Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 23 | No. 4 | pp. 1937-1955 | 2024

Original Research Paper

https://doi.org/10.46488/NEPT.2024.v23i04.005

Open Access Journal

Analysis of the Lebanese Society's Behavior Regarding Electronic Waste Management

M. Trad† and A. Harb
Faculty of Business Administration and Economics, Notre Dame University, Lebanon
†Corresponding author: M. Trad; mtrad@ndu.edu.lb

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 03-03-2024
Revised: 16-04-2024
Accepted: 26-04-2024

Key Words:
E-waste
E-cycling
Waste management
Environmental awareness
Refurbished products
Recycled materials

ABSTRACT

This paper examines electronic waste and cycling in Lebanon. It describes the current situation regarding e-waste among government agencies and non-governmental organizations. It addresses two research questions: The first one asks if the Lebanese society and government are aware of the dangers posed by electronic waste and whether any action has been taken to prevent an environmental catastrophe. The second question asks about Lebanese attitudes toward e-waste and whether they are willing to fight against it. Interviews provided the first question's responses. The authors have visited Organization A and NGO B. The first is worried about gathering waste in more prominent Beirut, while the second targets spreading attention to e-waste's risks on legislative and social levels the same. Question two was discussed through surveys filled out by arbitrary people from Lebanese society. The answers to both research questions came in a manner that demonstrates the two hypotheses expected toward the start of the study, specifically that e-waste represents an incredible danger to the Lebanese climate. Hypothesis two, if climate neighborliness and proclivity to right e-garbage removal rely upon the instructive level of some random resident, has been confirmed while analyzing the answers in the survey.

INTRODUCTION

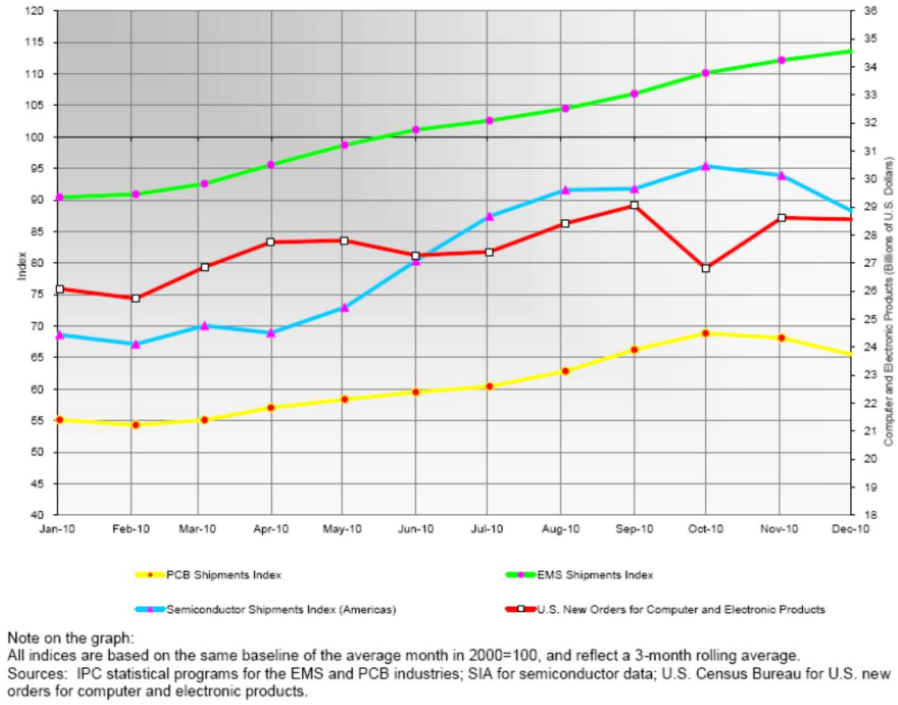
The reliance on technology is what most defines the twenty-first century and sets it apart from previous eras. These days, it is difficult to envision existence without PCs, cell phones, TVs, or some other electronic appliance; Furthermore, it is insufficient to use with about any computer, mobile device, or television: these should be ultramodern, or if nothing else present day for them to enough work. The consumer is being forced to follow technology's rapid development and occasionally purchase new electronic appliances, putting older devices that are no longer compatible with modern technology in the basement or junkyard. This unused electronic equipment will eventually be thrown out. The buyer electronics industry has been developing at an incredibly high rate. Interest in buying electronic products has forever been there, however, it has arrived at its peak in the past couple of years. This has brought about the extension of this area, which is presently one of the most productive in the worldwide economy (Nagajothi & Kala 2018, Chen 2010). Electronic waste, also known as e-waste or e-scrap, is discarded, broken, surplus, and obsolete electrical and electronic equipment; Additionally, the term "Waste Electrical and Electronic Equipment" (WEEE) is frequently utilized. E-squander signifies any item that holds an electronic board, a battery, or just electronic parts like a screen, capacitors, diodes, and transformators that are broken or presently not utilized. Examples of electrical and electronic devices that could turn into WEEE are TV and PC monitors, computers and computer peripherals (e.g., webcams, keyboards, scanners, printers, USB flash memory, etc.), Audio and stereo equipment (e.g., MP3 players, DVD, VCR, CD players, etc.), Corded & Wireless communication devices, Cameras, Fax and copy machines, video game consoles, batteries, adaptors, chargers and UPS, Home appliances such as Microwaves, Fridges, Irons etc. (Bortoleto 2015, Mor et al. 2021, Hong et al. 2015, Xue & Xu 2017). Throughout this paper, the terms electronic waste, e-scrap, WEEE, and e-waste are used interchangeably. As hardware keeps on propelling, there is more in innovation to anticipate. The development of electronic technology may improve the world, but it poses a greater threat to the environment. Pollution and the construction of buildings brought about by modernization harm trees and animal habitats. Flooding happens considering timberland deforestation. Electronic gadgets should be eco-friendly, so developers should think about that. Innovation must not ignore environmental concerns. Worldwide, waste of electrical and electronic equipment ranges from 20 to 50 million tons annually;

these electronic gadgets are, made of a wide assortment of material constituents. Constituents, like lead, nickel, cadmium, and mercury could present dangers to human wellbeing or the climate whenever fumbled at their finish of life. On the other hand, these components of e-waste are made of valuable resources like copper, precious metals, and engineered plastics, all of which take a lot of energy to process and make. By recovering these valuable materials through recycling (E-Cycling) or reusing less raw materials are taken from the earth, air and water pollution is reduced, gas emissions are reduced, and energy and resources are saved (Kaza et al. 2018, Murthy & Ramakrishna 2022, Islam et al. 2020, Kiddee et al. 2014). Hereby is an example of a study done by the EPA (Environment Protection Agency) of the United States of America. This study shows that recycling one million laptops saves energy equivalent to the electricity used by 3,657 US homes in a year. Given that study and other examples, a worldwide appeal for proper processing and management lately increased. The European Association has as of late fostered a progression of new strategy drives to additional location negative natural and human well-being effects of risky substances. In EU terms, three recent policy developments—two "directives" and one "regulation"—have a significant impact on the management of hazardous chemicals and e-waste in the future. The first directive covers waste electrical and electronic equipment (WEEE), and the second outlines restrictions on the use of certain hazardous substances in electrical and electronic equipment (RoHS). WEEE and RoHS entered into force in February 2003. In Lebanon, there are still no legislative guidelines or arrangements that treat the waste issue. As a result, citizens should be made more aware, and the government should deal with WEEE in accordance with international standards. The management of electronic waste in Lebanon will be illuminated in this paper. It will report on the existence of governmental and non-governmental organizations concerned with e-waste regulation or recycling as well as statistics regarding people's awareness of this issue. Through our research and interviews with various Lebanese parties, we intend to determine whether improper disposal of e-waste poses a threat to human and environmental health. Additionally, we target upgrading mindfulness among Lebanese residents, beginning with understudies in schools and colleges to any party worried about saving the earth from these perilous materials and edifying them about the approaches to taking care of waste created and what might be the advantage if fittingly managed. To effectively manage e-waste through either e-cycling (electronic recycling), reuse, or donation, the government and the public must acknowledge the issue and implement policies.

SIMILAR STUDIES IN THE PAST

The results of earlier research that was conducted by nations all over the world, such as the United States, Europe, and Japan, are presented in this section. Data is accumulated from articles, distributed booklets and studies led about the impact of E-Waste on the climate and the human well-being living around and its control cycle. People's lives have been drastically altered by the Industrial Revolution, which was followed by advances in information technology over the past century. Even though humans have benefited from this development, poor management has resulted in recent contamination and pollution issues. The technological competence acquired over the past century has brought about a new obstacle in waste management. A study on computer trends found that the steady rise in demand was remarkable. Computers are now used in a wider variety of settings, including schools, offices, homes, and manufacturing facilities, than ever before (Rathi & Shyamalendu 2015, Stoeva & Alriksson 2017). Regarding the expansion and availability of electronics in the United States, an IPC study demonstrates the rising demand for electronic goods:

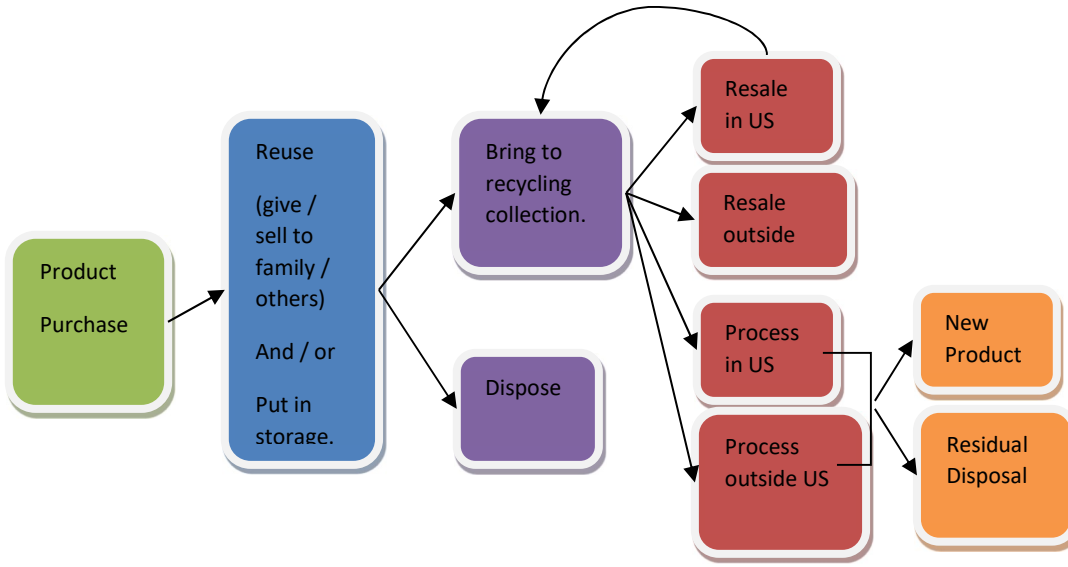
Fig. 1 shows that the U.S. economy grew at an annualized rate of 3.2 percent in the fourth quarter of 2018. The solid growth was attributed to consumer spending and foreign trade. Besides, a UN study found that the manufacturing of a computer and its screen takes at least 240 kg (530 pounds) of fossil fuels, 22 kg (48 pounds) of chemicals, and 1.5 tons of water – more than the weight of a rhinoceros or a car. As a result, household appliances, personal computers, and other electrical and electronic equipment (WEEE) waste is regarded as one of the hazardous waste categories with the fastest global growth. The preceding section cites research conducted by several organizations, which demonstrates that the volume of e-waste is without a doubt expanding at unprecedented rates. However, what is so distinctive about this kind of waste? What makes it unique in relation to various kinds of trash like biodegradable waste or paper and cardboard waste? Well, the toxicity and high value of its components are what make e-waste unique. A variety of substances, both non-hazardous and toxic, are contained in typical electrical waste. Take, for instance, a discarded small radio: This device has metal parts like the antenna and screws in a plastic casing. Inside the casing are one or more PCBs (Printed Circuit Boards) made of plastic or resin with thin copper layers and small electronic components and ICs (Integrated Circuits) that are attached to the PCB with lead solder. While copper, tin, tar, and plastic are nontoxic, nonetheless they can be reused and reused in the creation of new plastic and metal parts. Other non-risky materials can be found in small amounts in electrical and electronic



(Source: www.ipc.org)

Fig. 1: Trends in U.S. Computer and Electronic Products New orders and North American Sales Indices of Selected Supplier Industries in 2018.

items like this radio are aluminum (utilized in electrolytic capacitors), silicon (utilized in ICs), gold utilized as plating for connectors, and different components like zinc, lithium, germanium (Bhat & Patil 2021, Abbas et al. 2019, Ilankoon 2018, Song & Li 2015). The toxic substances in the radio are the lead contained in the solder, BFRs (Brominated Flame Retardants) used as a flame retardant in most electronic parts subject to prominent levels of heat, and cadmium used in batteries. Other toxic elements known to be used in various electronic devices are Americium, a radioactive element used in smoke detectors. Mercury: found in flat screens, mechanical doorbells, and fluorescent tubes. Sensory impairments, dermatitis, memory loss, and muscle weakness are negative health effects. Death, diminished fertility, and diminished growth are animal effects of the environment. Sulfur: utilized in lead-acid batteries. Health effects incorporate liver harm, kidney harm, heart harm, eye, and throat bothering. Sulfuric acid can result from its release into the environment. Cadmium: found in nickel-cadmium batteries, corrosion-resistant alloys, and light-sensitive resistors. Nickel-cadmium rechargeable batteries contain the most usual form of cadmium. It can leach into the soil, harming microorganisms and disrupting the soil ecosystem if it is not properly recycled. Cadmium exposure through inhalation has been linked to kidney damage and severe lung damage. Oxide of beryllium: filler in some materials used at the thermal interface, like the thermal grease on CPU and power transistor heatsinks. If taken orally, beryllium oxide is extremely harmful. One will find at least one of these harmful substances recorded above in each piece of electronics conveying genuinely a threat to the climate and the people. Since the nineties,' developed nations have mitigated the risks associated with irresponsible e-waste disposal (Bell et al. 2010, Adeola & Othman 2011, Sthiannopkao & Wong 2013). As previously stated, developed nations have conducted research and raised public awareness of this pressing issue because e-waste poses a risk to citizens and the environment. In the US, electronic gear has turned into a pillar of their lifestyle. Somehow, it is a fundamental piece of all that they do and possess TVs in homes, automobile GPSs, MP3 players and cell phones in their pockets, and laptops on desks and laps. Every year, the electronics industry makes $2 billion. Americans own three billion electronic items. For every new product that is introduced, one or more become out of date or obsolete. As a result, they are throwing away or storing older electronics more quickly than ever before. In 2015, the Environmental Protection Agency (EPA) estimated that between twenty-six and thirty-seven million computers became obsolete. In addition to that, the amount of used or unwanted electronics ranged between 1.9 and 2.2 million tons. Of these, about 1.5 to 1.8 million tons were primarily disposed of in landfills,



(Source: Electronics Waste Management in the U.S, Office of Solid Waste U.S Environmental Protection Agency)

Fig. 2: Framework for Modeling the Product Lifecycle.

and only 345,000 to 379,000 tons were recycled. So, the EPA has been collaborating with stakeholders to help improve awareness of the need for the recovery of electronics and access to safe reuse and recycling options. State and neighborhood legislatures, producers, and retailers, who are as of now mindful of the squeezing need to more likely deal with these materials, are providing more chances to recycle and reuse this equipment. Electronics cannot be disposed of in landfills in at least seven states, and four have established recovery programs. A form of legislation to regulate used electronics is being considered by a few additional states. To assist in the management of discarded household electronics, over eight hundred communities have established electronics collection events (Seeberger et al. 2016, Kahhat et al. 2008, Abalansa et al. 2021).

Key Findings

The electronic products lifecycle: Almost half or 976 million units, of all the products sold between 2000 and 2014 are still in use or reuse (Fig. 2). About 42 percent, or 842 million units, of the products sold between 2000 and 2014 have been recycled or disposed of.

The storage: From 1980 until 2005, 180 million electronic products had accumulated in storage. In 2005 alone, approximately 460 million products were put into storage and/or reuse. TVs account for 34-52 percent (by weight) of the units in storage. Desktop PCs account for approximately 24 percent (by weight) of stored units.

Recycling vs Disposal: In the period from 2003 to 2005, electronic products available for EOL management were recycled or disposed of in the following approximate percentages: About 15-20 percent was collected for recycling. The recycled/disposed split remained constant in the years from 1999 until 2005. Although recycling continues to increase, the percentage recycled is still constant because of the ever-increasing number of electronics available for EOL management. About 80-85 percent was disposed of (in landfills). In the two years period from 2003 until r2005, when products are included into storage or reuse. Approximately 44 percent of products were disposed of, and 11 percent recycled.

End markets: In 2005, approximately 61 percent, or 107,500 tons, of CRT monitors and TVs collected for recycling were exported for remanufacture or refurbishment. The next largest part (about 14 percent or 24,000 tons) was CRT glass sold to markets abroad for glass-to-glass processing, while lead recovery in North America accounts for about 6 percent (10,000 tons) of the materials. (Gibson & Tierney 2006, Ogunseitan et al. 2004, Kang & Schoenung 2005, Abalansa et al. 2021).

Fig. 3 stands for the average amount of electronics recycled, disposed of, or put into storage or reused from 2003 till 2005. In 2005 alone, approximately 460 million units were put into storage and/or reuse.

As for TVs and CRT monitors collected by electronic recyclers in the U.S., information is presented in Table 1.

According to the data, 61% of the CRT monitors and TVs that were collected for recycling are exported to produce

(Source: www.epa.gov)

Fig. 3: Electronic products, recycled, disposed, or Going into Storage/Reuse 2011-2017.

re-manufactured or refurbished CRT monitors and TVs. In terms of European nations, statistics from Euro stat indicate that the European Union alone generates three billion tons of waste each year, approximately ninety million of which are hazardous. This amounts to about six tons of solid waste for every man, woman, and child. Between 1990 and 1995, the amount of waste generated in Europe increased by 10%, according to the Organization for Economic Cooperation and Development (OECD). Additionally, waste is either disposed of in landfills or burned in incinerators (67 percent). However, these two methods harm the environment. In addition to taking up increasingly valuable land, landfilling pollutes the air, water, and soil by releasing carbon dioxide (CO2) and methane (CH4) into the atmosphere and chemicals and pesticides into the ground and groundwater. In turn, this is bad for people's health as well as for plants and animals (Propescu 2015). By 2020, the OECD estimates, that they would generate 45% more waste than they did in 1995. One of the four top priorities in the EU's Sixth Environment Action Program is waste prevention and management. Its essential objective is to decouple waste generation from financial action, so EU development will never again prompt expanded junk, and there are signs that this is starting to occur. The generation of municipal waste, for instance, decreased in the Netherlands and Germany during the 1990s. Through new waste prevention initiatives, improved resource utilization, and encouraging a shift to more sustainable consumption patterns, the EU is aiming for a significant reduction in garbage production (Vadoudi et al. 2015, Skinner et al. 2010, Mohanty et al. 2015).

Table 1: End Markets for EOL TVs and CRT Monitors Collected for Recycling in the U.S. in 2012 .

End Market	Tons/Year	% of Total
Resale 'as is' or after some repair/ upgrade in the US	3000	2%
Resale 'as is' or after some repair/ upgrade abroad	3500	2%
Refurbishing or remanufacturing into specialty monitors in the US	2500	1%
Refurbishing or remanufacturing into specialty monitors abroad	107500	61%
CRT glass-to-glass factories in the US	4000	2%
CRT glass-to-glass factories abroad	24000	14%
CRT glass to smelters in North America for lead recovery	10000	6%
Plastic, metal and other material recovery from remanufacturing	20500	12%
Total	175000	100%

(Source: World Reuse, Repair and Recycling Association)

The three guiding principles of the European Union's waste management strategy are:

1. Preventing waste: Any strategy for managing waste must include this. By reducing the presence of hazardous substances in products, we can reduce the amount of waste that is generated and make it less hazardous. This will make it easier to get rid of waste. 2. Improving

Fig. 4: E-waste disposal container at a German electronics company

Fig. 5: All out-of-order electronic parts end up here.

manufacturing techniques and influencing consumers to demand greener products and less packaging are all intertwined with waste prevention. 3. Recycling and reuse: Recovering as much of the materials as possible, preferably through recycling, should be done if waste cannot be avoided. The European Commission has characterized explicit 'waste streams' for need consideration, the point being to lessen their ecological effect. Waste from packaging, used cars, batteries, and electrical and electronic waste are all included in this. The collection, reuse, recycling, and disposal of these waste streams must now be regulated by Member States in accordance with EU directives. Over fifty percent of the waste packaging is already recycled in EU countries. Enhancing surveillance and final disposal: Waste that cannot be recycled or reused should be safely burned

Table 2: Estimated amount of WEEE currently collected and treated as a percentage of the total amounts of WEEE for the EU27, 2005.

Large household appliances (smaller items)	40%
Small household appliances, lighting equipment – luminaires and domestic medical devices	26.6%
IT and telecom excl. CRT's	27.8%
CRT monitors	35.3%
LCD monitors	40.5%
Consumer electronics excl. CRT's	40.1%
CRT TV's	29.9%
Flat-panel TVs	40.5%
Lighting equipment – Lamps	27.9%
Electrical and electronic tools	20.8%
Toys, leisure and sports equipment	24.3%
Medical devices	49.7
Monitoring and control instruments	65.2%
Automatic dispensers	59.4%

(Source: Best Practices for E-Waste Management in Developed countries)

instead of dumped in a landfill whenever possible. Both these techniques need close checking considering their true capacity for causing extreme natural harm. A directive with stringent management guidelines for landfills was recently approved by the EU. It boycotts specific sorts of waste, like utilized tires, and focuses on diminishing amounts of biodegradable garbage. Incinerator emission levels are tightly controlled by another recent directive. The Union also wants to reduce emissions of dioxins and acid gases such as nitrogen oxides (NO_x), Sulphur dioxides (SO_2), and hydrogen chlorides (HCL), which can be harmful to human health (Sthiannopkao et al. 2013, Mohanty et al. 2015, Vadoudi et al. 2015).

Regarding the infrastructure of e-waste management, Europe is considering three main types of e-waste management systems, namely, Take-back systems (collective-model), clearinghouse-model and European Recycling Platform (ERP).

National collective system: is the most widely used national system for managing WEEE collection within national boundaries (Table 2). Although their legal status varies from country to country, they are non-profit, non-governmental businesses owned by one or more trade associations. They are organized into product categories so that they can find markets for recycled material and product reuse and focus on making their recycling operations as efficient as possible. This framework has drawbacks: Cost prohibitive in comparison to the clearing house model in terms of enforcement and does not encourage cost reduction. On the other hand, this is the case in an environment where competition is constant, and the economics of the supply chain are a major driving factor.

Competitive clearing house system: is again a public system in which different accomplices. However, it lacks the knowledge and data necessary to effectively analyze and compare it to other collective schemes.

European recycling platform: enables member businesses to meet the WEEE's product take-back obligations at a competitive cost, benefiting both customers and the environment (Sthiannopkao et al. 2013).

In conclusion, previous experiences with electronic waste policies in developed nations demonstrate that legislation ought to serve a variety of broader societal objectives. It ought to likewise obviously characterize the jobs, obligations, and meanings of waste included under the umbrella of the regulation to limit managerial burden and confusion. It is essential and beneficial for implementation to separate operational standards from the fundamental legal framework. E-waste management is a long-term process that requires collaboration among various stakeholders and technological advancements to better manage the issue and reduce e-waste through the design of future electronic products. Even in developed nations like Japan and the EU, where e-waste management has been practiced for a long time, there is a lot of room for improvement in the way e-waste is collected and managed in the future. Notwithstanding, existing great practices from created nations give significant illustrations and bits of knowledge to developing nations to manage e-waste and its management both as far as great practices can be taken on and thought about in figuring out or auditing existing e-waste regulation in the country. Once we see the success of the other countries around the world in dealing with e-waste management, we deduce the necessity of such policies and regulations' implementation as well as rising awareness among citizens. All these facts have driven us to focus on the current Lebanese situation and the e-waste status. Our paper will be looking at this issue in terms of current circumstances, management, and awareness.

MATERIALS AND METHODS

This study will make use of both primary and secondary data. Interview-based primary data and reliable secondary data, such as articles in journals and magazines, previous studies and research, published books, and websites. We found that Lebanon is in great danger for the environment if society does not change its perception of undifferentiated waste disposal at the nearest dumping site or valley, and it was urgent to assess the local situation to determine which

organizations are working on this matter, which laws or drafts of laws are in place to curb the environmental disaster that is about to occur and to determine whether citizens are aware of the e-waste danger, how they deal with their old electronic appliances, and whether they would be willing to do more to save nature. Hence, in essence, this paper will answer two questions through research

1. Is there such hazardous waste in Lebanon, and if so, what campaigns have been launched to combat it? In addition, does the government of Lebanon enact any legislation to combat waste?
2. How does the typical Lebanese feel about e-waste, and how willing is he or she to fight it?

Following our research questions, two theories are molded. These hypotheses help in guiding the study, showing realities, and providing a system for diving into conclusions and suggestions. In our study, two hypotheses are developed.

The first hypothesis says the following:

Governmental and NGO actions, translated into easing e-cycling and raising awareness among the citizens, will have a positive impact on cutting environmental hazards, reducing pollution, and saving natural resources.

As for the second hypothesis, it claims that:

The purchase of recycled products is highly affected by the consumer's prejudgment and status.

In our stated hypotheses, the independent variables are as follows: In the first hypothesis, awareness campaigns and facilitation of e-cycling are the independent variables that have a direct effect on human health and nature. E-cycling refers to the recycling of waste associated with electrical or electronic products like computers, mobile phones, televisions, and microwaves, as opposed to throwing them away and creating e-waste. Encouraging people and raising their awareness to be socially and environmentally involved in saving the planet and their health through buying refurbished products will also save natural resources and reduce costs. In the second hypothesis, the purchase of electronics is the dependent variable while it is linked to the independent ones: consumer's prejudgment and status. The level of consumption of such recycled goods would rise because of raising awareness among Lebanese people, and it is important to note that status would play a significant role in influencing buyers' actions. In our paper, we can notice that the dependent and independent variables are more qualitative than quantitative due to the type of primary data collected. They assist us in providing useful recommendations and are utilized for the evaluation of e-waste in Lebanon. The authors of this paper, for reasons of confidentiality, refer to interviews with Company A and NGO B to support their hypothesis regarding the Lebanese actions and their impact on e-waste to demonstrate that hypothesis one is true.

Data used to support hypothesis #1 is extracted from two diverse sources: To demonstrate that e-cycling is the most practical approach to addressing the e-waste issue, the authors rely on online literature on a global scale. Due to the lack of literature on the effect of laws and recycling initiatives in Lebanon, the authors resorted to interviewing officials in two local organizations concerned with e-waste treatment in Lebanon. As mentioned, if we go through the hazards engendered by e-waste, we remark that this e-waste has toxic substances that are harmful to humans and the environment. Electronic products and their components, such as semiconductor chips, circuit boards, and disk drives, are made of over one thousand different elements, including chlorinated solvents, PVC (polyvinyl chloride), heavy metals, plastics, and gazes. E-waste risks are minimal when these components are securely encased in the purchased goods. Issues can happen when devices break. They can leak and contaminate their immediate surroundings—the house, the school, the street, the natural world, or the landfill—at this point. Over time, the toxic chemicals of landfill e-waste can seep into the ground, enter the water supply, or they can escape into the atmosphere, thus affecting the health of nearby communities. Hazardous waste reuse, recycling, and reclamation can avoid environmental hazards and pollution. In terms of environmental benefits, recycling hazardous waste fulfills two of RCRA's (Resource Conservation & Recovery Act) goals by reducing the consumption of raw materials and reducing the volume of waste materials that must be treated or disposed of. Primary data has been gathered through qualitative interviews conducted with an NGO named B, founded in 2008, whose primary goal is to promote good environmental practices among the MENA communities for sustainable development, and with Company A, which takes care of cleaning the cities from streets to urban areas to parks and public spaces. Starting in Beirut, they now cover the Greater Beirut area and Mount Lebanon, serving more than two million residents. Interview protocols were structured following the research questions developed and addressed in our paper, one for the president of NGO B and one for the representative of company A. Regarding the second hypothesis, which says that the environmentally aware behavior of the consumer in Lebanon varies depending on his education and social status, the authors support their hypothesis by conducting a survey on a sample of fifty individuals, chosen randomly but of diversified age span, gender, and education level. After analyzing our data via the Statistical Software "SPSS," the indicators that shall be noted are mentioned in Tables 3 and 4. The educational level of the polled sample is distributed as in Table 4.

Table 3: Population.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	26	52.0	52.0	52.0
	Female	24	48.0	48.0	100.0
	Total	50	100.0	100.0	

Table 4: Educational Level.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Brevet	2	4.0	4.0	4.0
	Official Baccalaureate (Lebanese or equivalent)	5	10.0	10.0	14.0
	University degree	43	86.0	86.0	100.0
	Total	50	100.0	100.0	

As a conclusion, research questions and hypotheses were developed and stated explicitly. The dependent and independent variables were identified, and the collection of secondary and primary data was performed through various research instruments that were introduced and explained above. The basis of the SPSS survey was defined, and the general framework for the two interviews with company A and NGO B was described.

RESULTS AND DISCUSSION

This part presents the results of the interviews conducted with the two parties involved with e-waste management in Lebanon, namely company A and NGO B. It also lists the results of the conducted survey on a sample of 150 Lebanese citizens and concludes the given answers in the form of statistics. The president of NGO B started the interview by introducing the organization as a non-governmental (NGO) founded in 2008 and aims to promote good environmental practices among the MENA communities for sustainable development. The organization's mission is to induce a change in the behavior of the MENA region communities to protect and save the environment. To promote public-private partnerships to successfully implement community-based environmental development projects. To lobby for the practice of sustainable environmental behavior in the MENA region both at grassroots and national levels and to adopt and adapt environmentally sound technologies for solid and wastewater management.

NGO B representative afterward cited a couple of events recently held across Lebanon to promote awareness for e-waste in society and at the official level. The most notable events were:

The NGO Launches the Arab Forum for E-Waste Management

The workshop was held in Beirut with the presence of well-respected officials from both the public and private sectors who spoke about their partnership with NGO B, which focuses on encouraging the reuse of computers before recycling them by providing licensed software that is compatible with refurbished computers. This process is part of their environmental initiative in the Middle East and North Africa.

And to sum up the event, the below list of recommendations that will be addressed to the board of the Arab Ministries for further advocacy includes enacting and amending legislation to conform with the needs of e-waste management. Preparing national action plans that tackle the e-waste issue. Applying and issuing internationally approved guidelines for the sound management of e-waste and adjusting them to suit the participating countries. Building the abilities of relevant institutions (Government, private sector, civil society, and media) on e-waste hazards and proper management. Raising the level of awareness and knowledge among producers, importers, and wholesalers of electrical and electronic devices, setting up a mechanism to communicate with them through Chambers of Commerce. Strengthening the partnership between the public and the private sector and the civil society organizations for e-waste management. Creating coordination mechanisms between the institutions of civil society and introducing e-waste awareness in schools, technical institutes, and universities' curricula.

The NGO Collaborates with the American University of Beirut to Spread Awareness of the Dangers of E-Waste

The event took place with the collaboration of the American University of Beirut's Center of Civic Engagement and Community Services and the University's environmental club. It was under the patronage and presence of a top-level representative of the Ministry of Environment that NGO B organized this E-Waste awareness and collection day at the American University of Beirut. Through this collaboration, NGO B and the latter university aim to spread awareness on the E-Waste issue where they pointed out that 65% of the

Lebanese population keep their E-waste at home, "ignoring the health risks of this silent killer" and help guide university students along with the surrounding to support this movement and encouraging the sustainability of the operation. The named university will be acting as an official E-Waste collection point.

The NGO Launches "E-waste Best Management in Public Administrations and Institutions"

NGO B's president pointed out the dangers of the improper disposal of e-waste, knowing that it has more than one thousand toxic substances. He then declared that the project aims to raise the level of awareness on this matter among workers of public administrations and institutions. As for the director of the NGO, she declared that currently, e-waste occupies approximately 22,000 cubic meters of storage in public institutions.

The NGO Lobbies for the Approval of a Decree for the Best Management of E-Waste in Public Administrations and Institutions

This event was organized with the presence of other NGOs alongside ministries' representatives and officials.

The key achievements of the NGO's project were announced by its president as follows: Raising awareness in the ministries and public institutions about the dangers of E-waste and the environmental and health problems attributed to it. Drafting a decree that would set up guidelines to check and collect e-waste in the ministries. It has been sent to the Lebanese Ministry of Environment to be reviewed and then to be given to the Council of Ministers. Setting up an inter-ministerial committee that would sustain the E-waste collection in the ministries, in cooperation with NGO B, Including more public and private schools that receive help from awareness material. Launching a TVC that used social media like Facebook and YouTube to reach a wider range of the public, and which will soon be on television.

A USAID representative discussed the importance of initiatives as such, targeting extremely dangerous issues like the e-waste problem. He affirmed that USAID is always willing to encourage civil society organizations in Lebanon to play a more active role in promoting good governance in both the public and the private sectors. One representative from the Ministry of Environment (MoE) talked about the sustainability of the cooperation between the Lebanese MoE and NGO B, stressing the importance of this environmental initiative, knowing that Lebanon has signed International Conventions that include e-waste management within their scope of work. She declared that environmental safety is one of the most fundamental rights for the generations to come, and it is our duty to provide them with the best conditions possible. Besides, the results of the conducted assessment by NGO B on the status of e-waste in ministries were as per the following: When stored, the electronic waste is revealed to be a costly operation for the ministries, which can reach up to 12,000 USD a year. The average turnover rate is 4 years; however, a computer's lifespan could reach up to 7 years or until it is broken before disposing of it. There are no common procedures for the disposal of E-waste nor is there a department responsible for their disposal.

Microsoft and NGO B Launch "The Responsible E-learning through E-Waste Best Management"

Together, NGO B and Microsoft organized a connection day/workshop. This workshop was under the high patronage of the Lebanese Ministry of Environment. During this event, Lebanon Country Manager in Microsoft, spoke of the corporation's green initiative and the support it provides to the civil society through technology. Also, she portrayed the environmental policies applied at Microsoft's buildings worldwide. The purpose of this workshop was explained to the participants as follows: "Our goal is to set an action plan that helps provide the public with a realistic and sustainable solution for the E-waste problem by making use of technology; hence, we would be forming responsible E-generators through our educational activities." Increased events and projects were and will be launched by this NGO aiming at raising awareness about E-Waste dangers and the best way of managing it. They are highly focused on the new generation through workshops organized at schools and summer camps, in addition to the competitions that improve commitment and excitement about this issue. Besides, during their organized events and workshops, they insisted on the hazards of E-Waste on human health and the environment and the way to prevent such impacts. NGO B has prepared a hierarchy of e-waste management standing for a continuum from the least favored choice to the most favored one: disposal, energy recovery, recycling, reuse, minimization, and prevention. They consider that prevention is the most desired action that should be admitted by users since once they are aware of their impact, people will think twice before acting. On the other hand, we should recognize that the Ministry of Environment and the EU are getting the proper approval for NGO B to ship the e-waste collected in Lebanon to recycling plants in Europe. However, this exporting procedure faces difficulties due to the Basel Convention, which is an international treaty that was issued to reduce and prevent the movement of hazardous waste between nations. As for the recycling process, named "E-cycle," which is encouraged by NGO B through their e-cycle program, it is the act of reprocessing the waste to produce the latest items.

Instead of throwing unwanted materials away, recycling is the process of breaking down and reusing parts to make new things. By recycling, the amount of waste that goes into landfills is being reduced; thus reducing the amount of toxic chemicals absorbed into the earth. The e-cycling process includes four steps:

Detoxication: It is the removal of critical components from the E-waste to avoid contamination with toxic substances during the dismantling process. Such critical components include lead, glass from screens, CFC gases from refrigerators, light bulbs, and batteries. For example, tube lights have mercury in the fill gas, and the starter electronic may use capacitors holding Polychlorinated Biphenyls (PCB). Both mercury and PCBs are highly toxic substances and need to be carefully removed before dismantling. As for batteries, they hold mercury, cadmium, and lead. Batteries should be managed carefully to avoid leakage during usage and transport.

Dismantling: Equipment is then dismantled in various parts (metal frames, power supplies, circuit boards, plastics), often by hand. The advantages of using manual labor are the ability of human workers to recognize and save working and repairable parts, including chips, transistors, and RAM, and the disadvantage is that labor is often cheapest in countries with the lowest health conditions and safety standards.

Shredding: Mechanical processing is the next step in E-Waste treatment. This is usually a large-scale industrial operation to obtain concentrates of recyclable materials in a dedicated fraction and to further separate hazardous materials. Typical components of a mechanical processing plant are crushing units, shredders, and magnetic and air separators. The gas emissions are filtered, and effluents are treated to minimize environmental impact. Indoor exposure is checked and assessed and kept within Maximum Allowable Concentration (MAC) levels to assure workers' safety. For instance, the Glass and metal parts of a light bulb are separated. Luminescent substances from new-generation lamps are recovered separately to ease the direct re-use of phosphorus powder. The luminescent powder of older fluorescent lamp models must be disposed of in a special storage facility. Clean glass tubes are shredded and the remaining metal parts are stored with a metal stripper.

Refining: The last step of the "E-Cycling" is refining. Refinement of resources in e-waste is possible, and technical solutions exist to recover raw materials with minimal environmental impact. On the other hand, the fractions need to be refined or conditioned to be sold as secondary raw materials or to be disposed of in a final disposal site, respectively. Throughout the refining process, attention must be paid to three flows of materials: metals, plastics, and glass.

Metals are recovered in a large refinery. Due to economies of scale, specialization, and division of labor, such large installations are not needed in every country. This "integrated smelting" process is a combination of metallurgical and chemical unit processes, which recovers seventeen different metals in total. As for plastics, not all of them can be reused since they are often chemically treated and contaminated with undesired flame retardants. Plastics need to be separated according to their contents and treated separately. Plastics that cannot be reused are recycled thermally as fuel oil in cement works for example. Whereas the glass from fluorescent lamps used in CRT computers and television monitors has lead and other harmful substances. CRT glass is now being recycled into glass wool, a material used for sound and heat insulation. Once these hazardous wastes are recycled, less energy is needed to extract, transport, and process raw materials used in goods manufacture. Consequently, when energy demand decreases, fewer fossil fuels are burned, and less CO2 is emitted into the atmosphere. Not to forget that the emissions of other air pollutants can be reduced, too, as recycling can decrease releases of air toxins from waste incineration. For instance, recycling aluminum cans would save about 95 percent of the energy needed to make the same amount of aluminum from raw materials. Besides, each ton of aluminum would save approximately ten cubic yards of landfill space. The Glass Packaging Institute in the US provides another example. It says that recycling glass reduces related air pollution by 20% and water pollution by 50%. Also, in the same context, electronics hold plastic, glass, steel, copper, lead, and cadmium, among others. Those, if recycled, will save natural resources and reduce pollution and energy usage during production. As an example, one of the substances used in making capacitors for cell phones, iPods, and computers is coltan or columbo tantalite. Coltan, found in few places in the world, has sold for as much as $400 per pound. Eighty percent of coltan deposits are found in the Congo, home to the highly endangered eastern lowland gorilla. Logging in the forests and reserves of the Congo seems to take a worse toll on habitat and wildlife than mining. Thus, recycling and processing of used materials into new products to prevent waste of potentially useful materials, reduce the consumption of virgin components, use of energy, air pollution through incineration, and water pollution from landfilling. In view of the above, here are a few examples of the Metal and Material composition of E-Waste: A laptop is composed of 40% metals, 23% plastics, 11% printed circuit boards, 1% cables, 4% glass, and 8% pollutants. As for a CRT monitor, it has about 53% metals, 9% glass, 36% plastics, and 2% metal/plastic mix. Besides, to highlight the importance of proper

Table 5: Population.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	26	52.0	52.0	52.0
	Female	24	48.0	48.0	100.0
	Total	50	100.0	100.0	

(Source: Author's Own Elaboration)

Table 6: Awareness Level.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	50	100.0	100.0	100.0

(Source: Author's Own Elaboration).

e-waste disposal, a survey was conducted in collaboration with Microsoft, showing the usage of ICT (Information Communications Technology). It was found that people aged between 16 and 22 use 90% of this ICT, while usage of IT decreases inversely proportional to age to reach a 3% level for people aged above 55. Another study conducted by this NGO showed that 65% of the people store these electronics at home, ignoring their hazards, 19% donate them, 9% throw them in municipal waste, and 7% resell these items. To find out what happens with e-waste collected throughout Beirut and large parts of Mount Lebanon, the authors resorted to interviewing a company A official. Company A is the company entrusted by the Lebanese government to collect all kinds of waste and garbage in the greater Beirut area and the Mount Lebanon region, thus serving around two million inhabitants. The interview was conducted in July 2011 with Company A representative. When asked to describe actions and procedures that the company has in place to collect, separate, and recycle electrical appliances and electronics, the representative declined to give any details about that, commenting that it is a bit of a complicated issue since their collection process is random and the sorting is done in part manually. The mechanical separators only distinguish between non-organic and organic waste for later treatment. When asked to reveal the quantities of e-waste collected monthly and whether there are any companies which company A cooperates with, she said that they do not have statistics or Fig. 4 and 5 about electronic quantities collected, but she assured the company is committed to preserving the environment through recycling. To explore the society's opinion of e-waste and e-cycling and find out whether the Lebanese attitude towards the environment depends anyhow on education or gender, the authors put together seven questions into a survey that was then distributed to fifty adult subjects. The poll included 52% males and 48% females, as given in Table 5.

The survey started by mentioning a goal to understand whether people are aware of the Lebanese environment and the importance of protecting it.

The result came 100% positive as shown in Table 6.

Since all subjects declared being concerned about protecting the environment, there was a need to recognize whether any actions were taken to preserve our environment.

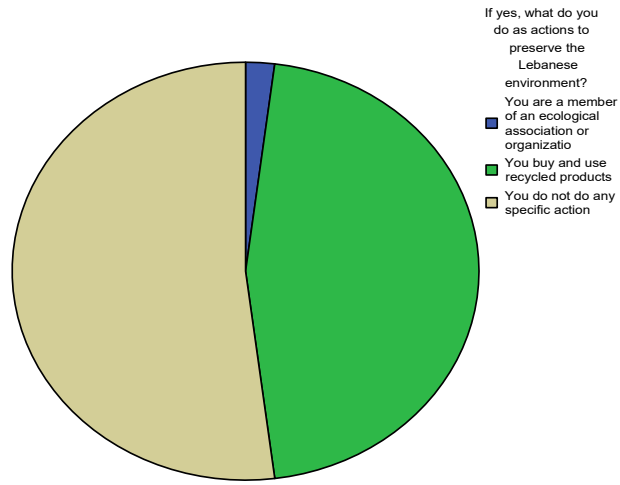


Fig. 6: Preservation actions/Authors' elaboration.

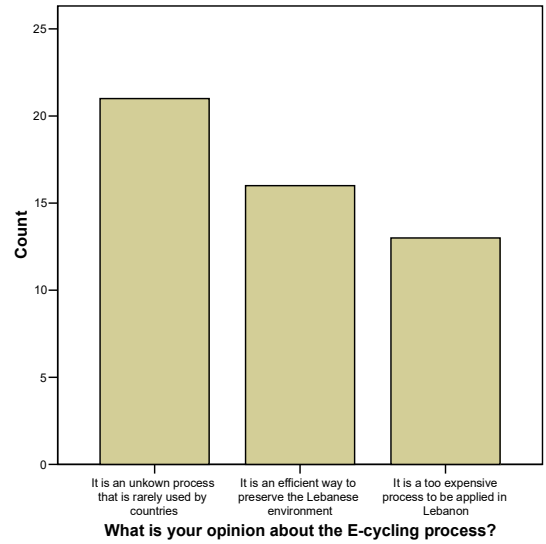


Fig. 7: E-cycling Opinion.

Fifty-five percent could not remember any specific action they took to preserve the environment, while 40% said they buy and use recycled or refurbished products. Five percent announced being members of a certain ecologic organization. The pie chart in Fig. 6 depicts the result.

The concern then is related to the recycling of e-waste in Lebanon. The aim is to find citizens who are familiar with the notion of e-cycling and to know, out of those familiar with the process, the number of people who think that it is a workable possibility for Lebanon. Results as shown in Fig. 7.

Twenty-one people claimed that they were not familiar with e-cycling, while thirteen thought that this choice was too expensive to be realized in Lebanon. Only sixteen subjects

Table 7: Purchase of recycled/refurbished products

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	25	50.0	50.0	50.0
	No	25	50.0	50.0	100.0
	Total	50	100.0	100.0	

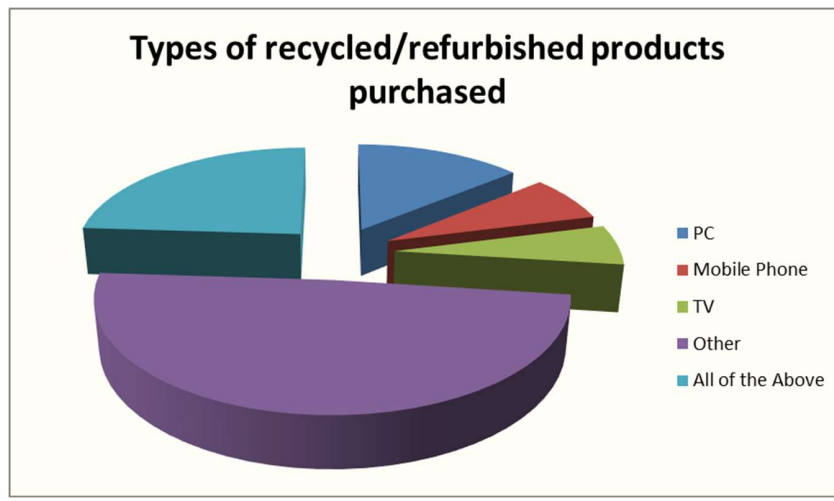


Fig. 8: Types of recycled/refurbished products purchased.

(32%) were optimistic about the benefits of e-cycling in Lebanon.

Furthermore, it is worth knowing whether the respondents own or plan to buy any electronic recycled/refurbished products. Answers were fifty-fifty, showing that half of the polled subjects already support e-waste recycling by buying products either made of recycled material or revamped and refurbished. The numbers are presented in Table 7.

For the 50% who answered yes to question 4 (25 persons), the authors asked them to specify what type of recycled or refurbished instrument they bought. The answers came as follows: 17% said they bought a used PC/Laptop. Seven percent specified a mobile phone, and another 6% opted for secondhand TVs. Surprisingly, a considerable number, 24%, have stated having purchased all the above-mentioned appliances they used before, and 49% allegedly have at one point in the past bought a refurbished electrical or electronic machine other than the ones above. The pie chart in Fig.8 gives a better view of the proportions.

For the 50% who said they have not and would not buy any recycled or refurbished products, the authors tried to understand the reason mostly influencing their decision. The answers were: 30% chose to buy new products because of better quality or features, 20% justified their choice by a longer life, and the rest (50%) did not

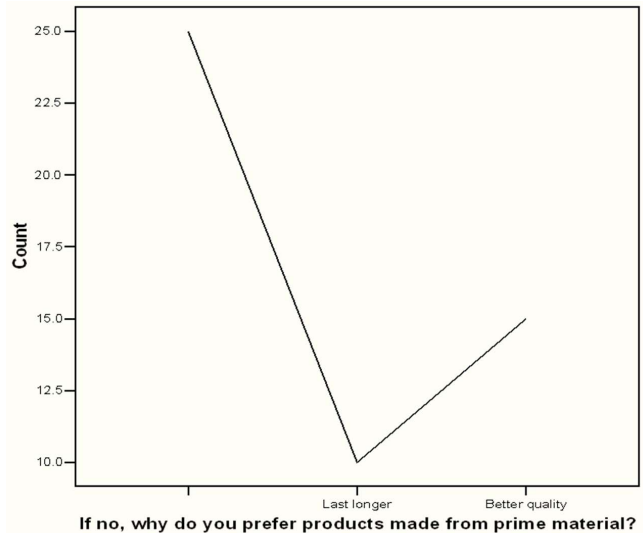


Fig. 9: Purchase of prime products.

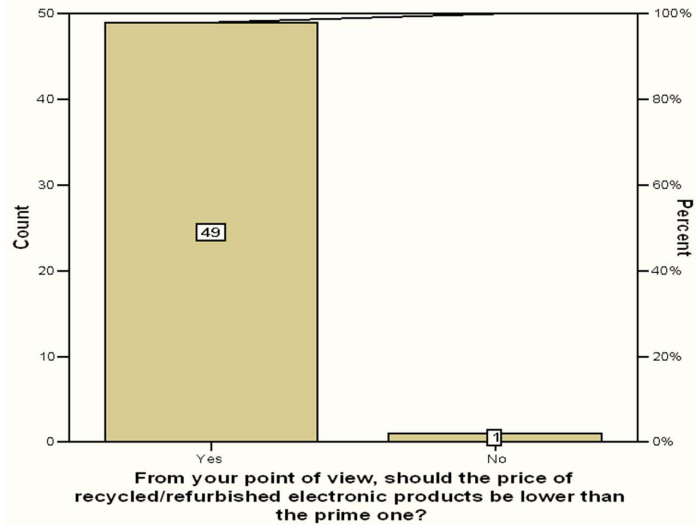


Fig. 10: Price of recycled/refurbished products.

specify a particular reason, as depicted in the following Fig. 9.

Moreover, the authors tried to understand the respondent's perspective on price and to what extent they believe that the price of recycled and refurbished products should be lower than that of prime, brand-new equivalents. The aim is to find out if subjects realize that recycling and refurbishment of products, including collection, marketing, and redistribution, might cost as much or even more than a new product. In addition, the authors wanted to have an idea about people who would accept a not-so-competitive price just for the well-being of the environment.

Results in Fig. 10 show that 98% of polled individuals are unaware of the recycling costs issue, or they are willing to buy a used product only if it offers a cost advantage.

So, it is crucial to recognize from the authors' perspective the factors that primarily influence the purchase decision when it comes to buying electrical and electronic appliances. Among the answers to choose from are price, quality, discounts, advertisement campaigns, advertisement on the internet, government subsidy, or TV commercials.

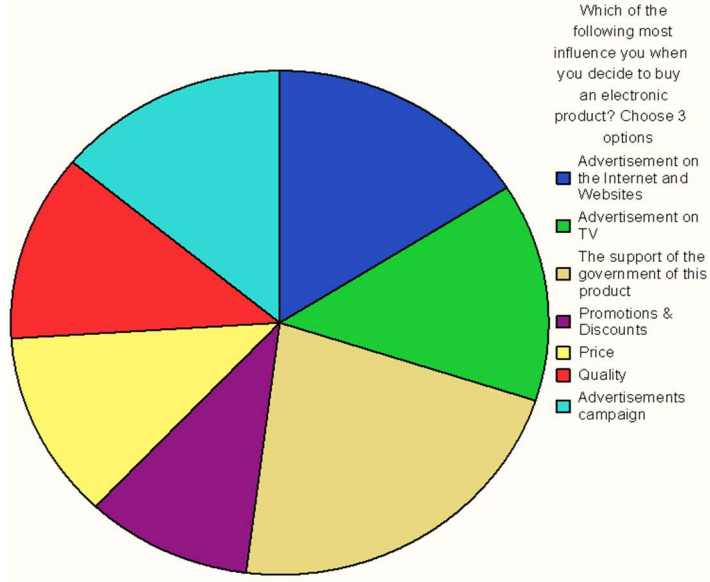


Fig. 11: Influence methods.

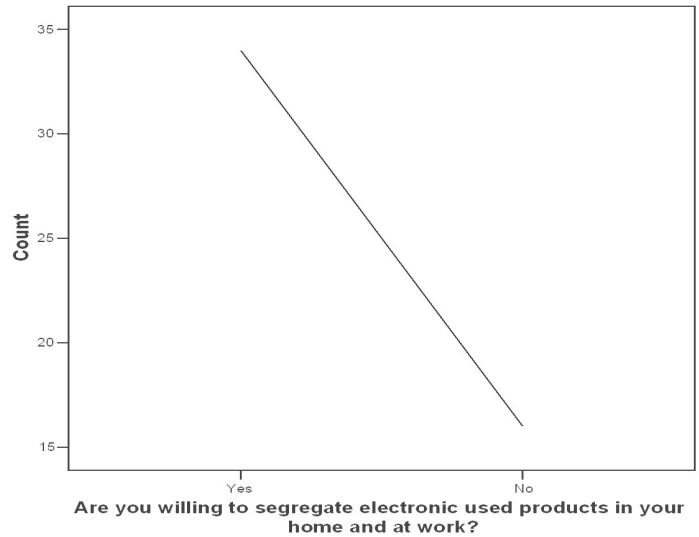


Fig. 12: Segregation Willingness.

Government subsidy was the most chosen answer with 19%, followed by advertisement on the internet with 17%. Advertising campaigns and TV commercials got each 15%. Price and quality were selected by 13% each. Eight percent went to promotion and discount, as shown in Fig. 11 .

At the end of the survey, the authors attempted to assess the future trend in e-waste acceptance in Lebanon. Survey participants were asked if they would be willing to use special containers or disposal procedures for e-waste as opposed to other kinds of domestic garbage. 35 of 50 participants answered positively while the remaining fifteen said they were not willing to bother themselves going the extra mile to separate e-waste from the rest. Refer to Fig. 12 for a graphical representation of the results.

Furthermore, to see if these numbers relate anyhow to the educational level of the participant, we present the results in Table 8 and Fig. 13.

Table 8: Correlation of Education Level to Acceptance of E-waste Segregation.

		Count	%	In Favor of e-cycling (% of count)	Indifferent to e-cycling (% of count)
Valid	Brevet or Less	2	4.0	50	50
	Official Baccalaureate (Lebanese or equivalent)	5	10.0	40	60
	University degree	43	86.0	74.5	25.5
	Total	50	100.0		

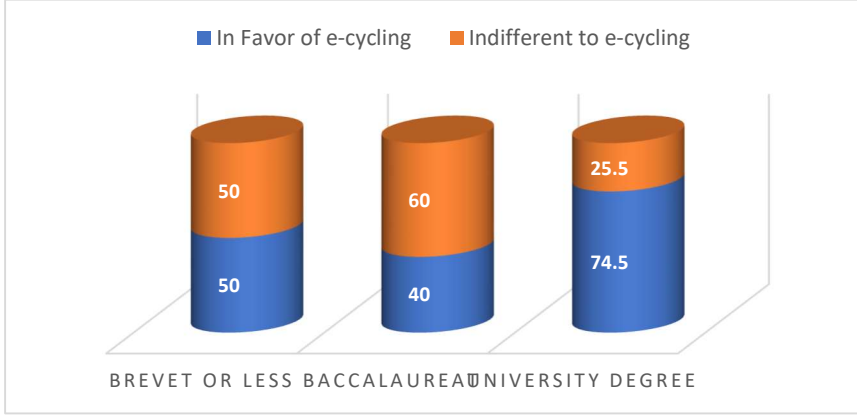


Fig. 13: Correlation of Education Level to Acceptance of E-waste Segregation.

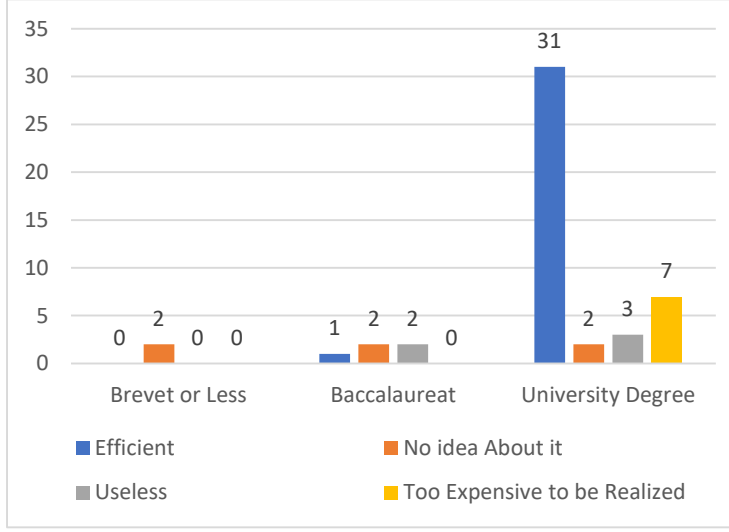


Fig. 14: Correlation of Education Level with Opinion about e-cycling.

This statistic proves the validity of hypothesis two; except for the "Brevet or Less" category, the other two categories show that people of higher education are more aware of the e-waste dangers and are more willing to do something about it. The sample of people with a Brevet degree or less consists only of two people, which is too little a sample to be considered of statistical significance. The next analytical statistics correlate the educational class of the survey participants with their answers in relation to opinions about e-cycling.

As shown in Fig. 14, only participants with an academic degree thought that e-cycling is an efficient way to curb pollution resulting from WEEE. Below that level of education, participants do not seem to be informed enough about that process; neither do they recognize its virtues and disadvantages.

CONCLUSIONS

The paper comes with suggestions for making Lebanon a better place free of electronic waste and an outlook on how electronic waste management might change in the future. The authors used two tools to conduct their research on the e-waste and e-cycling situation in Lebanon, as was extensively discussed in the preceding section: interviews with concerned associations and a survey. While the interviews provided information about the state of organized work on e-waste and the government's stance on the issue, the survey was an effective way to find out what people think and how they feel about e-waste, and how to solve it. Company A, a private company contracted by the Lebanese government to collect all waste in Greater Beirut, and NGO B, whose mission is to raise awareness of the dangers of electronic waste throughout the Arab world and collaborate with societies and governments to define frameworks for electronic waste management, were questioned by the authors. These interviews were conducted to learn more about the current situation and potential future of e-waste in Lebanon. Since there is practically no literature on the position of the Lebanese government in regard to e-waste, and on the grounds that the service of Climate declined to accord the authors an interview or supply them with dependable sources, the last option turned to reaching the main NGO that they accept may be useful and has an involvement with e-waste circumstance in Lebanon - NGO B, and the main organization gathering trash in the capital - Organization A. A representative of NGO B claims that their organization has been successful in educating officials and citizens alike about the danger posed by e-waste up until this point. She provided examples of workshops and events that they had been organizing with the help of other universities, USAID, and the ministry of the Environment. She said that e-waste recycling, collection, and disposal are being regulated by laws but that they are working toward it. She also said that she hoped the government would pass a law through the Ministry of the environment that would prohibit the random and uncontrolled disposal of WEEE in backyards, landfills, and nature in general. She also expressed the hope that the government would, in the future, encourage the recycling and repurposing of e-waste as much as possible by providing subsidies. The other interview was more informative than the one with Company A. Even though the representative of company A assured them that they are aware of the dangers associated with e-waste and are treating this issue with the utmost seriousness, the authors observed a significant hesitation from the representative to provide tangible, hard facts. A request to visit the locales where e-waste arranging is done was turned down on the premise that it is against the organization's strategy.

While conducting this research, the authors faced a few limitations: The literature review was based on secondary data collection, where this data, for instance, cannot be checked by the researcher personally in terms of reliability, accuracy, and credibility. Internal policy issues have driven a few interviewed people at the waste management company in Lebanon, "Company A," to refuse to provide us with statistics and documents other than the leaflet to be able to use in this paper. After going through this study about e-waste management in terms of effective and efficient processes and regulations, we can formulate some useful recommendations targeting the government, manufacturers, and consumers: The government, when developing an e-waste management strategy or regulation, should aim to encourage resource efficiency and minimize the risks and impacts to the environment associated with the treatment and disposal of e-waste. The Lebanese Ministry ought to approve the decree as soon as possible, considering the lessons learned from the case studies to guarantee a secure disposal and an adequate collection system. To follow the law, citizens should attend awareness seminars. In terms of their products in the future, manufacturers must bear the responsibility. These producers ought to utilize creative systems for renting and growing secondhand business sectors. Producers can make their products last longer by doing this. Along these lines, the interest in fresh out of the, out-of-the-box new products will diminish as well with respect to assets. Not to mention that encouraging reconditioned and secondhand goods will save energy and reduce pollution. The customers receive the primary recommendation. They must make use of their market power to change the stages before and after consumption. Consumers, for instance, have the option of donating their old computers to charitable organizations

that support literacy programs or low-income families. In addition, these consumers must consider any electronic device to be an investment. By purchasing quality things that are viable for overhauls and add-ons, assets and energy will be saved in a roundabout way and, subsequently, changes in the climate. Finally, educating the Lebanese about the dangers of electronic waste is essential eventually. In schools, children should be taught to respect nature and protect the environment. Television shows, particularly those geared toward children, can play a significant role in raising public awareness. The purpose of this paper is to explore multiple sides of e-waste management to develop a sound understanding of the problem and the measures that should be taken to overcome such issues. This research supplies insights on e-waste management, particularly about Lebanese consumers' willingness to support e-cycling and pay for environmentally friendly electronics. The acknowledgment of the e-waste issue and its risks by the Lebanese parties will straightforwardly affect the climate and the well-being of people living around it. It was found that these electronic devices contained a wide range of toxic materials, including mercury, lead, and cadmium, which, if disposed of improperly, could harm human and environmental health. The typical life expectancy of these things has dropped altogether in the previous years, with shoppers progressively purchasing the most up-to-date stuff and discarding the more seasoned and less high-level ones.

Consequently, e-waste management has drawn impressive consideration from NGOs, administrative associations as well as companies. In Lebanon, NGO B, in conjunction with the Ministry of Environment and well-known parties like Microsoft and AUB, frequently organizes seminars, presentations, and competitions in schools to raise awareness of this risky issue and develop a strategy for dealing with it. They believe that the new generation will easily adapt to change and will readily embrace the green idea, which is why they are targeting them with summer camps and school competitions. On the legislative and official front, NGO B has sent the Ministry of Environment a draft decree on e-waste management, which will be reviewed and sent to the Council of Ministries. The project will be launched first in the private sector and then in the public sector, which is their goal. Concerning waste administration organizations, for example, organization A they are worried about keeping the urban communities clean yet at the same time does not systematically sort e-waste and treat it by isolating the plastic from the metal and electronic parts (resistors, capacitors, ICs) in view of raised costs.

REFERENCES

Abalansa, S., El Mahrad, B., Icely, J. and Newton, A., 2021. Electronic waste, an environmental problem exported to developing countries: The good, the bad and the ugly. *Sustainability*, 13(9), pp.5302.

Abbas, I., Chaaban, J., Al-Rabaa, A. and Shaar, A., 2019. Solid waste management in Lebanon: Challenges and recommendations. *Journal of Environment and Waste Management*, 4(2), pp.53-63.

Adeola, A.M. and Othman, M., 2011. An overview of ICT waste management: suggestions of best practices from developed countries to developing nations (Nigeria). *7th International Conference on Networked Computing*, 161, pp.109–115.

Bell, J., Huber, J. and Viscusi, W., 2010. Alternative policies to increase recycling of plastic water bottles in the United States. *Review of Environmental Economics and Policy*, 6(2), pp.190-211.

Bhat, V. and Patil, Y., 2021. An integrated and sustainable model for e-waste management for Pune City households. *Journal of Physics: Conference Series*, 14, pp.1-10.

Bortoleto, A., 2015. *Waste Prevention Policy and Behavior: New Approaches to Reducing Waste Generation and its Environmental Impacts*. Oxon.

Chen, C.C., 2010. Spatial inequality in municipal solid waste disposal across regions in developing countries. *International Journal of Environmental Science and Technology*, 7, pp.447–456.

Gibson, K. and Tierney, J., 2006. Electronics waste management and disposal issues and alternatives. *Environmental Claims Journal*, 18(4), pp.321–332.

Hong, J., Shi, W., Wang, Y., Chen, W. and Li, X., 2015. Life cycle assessment of electronic waste treatment. *Waste Management*, 38, pp.357–365.

Ilankoon, I., 2018. E-waste in the international context: a review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery. *Waste Management*, 82, pp.258–275.

Islam, A., Ahmed, T., Awual, M.R., Rahman, A., Sultana, M., Aziz, A.A., Monir, M.U., Teo, S.H. and Hasan, M., 2020. Advances in sustainable approaches to recover metals from e-waste: A review. *Journal of Cleaner Production*, 244, 118815.

Kahhat, R., Kim, J., Xu, M., Allenby, B., Williams, E. and Zhang, P., 2008. Exploring e-waste management in the United States. *Resources, Conservation and Recycling*, 52(7), pp.955-964.

Kang, H.Y. and Schoenung, J.M., 2005. Electronic waste recycling: A review of U.S. infrastructure and technology options. *Resources, Conservation and Recycling*, 45(4), pp.368-400.

Kaza, S., Lisa, C., Bhada-Tata, P. and Van Woerden, F., 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. World Bank.

Kiddee, P., Naidu, R. and Wong, M.H., 2013. Electronic waste management approaches: An overview. *Waste Management*, 33, pp.1237–1250.

Mohanty, S., Vermeersch, E., Di Cortemiglia, H.J., Vittoria, L. and Liddane, M., 2015. Weaknesses in European e-waste managemen. *Proceedings of the Hamburg International Conference of Logistics (HICL)*, 22, pp.535-561.

Mor, R.S., Sangwan, K.S., Singh, S., Singh, A. and Kharub, M., 2021. E-waste management for environmental sustainability: An exploratory study. *28th CIRP Conference on Life Cycle Engineering*, 98, pp.193–198.

Murthy, V. and Ramakrishna, S., 2022. A review on global e-waste management: Urban mining towards a sustainable future and circular economy. *Sustainability*, 14, pp.647.

Nagajothi, P.G. and Kala, F., 2018. Electronic waste management: A review. *International Journal of Applied Engineering Research*, 10(68), p.4123.

Ogunseitan, O.A., Saphores, J. and Shapiro, A.A., 2004. Environmental and economic trade-offs in consumer electronic products recycling: A case study of cell phones and computers. In: *Proceedings of the 2004 IEEE International Symposium on Electronics and the Environment*, IEEE, pp.74–79.

Propescu, M., 2015. Waste electrical and electronic equipment management in Romania: harmonizing National Environmental Law with the EU Legislation. *Social and Behavioral Sciences*, 188, pp.264-269.

Rathi, S. and Shyamalendu, N., 2015. E-waste management: Save earth. *International Journal of Computer Applications*, 127(4).

Seeberger, J., Gandhi, R., Kim, S. S., Mase, W.A., Reponen, T., Ho, S. and Chen, A., 2016. SPECIAL REPORT: E-Waste Management in the United States and Public Health Implications. *Journal of Environmental Health*, 79(3), pp.8–17.

Skinner, A., Dinter, Y., Lloyd, A. and Strothmann, P., 2010. The challenges of e-waste management in India: Can India draw lessons from the EU and the USA? *ASIEN*, 117, pp.7-26.

Song, Q. and Li, J., 2015. A review on human health consequences of metals exposure to e-waste in China. *Environmental Pollution*, 196, pp.450–461.

Spišáková, M., Mandičák, T., Mésároš, P. and Špak, M., 2022. Waste management in a sustainable circular economy as a part of design of construction. *Applied Sciences*, 12, pp.4553.

Sthiannopkao, S. and Wong, M.H., 2013. Handling e-waste in developed and developing countries: initiatives, practices, and consequences. *Science of the Total Environment*, 463, pp.1147–1153.

Stoeva, K. and Alriksson, S., 2017. Influence of recycling programs on waste separation behavior. *Waste Management*, 68, pp. 732-741.

Vadoudi, K., Kim, J., Laratte, B., Lee, S.J. and Troussier, N. E., 2015. Waste management and resources recovery in France. *Waste Management & Research*, 33(10), pp.919-929.

Xue, M. and Xu, Z., 2017. Application of life cycle assessment on electronic waste management: A review. *Environmental Management*, 59, pp.693–707.