste, distinguish between hazardous and non-hazardous materials involved in e-waste, and address the treatment of parts containing hazardous materials, establishing education programs to encourage the responsible e-waste disposal practices, increase collection points to be present in universities, schools, family club, and shopping malls to make it easier for the consumer to dispose discarded electronic devices. Launching awareness campaigns among youth in schools and universities as they are with greatest potential to commit to safe disposal of electronic devices and using social media platforms to spread the awareness as it is an effective tool for fast spreading. Doing this, effective e-waste management system can be achieved through high rates of consumer's participation that is resulted from increased awareness and positive disposal behavior.

7. Research Limitations

This study analyzes the impact of households' e-waste awareness and disposal behavior on customer participation in Egypt. It has potential limitations that should be acknowledged. Firstly, Governmental legislations and procedures for the proper handling and recycling of electronic waste are not studied. Secondly, the hazardous effect of e-waste on human health is not investigated. Additionally, the environmental assessment of e-waste is not analyzed. Furthermore, the financial indicators and economic returns of e-waste collection is not addressed.

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