Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AP06.20250088
Published: August 5, 2025

E-Waste Disposal Behavior and Management Model: Integrating Local Government and Industry Roles in the Philippines

Dr. Rey Julius C. Fortuna
Open University System
Polytechnic University of the Philippines
Manila, Philippines
College of Liberal Arts
Technological University of the Philippines
Manila, Philippines
joan.fortuna@cvsu.edu.ph

Abstract

Electronic waste or *e-waste* has been characterized as an emerging global problem. Collection and recycling are key aspects to address the problem. Principally, it is hypothesized that the type and brand of gadgets, as well as individual profiles of the users are determinants of disposal practices of e-waste. E-waste is operationally defined as obsolete or dysfunctional electronic gadgets like smartphones, tablets, laptops, and desktops. Quantitative method of research was used for inferential analysis, while qualitative method was employed to probe deeper into the practices of disposing of one's pre-loved electronic gadgets. A total of 218 respondents from the municipality of Carmona, Cavite, Philippines, were tapped to provide data and information. It appears that among 55 percent of all respondents, smartphones are the most predominant e-wastes accumulated. Storing or keeping is the most common way of getting rid of obsolete or dysfunctional electronic gadgets. Using logistic regression analysis, it appears that the category of smartphones is significantly related to the disposal practice of storing or keeping. This was further established and confirmed via a mathematical logistic function modeling procedure. For the qualitative analysis, eight (8) respondents were interviewed. Themes were analyzed, categorized, and transformed into a qualitative model. Combining quantitative and qualitative findings, a Management Model was formed. It is a model that primarily aims to lowering or minimizing the accumulation of electronic wastes. Lastly, as the model suggests, effectiveness of the programs/policies is evaluated based on antecedently set benchmarks against actual e-wastes collected.

Keywords
Electronic waste, Inferential analysis, Management model, Management science, Waste management

1. Introduction
As reported in the 2024 Global E-Waste Monitor, a record of 62 million tons (Mt) of e-waste was produced in 2022. Up 82% from 2010. On track to rise another 32%, to 82 million tons, in 2030. Sadly, just 1% of rare earth element demand is met by e-waste recycling. Moreover, the 62 million tons of e-waste generated in 2022 would fill 1.55 million 40-tonne trucks.

The Philippines faces a great deal of problem in terms of garbage. The country's garbage problem goes beyond the tons of plastic products in many areas that may eventually clog rivers, waterways, and the seas. Even before the Covid-19 Pandemic in 2020, Electronic Waste or E-Waste has been accumulating largely not only in the Philippines. A study conducted by engineers from the University of the Philippines (Galang, et al., 2017) revealed that Filipinos discard millions of mobile phones every year, underlining the need for a nationwide policy to handle e-waste. Moreover, the study revealed a stable figure on the estimated number of smartphone waste in the Philippines which is a staggering 22 million units in 2016. The number continued to increase in the succeeding years, with over an average of 24.9 million units of discarded smartphones predicted in 2021. What's worse is that the study found that 95 percent or almost all of the respondents have no knowledge on proper waste disposal of smartphones. This is just for smartphones.

At present, in a posted report by the Philippine, Department of Environmental and Natural Resources (DENR) in October 2023, referring to the data by the United Nations Industrial Development Organization (UNIDO), it showed that the Philippines is one of the top e-waste generators in Southeast Asia, with a per capita e-waste generation of over 4kg. The report added that the volume of e-waste is increasing due to higher consumption of electrical and electronic equipment, shorter product life cycles and limited repair options.

1.1 Objectives

This study aimed to accomplish two (2) objectives: (1) investigate the manner of electronic waste disposal and identify social factors related to its generation; (2) and develop an E-Waste management model as basis of municipal level policy interventions, projects, and systems/strategies. Moreover, contributary factors below summarizes the contribution of this paper:

Theoretical. By developing an e-waste management model that leverages the synergy between local governments (LGUs) and manufacturers/telecom operators.
Empirical. By providing local evidence that smartphones represent the most dominant form of e-waste, with a tendency to be stored rather than recycled.
Methodological. By utilizing a mixed-methods approach, combining logistic regression for quantitative analysis and phenomenology for qualitative exploration.
Public Policy. By offering policy recommendations based on local data, including the establishment of e-waste benchmarks to serve as a foundation for management programs.

2. Literature Review

Electronic Waste

Global problems on electronic waste (e-waste) are growing in large scale. The volume of e-waste globally has been rising at approximately 4.2% per annum over the period 2010–2016. Based on indicated volumes, other studies suggest the worldwide volumes of e-waste will continue to grow at the rate of 3.2% per annum, which amounts to an annual generation of around 52.2 million tons by 2021 (Salsabil, et al., 2019).

In an article by BBC in 2022, as reported on international *WEEE Forum*, 5.3 billion mobile phones will be thrown away in 2022. The report added that only 17 percent or less than 20 percent of all the estimated world e-waste is properly recycled back in 2019. In relation to this, also in the report, emphasis is made that the reason for this is because many people keep old phones rather than recycle them. In support to this observation, a survey conducted in the United Kingdom by the Royal Society of Chemistry in 2019 found that 51% of UK households have at least one unused electronic device – such as mobile phones, computers, smart TVs, MP3 players or e-readers – and 45% have up to five. The survey also indicated that 82% have no plans to recycle or sell their devices after they fall out of use.

Similarly, in the Philippines, there are very few initiatives that offer a system for disposing this unique type of garbage. Several studies imply that it is crucial for world governments not to overlook the e-waste disposal capabilities of their respective areas of responsibility. On October 2020, the country's Department of Environment and Natural Resources (DENR), Environmental Management Bureau (EMB) reported that Waste Electrical and Electronic Equipment (WEEE) is considered as the fastest growing waste streams in the Philippines, and if not properly managed, may cause major environmental problems. Also, the report stated that 32,664.41 metric tons of WEEE were generated in 2019 in the Philippines alone.

At present, in a report contained in the 2024 Global E-Waste Monitor, the Philippines was the 3rd largest e-waste producer in southeast Asia next to Thailand and Indonesia. The report also highlights that the primary types of e-waste in the Philippines are consumer electronics such as televisions, refrigerators, washing machines and mobile phones. Relatively, the report emphasized that key challenge in the Philippines is the lack of access to proper e-waste disposal facilities and infrastructure, especially in rural areas. This limits the collection and disposal of e-waste in these areas, and often results in the illegal dumping of e-waste in rivers, landfills and other areas. There is also a lack of proper regulation and enforcement of existing laws and regulations related to e-waste management. (Global E-Waste Monitor, 2024)

Methods of Disposal
E-waste Recycling
Sustainable economic system is needed to create a sustainable ecology. Manufacturers and consumers both have the responsibility to understand this necessity. Governments around the world need to formulate regulations and policies and monitor their implementation to sustain the cycle of ecology.

In Japan, various methods of disposal and recycling have been put in place. One method is the 3 R's (Reduce, Reuse, Recycle). On the website of the Japanese Ministry of Economy, Trade and Industry, emphasis is made on the importance of implementing 3R's--most notably in encouraging the use of market mechanisms through the strength of the private sector, the creation and expansion of new recycling-oriented and environmental businesses, and focused investment into research and development of 3R technologies.

Informal E-waste Recycling
As early as the year 2010, studies predict the exponential rise of electronic waste due to technological advancements. Chi, et al., (2010) asserted that informal recycling is a new and increasing approach for managing Waste Electrical and Electronic Equipment at cheap cost (WEEE or e-waste). The said authors further suggested that government must focus on how to boost formal sector e-waste flows, how to maximize informal collecting networks for end-of-life EEEs from households, how to build effective incentive schemes for informal collectors and recyclers, and how to improve the technical aspects of informal recycling. However, these things cannot easily be done and/or implemented because, per reports, the volume of e-waste still recycled by unorganized sectors in China is still huge because e-waste recycling is one of the livelihood options of the informal sector (Abhishek, et al., 2018).

Wang, et al, (2020) supported the claim above stating that the informal sector's recycling of e-waste has brought raw materials (such as metals and plastics) used electronic equipment and components, and economic opportunities to countries in the Global South--alongside with horrific environmental pollutions and health problems. With China's waste import policies tightening, e-waste economies are increasingly emphasizing domestic recycling while rejecting global e-waste.

Formal E-waste Recycling
Formal e-recycling facilities, often larger and more equipped, are more common in developed countries, according to Ceballos, et al, (2016). Dismantling and shredding electronics into separate recyclable components like plastic and metal is common practice at these plants.

Formal e-recycling facilities offer environmental services to society and deliver immense benefits to local communities. Recycling electronics in an acceptable manner is beneficial to the environment since it recovers resources for reuse and lowers landfill waste. Formalization is a desirable trend for the e-recycling industry. Formal e-recycling facilities are anticipated to have better occupational and environmental health processes and standards than those in informal e-recycling.

Even in the most high-tech formal e-recycling facilities, figuring out how to measure and control chemical exposure is still a challenge. To strengthen the current formal e-recycling industry around the world, more government and private funding is urgently needed to support a multi-pronged multi-stakeholder research framework. This framework should give priority to developing a new generation of safer electronics, improving processes and controls specific to formal e-recycling, and understanding health concerns in the complexity of chemical mixture exposures typical of recycling electronics.

In the Philippines, there are only 3 formal e-waste recycling facility namely:

E**-Waste Management Philippines**. The E-Waste Recycling Program makes electronic waste disposal easier by heading straight to one's doorstep. Additionally, this team offers to help sell items that one is not ready to dispose of them. Products accepted include old laptops, CPU units, Li-ion batteries, cellphones, cellphone batteries, UPS power supplies, power banks, and emergency light batteries. [Contact (947) 990 9446 for e-waste pick-up in select areas]

E-Waste Project, University of the Philippines, Diliman. A year-long initiative borne from the combined efforts of the Diliman, Manila and Los Baños campuses of the University of the Philippines, the E-Waste Project aims to raise awareness of the "threat posed by the growing number of improperly disposed electronic devices." Along with this, week-long drives are set up in select months as people are encouraged to bring e-waste donations from their homes to the UP Diliman campus, e.g., computer motherboards, flash drives, sound cards, cellphone chargers and video cards, air conditioning units, speakers, and even washing machines.

Envirocycle Philippines Inc. A full-service recycling company accredited by the Department of Environment and Natural Resources (DENR), Envirocycle Philippines takes care of e-waste management for other large-scale establishments as well as smaller organizations. Other recyclable materials accepted by Envirocycle Philippines, Inc include PET bottles, glass, plastic containers, industrial sacks, cardboard and papers. (Location: Daystar Industrial Park, Pulong Sta. Cruz, Sta. Rosa, Laguna)

Consonant to the abovementioned E-Waste recycling initiatives, the awareness of community is one of the focal grounds of this study. It is the understanding of the researcher that effective waste recycling is grounded on better policies and programs by the government and producers, which in turn are the ultimate factors of consumer awareness.

The researcher believes that the creation of a policy or law in the Philippines that is specific to e-waste management and disposal is of primal importance. The establishment of these regulations will not only control the emerging waste problem but can also establish means of recycling e-waste materials.

Household E-Waste Disposal Practices (Dependent Variables, DV)
Household e-waste disposal practices are the dependent variables of the study.
In the Philippines, the most commonly used practices to dispose of electronic wastes upon their obsolescence, as observed by Peralta (2019), are reuse, store, recycle, landfill (garbage). Ibrahim, et al., (2019) said that it is evident that too much waste is left uncollected, say, on the roadways--causing annoyance, environmental pollution, and public health hazard. As a result, household waste management is receiving and/or should receive increasing attention.

In addition, the researchers (Ibrahim, et. al) found statistically significant differences between the families' total knowledge and their reported habits before and after the implementation of the health law. Moreover, the use of a health education program enhanced the knowledge and reported habits of families about domestic waste management. Hence, they strongly suggested utilizing he media, particularly television, to efficiently inform families on how to manage waste healthily in the larger communities of Greater Cairo.

Independent Variables
The independent variables used in the study are: *type of electronic gadgets* and *brand of gadgets.*
Type of Electronic Gadgets. ***Discarded electronic gadgets*** are herein defined as E-waste. Several studies mentioned different types or classes of E-wastes. An attempt to standardize its definition based on similar composition and use is stated in the journal published in 2018 (UNU KEYS). Elements of a product group (type or class) share comparable average weights, material compositions, end-of-life characteristics, and life-time distributions. This scheme makes the system very useful for compiling e-waste statistics (Forti, et al., 2018). The most common electronic products that can be found in households, most notably during this digital age and the Covid 19 Pandemic are: *smartphones, tablets, laptops and desktops*. The restrictions brought about by the recent pandemic has catapulted the demand and production of these electronic gadgets. The control of these wastes, i.e., their disposal and eventual recyclability must be carefully understood by ecological stakeholders, especially governments around the world and manufacturers.

Brand of Gadgets. There are very many brands of gadgets available nowadays, varying from cheap electronics to high-end expensive gadgets. Cheap electronics may tend to contain sub-standard parts, and can therefore, have much less lifespan. High-end brands on the other hand have more quality in terms of parts and craftsmanship that may add to longer lifespan. These attributes may affect disposal practices and e-waste generation.

Product brand is important factor in consumer buying behavior, e.g., their product features. In 2020, Rajakumar, et al, conducted a study to determine students' purchasing patterns. Their study revealed that students are at ease acquiring electronics from online stores, and that they rely much on product kind, quality, and cost. In addition, roughly 96 percent (96%) of the students choose current smartphones due to their abundance of features for doing and/or completing their personal, social, and professional responsibilities.

Globally, top brands of electronic products vary from brand after the other. It depends on the geographical and cultural inclination of consumers. To cite an example, Apple products cannot fully penetrate the Asian region, while Samsung products experience the same in the North and South American regions.

Control Variables

Age. Nowadays, age is not any more a factor of owning an electronic gadget. Even infants and geriatrics use smartphones and other gadgets. The big question is, upon obsolescence of equipment, will they know how to go about its disposal.

According to Delcea (2020), demographic or socioeconomic variables, such as age, gender, income, education, number of family members, etc., play a role in determining the pro-recycling behavior of customers. Delcea further stated that demographic characteristics such as age and gender can help predict the pro-e-waste recycling behavior of people.

Civil Status. There is no connection whatsoever in terms of marital status as regards one's awareness of proper disposal of e-waste. This is true as shown by a study done by Miner, et al, in 2020 which showed that respondents' levels of awareness and knowledge were unaffected by any of their socio-demographic features including marital status. Similarly, there were no significant variations in desire to participate in e-waste management among respondents. However, for this research, it is assumed by the researcher that *civil status* needs to be a control variable.

Educational Attainment. In a study conducted by Noufal, et al., (2019) elements affecting the rate of waste generation and the composition of waste are discussed. It was found that there was a positive correlation between home waste generation and each of the following: monthly income, household size, and the age of the household head; and a negative correlation between household waste generation and the household head's educational level.

In the Philippines, it is a common idea that almost everyone, anyone, everybody owns a smartphone. Mobile phones are one of the most desirable devices in the Philippines as they constitute the preferred mode of communication, by 65% of Filipinos (Galang, et al., 2017).

Occupation. The need for electronic gadgets depends on the kind of work an individual has. It is assumed that work-from-home arrangements may affect the number of electronic wastes generated by an individual. Hence, the researcher is inclined to believe that *occupation* needs to be a control variable in this study.

Monthly Income. Obviously, the more a family or individual can afford to buy electronic gadgets, the more electronic waste it can generate over time. In economics, the higher the employment rate is, the more money is in circulation, and, therefore, this leads to more spending.

This is supported by a study on the correlation of Gross Domestic Product (GDP) and the accumulation of WEEE. A study by Awasthi, et al., (2018) showed strong linear correlation between worldwide e-waste generation and GDP. GDP is indicative of the extent of overall economic activities in a nation.

Ease in Electronic Gadget Acquisition. During the 2020 Covid pandemic, people adjusted to the new normal in purchasing products. The online platform became a trend in purchasing electronic gadgets. This is supported by a 2021 study by Vidodhini, et al., which showed that online purchasing is more popular, since it allows customers to shop at any time of day or night, offers a wide range of devices, and delivers products directly to their homes.

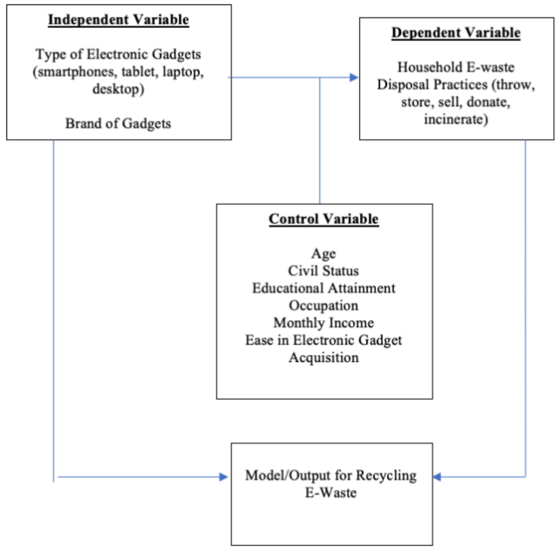

Figure 1. Research Paradigm

Figure 1 suggests that the review of the related studies and literature appears to support the theory that the type of electronic gadgets owned by individuals and brand of gadgets are determinants of e-waste disposal practices. Moreover, control variables which include profiles of respondents may also be predictors of the dependent variable e-waste disposal practices.

The study is both quantitative and qualitative. Quantitative, because it empirically tests for the practices of disposing waste. The theorized factors/determinants for disposing waste were tested. It was necessary to test for the extraneous effects, if any, of some personal factors (i.e., age, civil status, educational attainment, occupation, monthly income, and ease in acquisition)—as control variables.

The study is likewise qualitative. The framework is shown in Figure 2. It deals deeper into the practices of waste disposal and recycling via a phenomenological approach – that is, digging deeper into how such practices evolved and its considerations. The conceptual framework for the qualitative is shown below.

Qualitative Framework

This study employed the use of a Venn Diagram to show qualitative relationships of specific perceived factors. A Venn Diagram is an illustration that uses circles to show the relationships among things or finite groups of things. Circles that overlap have a commonality, while circles that do not overlap do not share those traits. This study used the modified Venn Diagram inspired by the study done by Shambavi (2015) on Management of Environmental Quality, to identify qualitative relationships of perceived factors.

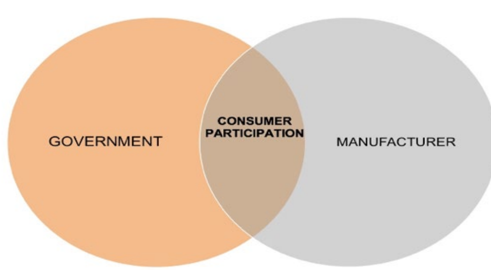

Figure 2. Qualitative Framework

Figure 2 shows the conceptual framework that guided the qualitative thematic analysis. It projects the idea that Government and Manufacturers of electronic devices have a significant shared responsibility in driving awareness of consumers, and ultimately drive participation in electronic waste recycling.

3. Methods

This study primarily employed descriptive research and ex-post facto or causal comparative research. Both quantitative and qualitative approaches were used. According to Catane (2000), descriptive research focuses on describing the features of the population. It attempts to determine the relationship between, say, certain specific demographic characteristics and certain dependent variable(s).

There are three major steps in doing a causal comparative study, according to Fraenkel & Wallen (2009). First is identifying root causes which focus on the subject as an independent variable. It goes into details about the reasons why certain study topics stand out from the rest. The second part of the investigation is a look into the probable effects of the aforesaid "root causes" on the dependent variable(s). The third step focuses on ascertaining such effects.

Quantitative design. As a causal comparative research, the study investigated the probable effects of the independent variable(s) on the dependent variable(s). A crucial and integral part of the investigation was the determination and/or isolation of the probable extraneous effects of the aforementioned control variables. The items in the questionnaire were numerically coded (assigned numeric values), prefatory to statistical analysis.

Qualitative design. Moreover, this research used qualitative method to make for a deeper analysis of data. Qualitative or deductive or the phenomenological method was further used to capture pieces of information not conveyed by the quantitative data, e.g., about beliefs, values, feelings, and motivations that underlie practices in disposing electronic waste.

The goal of phenomenological research is to arrive at the essence of the lived experience of a phenomenon (Moustakas,1994), cited by Randolph (2009). Applied as a review technique, the goal was to arrive at the essence of empirical experiences about a certain phenomenon. In first-hand phenomenology, the individuals who have experienced a certain phenomenon are interviewed.

Specifically, the process of analyzing data using NVivo software is the template used for this study. NVivo is the modern tool in congregating qualitative data. According to AIY Ahmady Hamed Hilal Saleh Said Alabri Ministry of Education (2013), NVivo, the qualitative data analysis software--designed and developed to manage the "coding" procedures--is considered the best in this regard. However, for this study, the present researcher only used the step-by-step procedure from the NVivo software to do thematic analysis. This was on account of the fact that the data gathered from the interview yielded responses that are short and can be coded manually.

4. Data Collection

This study employed purposive random sampling and targeted to survey a total of 82 households divided among the 14 barangays of Carmona, Cavite. According to Wilson & Morgan (2007), a correlation or regression study should have at least 50 respondents. As Wilson & Morgan (2007) noted, Green (1991) provided a clear description of how to determine the size of a regression sample. He suggests N>50 +8 m (m denotes the number of IVs) for multiple regression evaluation. The formula for the ideal total number of responders, according to Green (1991) is N>50+8 (5). For this study, a target of 90 respondents or more, ensured an optimal data power. Rounding off the optimal number of respondents as suggested above, originally, a total of 100 randomly selected respondents were the target sample for this study, but the data gathering yielded a favorable number of 218 respondents. This was for the quantitative portion. After answering the instruments, 8 participants were randomly selected for in-depth interview. Braun & Clarke (2006) recommend six (6) interviewees. The 8 interviewees allowed the researcher to reach the saturation point in qualitative research. Ultimately, the in-depth interviews complied with the phenomenological (qualitative) portion of this study. And later on, themes got to be developed.

5. Results and Discussion

5.1 Numerical Results

Inferential Findings (Quantitative)

The first logistic regression analysis involved the: *type of electronic gadgets* and *brand of gadgets*. The dependent variable is *household e-waste disposal practices*, where *stored* is coded as "1", and *other* is coded as "0". The second logistic regression analysis involved the inclusion of the additional set of regressors, i.e., the control variables (age, civil status, educational attainment, occupation, monthly income and ease in electronic gadget acquisition).

Logistic regression is used to predict the *odds* of, say, being "in" or being a "win" or being "heads", based on the variate values of the *independent variables* or *predictors* (IV). The *odds* is the ratio of the probability of a particular outcome or value occurring, say, being "in" to the probability of its non-occurrence (i.e., being "out"), in the context of a random Bernoulli trial (Alicias, 2017).

Logistic Regression Between the Independent Variable (IV) and the Dependent Variable (DV)

The first run of the logistic regression algorithm (without the control variables)—involving only the primary regressors: type of electronic gadgets and brand of gadgets—was done via the SPSS software (Table 1).

Table 1. Classification Table 1 (E-Gadget vs. Disposal Practice)

Model		Predicted		
		Disposal Practices		
	Observed	.00	1.00	Percentage Correct
Step 1	Disposal Practices .00	45	52	46.4
	1.00	38	83	68.6
	Overall Percentage			58.7

a. The cut value is .500

Table 1 above presents the classification table of the dichotomous dependent variable. The dependent variable (*household e-waste disposal practices*) has variate values: 0 = *other* disposal practices, and 1 = *store.* Table 1 above also shows that there are 45 respondents who indicated that they would rather use *other* disposal practice, and 52 respondents indicated that they would *store* or keep their obsolete/dysfunctional electronic gadgets. Further, table 12 shows that 58.7 percent is the predicted correct percentage correct.

The factors that affect the choice of e-waste disposal practice are presented in Table 2.

Table 2. Primary Regressor in the Logistic Equation (*E-Gadget* Brand vs. *Disposal Practices*)

Variable		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Smartphones	.192	.082	5.534	1	.019	1.212
	Constant	-.062	.176	.122	1	.727	.940

a. Variable(s) entered on step 1: Smartphones.

Table 2 above shows that *smartphones* (B = .192; Wald = 5.534; p = .019) appear significantly positive, meaning that smartphones probably get to be stored or kept after they become dysfunctional or obsolete.

This finding is consonant to a study in South Korea in 2025 focusing on smartphone disposal behavior of respondents. The findings emphasized that many disused devices are stored rather than disposed of responsibly. It detailed that from a 943 respondents, 85% are storing at least 2 smartphones after disuse instead of properly disposing. The study further added that emotional attachments are factors to this phenomenon (Donghun et. al 2025).

Moreover, Ercan, *et al*., (2016) found a similar reason why smartphones are being kept. They found that that there are many phone manufacturing companies that don't have schemes or incentives for customers to return their old phones for recycling purposes.

Table 3. Model Summary 1 (E-gadget type vs. disposal practice)

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	292.373[a]	.032	.043

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Table 3 shows a *-2 Log likelihood* of 292.373, and the equation (stepwise) generated the optimal equation at Step 1. The Cox & Snell R Square amounts to .032, while that of Nagelkerke R Square amounts to .043. This indicates the low explanatory power of being "smartphones" vis-à-vis disposal practices.

Logistic Regression Between the Independent Variable and Dependent Variable Controlling for Some Socio-demographic Variables

The second run of logistic regression is that where the control variables are included as regressors: the respondent's age, civil status, educational attainment, occupation, monthly income and ease in electronic gadget. The following tables present the results of the analysis (Table 4).

Table 4. Second Classification Table (with inclusion of Control Variables)

Model		Predicted		
		Disposal Practices		
	Observed	others	store	Percentage Correct
Step 1	Disposal Practices			
	others	45	47	48.9
	store	37	79	68.1
	Overall Percentage			59.6

a. The cut value is .500

The second classification table (Table 4) above shows that the predicted overall percentage has increased to 59.6, from the previous 58.7 predicted percentage. This reveals the overall impact of the control variables, although not one appears significant. Related literature shows that a 1 percent increase is already substantial. The following table presents the resultant optimal equation (Table 5).

Table 5. Primary Regressor in the Logistic Equation (*E-Gadget* Brand vs. *Disposal Practices*): With Inclusion of Control Variables

Variable		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Smartphones	.229	.090	6.463	1	.011	1.257
	Constant	-.089	.182	.242	1	.623	.915

a. Variable(s) entered on step 1: Smartphones.

A look at Table 5 shows that no control variable entered in the optimal equation (step 1 of the stepwise algorithm). Only *smartphones* entered the equation where its B =.229, Wald = 6.463, degrees of freedom (df) = 1, and it is significant at p = .011. To repeat, no control variable entered the optimal equation (Table 6).

Table 6. Model Summary the Second Equation (with inclusion of Control Variables)

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	276.739[a]	.042	.056

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Table 6 shows that the Cox & Snell R Square = .042 which is now greater than the previous value (032)—without any control variable appearing significant. This value (.042) indicates 4.2 percent explanatory power of the equation, i.e., particularly of *smartphones*.

Taking off from the logistic function and using the steepness of the curve

in respect to *smartphone* (i.e., B = .229), the estimated overall probability of

store on account of *smartphones* appears as follows:

$$Y' = f(x) = \frac{1}{1 + e^{-k(x - x_0)}} = \frac{1}{1 + .2.718^{-.229\,(1-1)}} = \frac{1}{1 + 2.718}$$

$$= \frac{1}{3.718} = \mathbf{.269.}$$

This indicates that *smartphones*—considering the probable extraneous effects of the control variables--has odds (.269) of being *stored* when they become dysfunctional and/or obsolete, as compared with that (.731) of the *non-storing* practices of all the other e-gadgets (e-wastes.) These yield the *storing odds ratio* = .269/.731 = 0.3679.

Nevertheless, relative to all other e-waste disposal practices, ***storing significantly appears as the dominant e-waste disposal practice of all e-wastes which are dominated by smartphones***.

The low turnout off recycling is because many people keep old phones in their drawers and cabinets rather than recycling them due to emotional attachment. Awareness and addressing emotional attachment can promote responsible recycling, reducing smartphone hoarding (Donghun et. al 2025). Moreover, the above phenomenon is said to be attributed to the lack of awareness of users that their gadgets can be recycled and the scarcity of programs in place for customers to return their old phones for recycling purposes. (Ercan,2016)

This quantitative portion of the study addresses a gap in local e-waste behavioral analysis within the Philippine municipal context, emphasizing the critical role of cross-sectoral collaboration in waste reduction. While smartphone ownership and disposal behavior were a significant predictor, the model accounts for only 5.6% of the variance, suggesting the need to explore additional psychosocial and infrastructure-related variables that shall address the 94% unexplained variance.

Results of Interview (Qualitative)

After applying the *deductive method*, from Kuckartz & Rädiker (2019), the researcher came up with categories and developed them into themes. These themes constituted the output of the qualitative model. From the transcription column, we extracted themes that are later developed into an integrated model. These themes are the following.

Theme 1

Programs by the LGU. These are programs intended to collect and separate electronic wastes on the municipal and barangay level. These include the introduction of policies and other initiatives on electronic wastes--for the awareness of citizens.

Theme 2

Programs by the manufacturer/telecoms. These are programs that should be implemented by the manufacturers of electronic gadgets including the telecom companies that distribute smartphones and other electronic devices. These include buy-back policies, tradeoffs and store discounts.

Theme 3

Participation on buybacks/tradeoffs/discounts. This is dependent on the consumers' level of willingness to participate in such programs that intend to reduce the accumulation of obsolete and dysfunctional electronic devices.

Participation on better policies and initiatives. This is an option to which the current level of participation of consumer is very low or none at all.

Moreover, notable responses need to be presented, most specially the following;

N2 – *"…we have a lot of electronic device*[s] *for disposal* [I] *just do not know where to put it…"*

The remark of N2 is indeed noteworthy, because it supports the objective of this study to come up with a management model that would be the basis of programs for e-waste disposal and is accessible to the LGUs and barangay level units. It also appears consistent with the earlier finding that, say, smartphones are being stored or just kept inside homes because there are no programs for recycling.

N8 – *"…this will encourage me to not just store but properly dispose my electronic gadgets…"*

The comment of **N8** supports the quantitative finding of this study, i.e., that smartphones are being stored and kept by consumers once they become dysfunctional or obsolete.

N7 – "…not agree (on recycling) unless they will offer to securely delete all my information on my old device…"

N1 – "…agree (on recycling) as long as they will securely delete all my information from the old device first…"

Parenthetically, the subtle beauty of language is shown in the comments of **N7** and **N1**. They similarly and substantively meant one and the same thing--by agreeing and disagreeing at the same time.

These comments were not anticipated--until they came from actual users of electronic gadgets who are technically savvy to understand the issues of data imprints on semiconductors. These remarks are highly recommended for future investigation and research.

Extracted Themes

Based on the themes stated above, a visual qualitative model is constructed. The qualitative model is presented in the figure below in Figure 3.

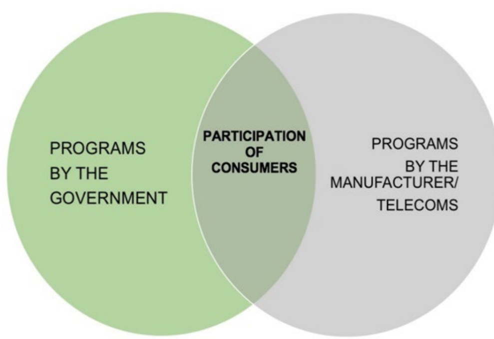

Figure 3. Qualitative Model of Disposal Awareness

Figure 3 above presents the qualitative model. There are three (3) themes that make up the Venn Diagram. The first circle represents actions from the Local Government Unit (LGU). The second circle represents actions from Manufacturer/Telecoms. These combination of actions and programs can be seen in the model as intersecting circles. This **Intersection** is described as the ultimate drivers of consumers participation on electronic waste disposal programs and recycling. This model further shows that two (2) drivers of consumer's willingness to participate are better than one (1).

Moreover, the qualitative findings are in consonant to the study in Malaysia in 2019 which suggests that although there are regulations directly dealing with e-waste in Malaysia, proper household e-waste management is in its infancy, with various proposed regulations on e-waste generated by households still far from completion. A proper e-waste management system for households is urgently required to not only reduce the possibility of e-waste flow into the current municipal solid waste facilities but also to maximize the utilization of currently available e-waste processing infrastructures and facilities. (Hanafia 2019)

Likewise, a study in India in 2025 also supports the above findings. In the said article, determinants and barriers are categorized under the framework of the Theory of planned behavior (TPB) to report variations in e-waste disposal behaviors and participation in formal e-waste collection initiatives (FEWC). The study's findings reveal that people are unable to participate in FEWC initiatives despite being environmentally conscious. Poor awareness of FEWC channels and lack of transparency in recycling processes are some crucial pivots that prevent adoption of FEWC channels.

5.2 Proposed Improvements

Integration and Synthesis of Findings

E-waste disposal in Carmona, Cavite, Philippines. Quantitative findings are that smartphones appear to be stored or kept by the users once they become obsolete or no longer functioning. On the other hand, the qualitative findings appear to suggest the importance of the development of programs, policies, interventions, strategies, projects and systems on how to go about the collection and/or disposal of electronic wastes. The quantitative and qualitative findings strongly suggest that these actions are to be implemented by the Local Government Unit and the Manufacturers/Telecoms as soon as possible.

Model Development. The integration of findings leads to the creation of a management model that can enlighten future research. This model is illustrated and discussed as follows in Figure 4:

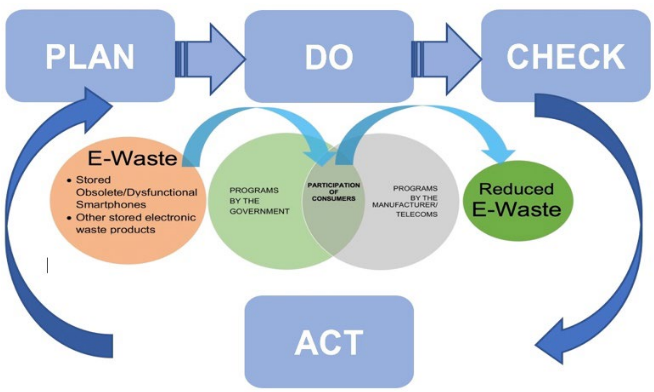

Figure 4. The E-Waste Management Model Superimposed in PCA Cycle

Figure 4 above shows how to manage an overarching production and consumption of electronic products as e-wastes. The essential part of the model is the *intersection* between government programs and those of manufacturers and telecoms as well as the use of a quality management framework – the Plan, Do, Check, Act (PDCA) Cycle for operationalization.

The E-waste Circle. The E-waste circle represents obsolete or dysfunctional electronic products comprised of but not limited to predominantly smartphones, tablets, laptops, and desktops. These items are stored and kept by most consumers because they do not know what to do with them. Usually, consumers are not aware of any programs or schemes on how to deal with these unusable products.

The Intersection. The intersection represents interventions to mitigate the adverse consequences of accumulated e-wastes. These are supposed-to-be synergistic programs by the LGU and the manufacturers or tele-companies. Metaphorically, this intersection seeks to suck out the contents of the E-waste circle.

The Reduced E-waste Circle. This represents the effects of the programs. The implementation of intervention programs must be evaluated using, say, the e-waste benchmarks vis-a-vis the actual e-waste products collected. Reduction is operationally defined using these benchmark numbers. The smaller/deflated circle represents the interventions programs are effective in mitigating e-wastes.

The superimposition of the PDCA Cycle suggests the following management actions to officially operationalize the model:

The Planning Phase identifies current benchmark on accumulated E-Wastes in the locale where the model will be applied, while simultaneously conceptualizing programs, policies and strategies by the government and industry players (Manufacturers/Telecoms).
The Do Phase is described mainly by the *Qualitative Model of Disposal Awareness*. The intersection represents participation of consumers to interventions in mitigating the adverse consequences of accumulated e-wastes. These are supposed-to-be synergistic programs, policies or strategies by the government and industry players.

The Check Phase evaluates the interventions implemented in the Do Phase It essentially evaluates whether government and manufacturer/telecom strategies have led to a significant reduction in electronic waste.

The Act Phase are actions to control non-conforming interventions evaluated from the Check Phase. This phase completes the cycle and recommends to again plan benchmark targets and actions.

6. Conclusion

Using logistics regression analysis, *smartphones* appear to be causally related to the respondents' disposal practice of *storing* or keeping. Also using logistics regression analysis, there were no other independent variables or control variables (socio-demographic traits) that appears significant.

Eight (8) respondents were selected to be interviewed for the qualitative portion. Themes were extracted, analyzed, and transformed into constituting a qualitative model.

The *Qualitative Model of Disposal Awareness* was formulated. It is composed of actions from the Local Government Unit (LGU) and the manufacturers/telecom of electronic gadgets. It is perceived by the respondents that synergistic programs from these concerned parties are imperative, so that they will be aware on what to do with their obsolete or dysfunctional electronic gadgets (e-wastes).

Integrating the quantitative and qualitative findings, the *E-Waste Management Model* was thereby formulated. It is a management model that primarily aims to lowering the accumulation of electronic wastes. It is hoped that it will serve as the basis of programs/policies of the LGU and manufacturers/telecoms. The programs must be customized to collect all the stored, unusable smartphones and other electronic products that have accumulated in households. Lastly, as the model suggests, effectiveness of the programs/policies is evaluated based on benchmark data on accumulated E-wastes vis-à-vis actual E-wastes collected and/or disposed. Finally, unusable smartphones appear to be stored or just kept by the consumers, primarily because of the scarcity or even lack of programs to recycle them, and/or lack of awareness on the part of consumers on how to deal with them.

References

Abbondanza, M.N.M., & Gabbay, de Souza R. Estimating the generation of household e-waste in municipalities using primary data from surveys: A case study of Sao Jose dos Campos, Brazil, 2019. *Research Gate*. DOI: 10.1016/j.wasman.2018.12.040.

Aberson, P. The deming cycle. *Balance Scorecard Institute*, 1998.

Abhishek, K., Mengmeng, W., Mrigendra, K. A., Zhishi, W., & Jinhui, L. Environmental pollution and human body burden from improper recycling of e-waste in China: A short-review. *Environmental Pollution*, 243(B), 1310-1316, 2018. ISSN 0269-7491. https://doi.org/10.1016/j.envpol.2018.08.037.

Alicias, Eduardo R. Jr. *Notes on the History and Philosophy of Scientific Inquiry*. Quezon City: Aurelio P. Ramos, Loyola Heights Student Center, Philippines, 2017.

Arain, AL., Pummill, R., Adu-Brimpong, J., Becker S, Green M, Ilardi M, Van Dam E, & Neitzel RL. Analysis of e-waste recycling behavior based on survey at a Midwestern US University. *Waste Manag*, 105, 119-127, 2020. doi: 10.1016/j.wasman.2020.02.002.

Awasthi, AK., Cucchiella, F., D'Adamo, I, Li J, Rosa, P., Terzi, S., Wei, G., & Zeng, X. Modelling the correlations of e-waste quantity with economic increase. *Sci Total Environ*, 613-614, 46-53, 2018. doi: 10.1016/j.scitotenv.2017.08.288.

Bazeley, P. *Qualitative Data Analysis with NVivo*. London: Sage, 2007. https://uk.sagepub.com/sites/default/files/upmassets/114916_book_item_114916.pdf.

BBC. Millions of old gadgets 'stockpiled in drawers', 2019. Retrieved from https://www.bbc.com/news/science-environment-49409055.

BBC. E-waste: Five billion phones to be thrown away in 2022, 2022. Retrieved from https://www.bbc.com/news/science-environment-63245150.

Besterfield et al. *Total Quality Management* (third edition). Pearson Education in South Asia, 2012. ISBN 9788131764961.

Borthakur A., & Govind, M. Public understandings of E-waste and its disposal in urban India: From a review towards a conceptual framework. *Research Gate Journal of Cleaner Production*, 172, 1053-1066, 2017. DOI: 10.1016/j.jclepro.2017.10.218.

Braun, V., & Clarke, V. Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101, 2006. https://doi.org/10.1191/1478088706qp063oa.

Ceballos, D.M., & Dong, Z. The formal electronic recycling industry: Challenges and opportunities in occupational and environmental health research. *Environmental International*, 2016. http://dx.doi.org/10.1016/j.envint.2016.07.010.

Chi X.A, Streicher-Porte M.B, Wang Mark Y.L., & Reuter, M.A. Informal electronic waste recycling: A sector review with special focus on China. *Waste Management*, 2010. doi:10.1016/j.wasman.2010.11.006.

DENR. Mb: national policy, regulatory framework already in place for e-waste mngt, 2020. Retrieved from https://www.denr.gov.ph/index.php/news-events/press-releases/1918-emb-national-policy-regulatory-framework-already-in-place-for-e-waste-mngt.

DENR. DENR-EMB pushes for safe, responsible E-waste disposal, 2023. Retrieved from https://denr.gov.ph/news-events/denr-emb-pushes-for-safe-responsible-e-waste-disposal/#:~:text=The%20E%2Dwaste%20can%20also,critical%20importance%20of%20proper%20disposal.&text=The%20Department%20of%20Environment%20and%20Natural%20Resources%20is%20the%20executive,of%20the%20country's%20natural%20resources.

Donghun Kang and Moon Choi. Factors Associated with Willingness to Engage in Responsible Smartphone Disposal Behaviors: Towards User-centric Policies for Sustainable Smartphone Management. *Cleaner and Responsible Consumption*, 18, 100301, 2025. ISSN 2666-7843. https://doi.org/10.1016/j.clrc.2025.100301.

Ercan, M., Malmodin J., Bergmark, P., & Kimfalk. E. Life Cycle Assessment of a Smartphone. *ICT for Sustainability 2016 Conference*, 2016. DOI:10.2991/ict4s-16.2016.15.

Ethelbhert, Derrick C. Yu, K.D., & Tan, R. Implications of the pandemic-induced electronic equipment demand surge on essential technology metals. *Science Direct*, 2020.

Derrick Ethelbhert C. Yu, Krista Danielle S. Yu, & Tan R. Implications of the pandemic-induced electronic equipment demand surge on essential technology metals. *Cleaner and Responsible Consumption*, 1, 100005, 2020. ISSN 2666-7843. https://doi.org/10.1016/j.clrc.2020.100005.

Haikal Ismail and Mm Hanafiah. Discovering Opportunities to meet the Challenges of an Effective E-waste electrical and electronic equipment recycling system in Malaysia. *Research Gate Journal of Cleaner Production*, 238, 117927, 2019. DOI 10.1016/j.jclepro.2019.117927.

Ibrahim W.F, Abd Ellatef, M.A, & Mohamed, A. Family health practices regarding household waste management in El-Zawia El-Hamra District. *Egyptian Nursing Journal*, 16, 101–114, 2019.

Ismail H., & M.M Hanafia. A review of sustainable e-waste generation and management: Present and future perspectives. *Department of Earth Sciences and Environment, Faculty of Science and Technology, Universiti Kebangsaan Malaysia*, 2020.

Jayaraman, K, Vejayon, S., Raman, S. & Mostafiz, I. The proposed e-waste management model from the conviction of individual laptop disposal practices- an empirical study in Malaysia. *Journal of Cleaner Production*, 208, 688-696, 2018.

Kenton, Will. SWOT Analysis: How To With Table and Example. *Investopedia*, 2022. https://www.investopedia.com/terms/s/swot.asp.

Kwadwo, A.A., Yaw Amoyaw-Osei, & Tetsuro A. E-waste recycling in Africa: risks and opportunities. *Current Opinion in Green and Sustainable Chemistry*, 109-117, 2019. ISSN 2452-2236. https://doi.org/10.1016/j.cogsc.2019.04.001.

Kuckartz, U., & Rädiker, S. *Analyzing qualitative data with MAXQDA*. Switzerland: Springer International Publishing, 2019.

Liang L, & Sharp A. Determination of the knowledge of e-waste disposal impacts on the environment among different gender and age groups in China, Laos, and Thailand. *Waste Management & Research*, 34(4), 388-395, 2016. doi:10.1177/0734242X16628978.

Leclerc S.H, & Badami M. G. Extended Producer Responsibility for E-waste Management: Policy Drivers and Challenges. *Journal of Cleaner Production*, 2019. https://doi.org/10.1016/j.jclepro.2019.119657.

Mahendra Garanayak, & Satyananda Champatiray. An Integrative Approach to develop E-Waste Management System for Developing Countries: A Review. *International Journal of Scientific & Engineering Research*, 10(11), 2019. ISSN 2229-5518.

Mithil Kosarkar and Sunil Barthwal. Environmentally Conscious but Helpless: Consumer challenges for participation in Formal E-Waste collection Initiatives of India. *Science Direct*. https://doi.org/10.1016/j. clwas2025.100363.

Nishant, S., & Ravi, T. Stepped Recycling: The Solution for E-waste Management and Sustainable Manufacturing in India. *Materials Today: Proceedings*, 4(8), 8911-8917, 2017. ISSN 2214-7853. https://doi.org/10.1016/j.matpr.2017.07.242.

Peralta, G., & Fontanos, P. E-waste issues and measures in the Philippines. *J Mater Cycles Waste Manag*, 8, 34–39, 2006. https://doi.org/10.1007/s10163-005-0142-5.

Phl's E-waste Problem: Over 24M Phones Discarded Yearly by 2021. *One News by the Philippine Star*, 2019. Retrieved on July 9, 2019 from https://onenews.ph/phl-s-e-waste-problem-over-24-m-phones-discarded-yearly-by-2021.

Rajakumar S., R. Prasanna S, & K.A Jeyaprakash. Students buying pattern of modern electronic (e)-gadgets. *International Journal of Advanced Research in Science, Engineering and Technology*, 7(11), 2020. ISSN: 2350-0328.

Ramos, Lara. 5 Places You Can Send or Donate Your Used Electronic To. *Globe Telecoms Article*, 2019. Retrieved on April 11, 2019 from https://www.globe.com.ph/go/technology/article/donate-used-electronics.html.

Republic Act 9003, 2001. Retrieved from https://www.officialgazette.gov.ph/2001/01/26/republic-act-no-9003-s-2001/.

Royal Society of Chemistry. As consumers we are accumulating more and more technology, 2019. Retrieved from https://www.rsc.org/new-perspectives/sustainability/elements-in-danger/.

Sajid M, Syed JH, Iqbal M, Abbas Z, Hussain I, & Baig MA. Assessing the generation, recycling and disposal practices of electronic/electrical-waste (E-Waste) from major cities in Pakistan. *Waste Manag*, 84, 394-401, 2019. doi: 10.1016/j.wasman.2018.11.026.

Salsabil S. et. al. An exploratory study of e-waste creation and disposal: Upstream considerations. *Victoria University Business School (VUBS)*, Victoria University, Melbourne, Victoria 3000, Australia, 2019.

Sathish Paulraj Gundupalli, Subrata Hait, Atul Thakur. Classification of metallic and non-metallic fractions of e-waste using thermal imaging-based technique. *Process Safety and Environmental Protection*, 118, 32-39, 2018. ISSN 0957-5820. https://doi.org/10.1016/j.psep.2018.06.022.

Shambavi Rajagopal, & Ipshita Bansal. "Waste disposal of fresh fruits and vegetables". *Management of Environmental Quality: An International Journal*, 26(5), 721-738, 2015. http://dx.doi.org/10.1108/MEQ-10-2013-0115.

Singh N., Duan H., Oladele A. Ogunseitan, Jinhui Li, & Yuanyuan Tang. Toxicity trends in E-Waste: A comparative analysis of metals in discarded mobile phones. *Journal of Hazardous Materials*, 380, 120898, 2019. ISSN 0304-3894. https://doi.org/10.1016/j.jhazmat.2019.120898.

Sivakumar, Bharat. Deming Cycle: Definition & Importance Of Plan-Do-Check-Act (PDCA) Cycle. *Feedough: The Entrepreneur Guide*, 2022.

Srivastava, R., & Pathak P. Policy issues for efficient management of E-waste in developing countries. *Elsevier*, 2019. DOI: 10.1016/B978-0-12-817030-4.00002-4.

Unitar. The Global E-waste Monitor 2024- Electronic Waste Rising Five Times Faster than Documented E-Waste Recycling: UN, 2024. Retrieved from https://ewastemonitor.info/the-global-e-waste-monitor-2024/.

Vanegas P, Martínez-Moscoso A, Sucozhañay D, Paño, Andrés Tello, P., Abril A, Izquierdo I, & Pacheco G, Craps M. E-waste management in Ecuador, current situation and perspectives. *Handbook of Electronic Waste Management*, 479-515, 2020. Butterworth-Heinemann. ISBN 9780128170304.

Vinodhini P., Dr. V. Sasikala , & Dr. U. Urathal Alias Sri Swathiga. Analysis on purchase of gadgets and accessories through online shopping. *Dogo Rangsang Research Journal*, 11(12), 2021. ISSN: 2347-7180.

Yahmady, H., Hilal, S., & Said, A. Using NVIVO For Data Analysis in Qualitative Research. *International Interdisciplinary Journal of Education*, 2(2), 2013.

Yang H, Zhang S, Ye W, Qin Y, Xu M, & Han L. Emission reduction benefits and efficiency of e-waste recycling in China. *Waste Manag*, 102, 541-549, 2020. doi: 10.1016/j.wasman.2019.11.016.

Ying Qu, Wenhua Wang, Yue Liu, & Qinghua Zhu. Understanding residents' preferences for e-waste collection in China - A case study of waste mobile phones. *Journal of Cleaner Production*, 228, 2019. ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2019.04.216.

Wang K, Qian J, & Liu L. Understanding Environmental Pollutions of Informal E-Waste Clustering in Global South via Multi-Scalar Regulatory Frameworks: A Case Study of Guiyu Town, China. *International Journal of Environmental Research and Public Health*, 17(8), 2802, 2020. https://doi.org/10.3390/ijerph17082802.

Wenhua Wang, Yihui Tian, Qinghua Zhu, & Yongguang Zhong. Barriers for household e-waste collection in China: Perspectives from formal collecting enterprises in Liaoning Province. *Journal of Cleaner Production*, 153, 299-308, 2017. ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2017.03.202.

Wilson Van Voorhis, Carmen R. & Morgan, Betsy L. Understanding Power and Rules of Thumb for Determing Sample Sizes. *Tutorials in Quantitative Methods for Psychology*, 3(2), 43-50, 2007. DOI 10. 20982/tqmp.03.2p043.

ZDNET. Study: Mobile phones not being recycled, 2008. Retrieved from https://www.zdnet.com/article/study-mobile-phones-not-being-recycled/.

ZDNET. Our old devices are creating a mountain of e-waste. And it's getting a lot bigger, 2021. Retrieved from https://www.zdnet.com/article/our-old-devices-are-creating-a-mountain-of-e-waste-and-its-getting-a-lot-bigger/.

Biography

Dr. Rey Julius C. Fortuna works at Philippine Amusement and Gaming Corporation, as a Senior Manager and a part-time professor at the Technological University of the Philippines and Special Lecturer at the Polytechnic University of the Philippines.