Electronic Waste (E-Waste) Management of Higher Education Institutions in South Central Mindanao, Philippines

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ABSTRACT

E-waste management is undoubtedly one of the important environmental concerns at present because the dependence on electronic devices has increased. There have been policies, legal provisions, and advocacy undertakings educating and introducing ways to manage and properly dispose of e-waste in the region yet there is no clear understanding of these practices, particularly in Higher Education Institutions (HEIs). The present study evaluates the e-waste management implementation of HEIs in South Central Mindanao, Philippines using survey questionnaires and in-depth interviews with 13 HEI representatives. The surveys showed that 39% of the HEIs have an annual budget of less than PhP100,000.00 (USD 1,950). Moreover, 23% of HEIs annually purchase 10-60 units of Information and Communication Technology (ICT) equipment. E-waste management among HEIs shows that 53.8% of ICT and electronic devices end up in landfills and 23.1% in informal sectors like junk shops. It can be noted that the yearly generation of e-waste among HEIs highly impacts the rise in the usage of IT equipment and electronic devices. Lack of awareness, e-waste disposal facilities, priorities, audit resolution and procedure and no definite legislation or laws among HEIs are the main challenges for e-waste management in the region. This study prompts mainstream e-waste management in HEIs and enlightens the public about appropriate strategies to address this issue. Furthermore, the findings of this study can be useful in formulating national and regional e-waste management plans and programs.

1. INTRODUCTION

The rapid advancement in technology, the constant introduction of innovative designs and smart functions, appealing marketing, and compatibility issues have caused the reduction in lifespan and accelerated obsolescence of electronic products, resulting in escalated quantities of e-waste (Kiddee et al., 2013; Agamuthu et al., 2015; Cucchiella et al., 2015; Kitila and Woldemikael, 2019). The Philippines is also facing these kinds of challenges due to the increasing usage of Information and Communication Technology (ICT) equipment and electronic devices both in basic education and higher learning institutions and with the onset of COVID-19 where online classes were implemented. Poor enforcement of environmental laws, lack of e-waste legislation or frameworks and shortage of e-waste management facilities have led to critical human and environmental problems, particularly in developing countries where 80% of discarded electronics from developed nations are transported (Lundgren, 2012; Kiddee et al., 2013; Kitila and Woldemikael, 2019). Several studies have reported that toxic metals and harmful chemicals such as polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) can be emitted from e-waste, adversely affecting human health through food chain contamination and direct occupational exposure on workers who engage in primitive recycling (Williams et al., 2008; Robinson, 2009; Kiddee et al., 2013).

The dilemma of e-waste generation in the country has become even more intricate to handle due to the importation of used and scrap electronics from developed nations; thus, the Philippines is beset with e-waste problems from two sources-the locally generated ones and the imported e-waste that contains discarded

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products from other countries (Gutierrez and Agarrado, 2011; Sasaki, 2021). In the case of government offices and institutional users of electronics (e.g., computers and laptops), obsolete products are cast-off through a lengthy and tiresome procedure of bidding by recyclers to procure the electronics for discarding (Alam, 2016). According to Celestial et al. (2018), there were 119 registered Treatment, Storage and Disposal (TSD) facilities in the Philippines as of 2011, but only 23 facilities are handling e-waste and only one in South Central Mindanao. There is no doubt that there will be a paucity of proper e-waste disposal schemes and facilities in the Philippines, especially in the region. Most obsolete electronics are simply stored, discarded with municipal wastes, or crudely recycled (Alam, 2016; Rosete and Valdez, 2018). Despite the existence of Philippine Republic Act No. 6969 or the Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 which controls substances with toxic components, there is no clear-cut provision for e-wastes, absence of appropriate recycling facilities and a lack of skilled manpower (Peralta and Fontanos, 2006). Hence, e-waste management in the country, including among HEIs, remains implausible. E-waste management entails the process of collecting e-waste, recovering, and recycling material in a safe manner and disposal of e-waste through appropriate techniques to reduce its adverse effects on the environment.

HEIs in the Philippines are currently intensifying the use of ICT, thereby increasing their procurement and consumption of electronic equipment such as computers, laptops, and printers for efficient delivery of learning. Considering their reliance on electronic goods, along with frequent upgrading or replacement of such equipment, higher learning institutions markedly contribute to the generation of e-waste (Agamuthu et al., 2015).

Given the gaps, this study seeks to evaluate the e-waste management implementation of HEIs in South Central Mindanao, Philippines. As emerging academic institutions in the region often institute higher standards for e-waste management for the protection of people, the environment, and other organizations, the results of this study not only contribute to the higher learning institutions but can also be used to support the policymakers, especially with mainstreaming the e-waste management system through revisiting audit procedures and establishment of appropriate recycling facilities. Furthermore, the findings could provide baseline information on e-waste management in the Philippines considering only a few to none have explored e-waste management among HEIs in the country.

2. METHODOLOGY

The study was conducted in South Central Mindanao, Philippines. It covers four provinces and one highly urbanized city. The study focuses on the province of Cotabato which covers 17 municipalities and one component city, with a total of 30 public and private (colleges and universities) (Figure 1). Letters were sent to 30 higher learning institutions as survey respondents. Of these, only 13 (4 public and 9 private) universities and colleges agreed to provide data for the study. This number is ample enough to represent the current condition of the institution toward e-waste management in the region as they are major institutions in the region. Primary information was gathered from the key respondents designated by each HEI, such as the ICT Laboratory Aid, Property Custodian and Electronics/Electrical Laboratory In-charge. These individuals were chosen by their ICT personnel because of their proficiency and profound link with the subject under investigation.

2.1 Data collection and analysis

Each key respondent was sent a survey questionnaire consisting of 19 items relating to the annual purchase of electronic devices by the HEIs, options available for management concerning the functional and/or damaged electronic items, solid waste disposal practices and e-waste management activities organized by the HEIs. Prior to the survey, the developed questionnaires were tested and verified to draw recommendations for improvement and assess their efficiency in capturing data. Since the study was carried out from January through June 2020, during the onset and height of the COVID-19 pandemic, the survey was delivered online through Google forms. A link was sent to each respondent through email.

To verify and seek to get more details about the survey results, the key respondents were visited by the research team for a key informant interview (KII). During the interview, the survey respondent was asked the same questions developed in the online survey from Google forms. By doing so, the survey responses were verified, validated, and elucidated. Descriptive statistics such as frequency, percentage and mean were used to analyse the collected data.

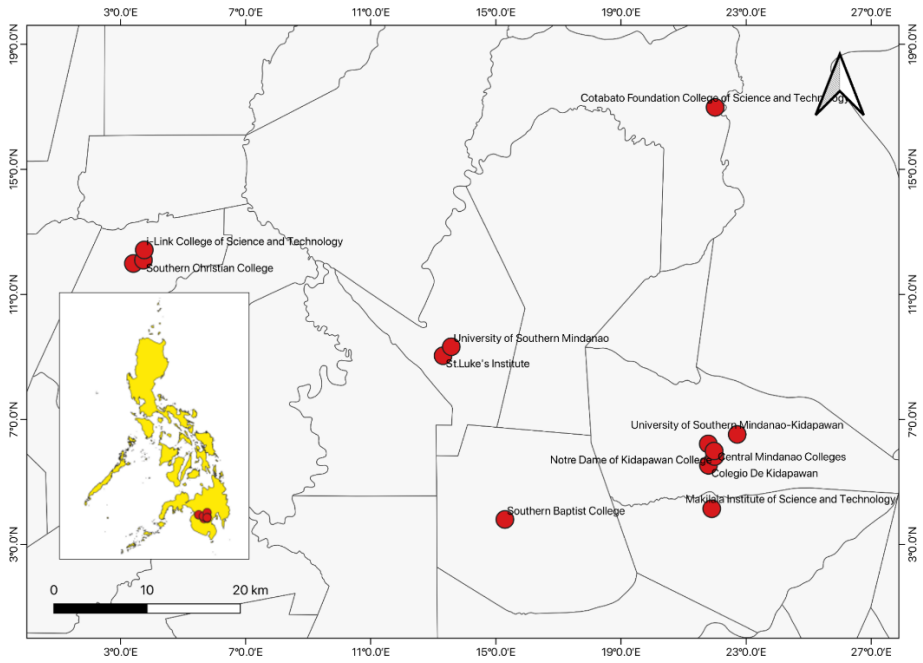

Figure 1. Map of South-Central Mindanao (13 colleges and universities)

3. RESULTS AND DISCUSSION

3.1 Annual purchase of electronic devices among HEIs

Colleges and universities need various types of electrical and electronic equipment in carrying out their daily undertakings, particularly ICT devices (e.g., desktop computers, laptops, computer mice, Wi-Fi routers, printers, copiers, televisions, projectors, and sound systems). Most of the interviewed learning institutions procure 1-9 electronic units yearly and allocate an annual budget of less than PhP 100,000.00 or USD 1,953.24 (38.5%) (Figure 2(a)). More than twenty-three percent (23%) have an annual purchase of 10-69 units of electronics and a minor proportion (15.4%) acquire over 70 units in a year. By and large, HEIs with more personnel and students procure more than 100 units of electronics and spend between PhP 100,000.00 and PhP 1,000,000.00 (USD 195,324) annually. The annual purchases typically consist of photocopiers, laptops, desktops, television, computer mouse, Wi-Fi router, printer, LCD projectors, mobile phones, electric fans, water dispensers, air conditioners, computer wires, and an LED wall. These electronic devices are important tools for HEIs, aiding them in intensifying their ICT efforts and realising their education and research objectives. HEIs relentless demand for electronic items, due to their need for more advanced technology or design, additional appliance, and features lacking in older and worn-out equipment, make HEIs one of the leading generators of e-waste.

The perceived life span of acquired items among HEIs such as laptops, desktop computers, television, and Wi-Fi router last for more than five years (Figure 2(b)), which agrees with the study of Islam et al. (2021), while mouse, LCD projectors, and printers have a relatively shorter life span of two years. Because of the frequent usage and multiple users of printers and LCD projectors, it is estimated to have a shorter life span.

HEIs have various considerations regarding whether to repair an impaired electronic device or not, such as (1) price, (2) warranty, (3) knowledge and skills in repairing, and (4) availability of spare parts as shown in Figure 2(c). Over seventy-six percent (76.9%) of the respondents indicated that the cost for repair relative to purchasing a new product is the factor most considered, closely followed by the validity of warranty service (69.2%). When the cost for repair is comparably higher than the price for a new item, HEIs would rather replace the impaired product. Public HEIs opted to replace impaired products especially when there was no allotment for repair indicated in the procurement plan. When the product is under warranty and it's already impaired, only the supplier can repair otherwise warranty will be void. The product that required higher knowledge and skills in repairing that are hard to find, thus HEIs opted to replace with a new one.

The number of HEI-owned ICT and electronics equipment being repaired yearly is between 10-39 and a marginal proportion (7.7%) renders 70-99 items for repair as presented in Figure 2(d). Regarding the results of KII, HEIs opt not to repair their equipment because of warranty service for some recently acquired electronic devices and the limited availability of needed spare parts.

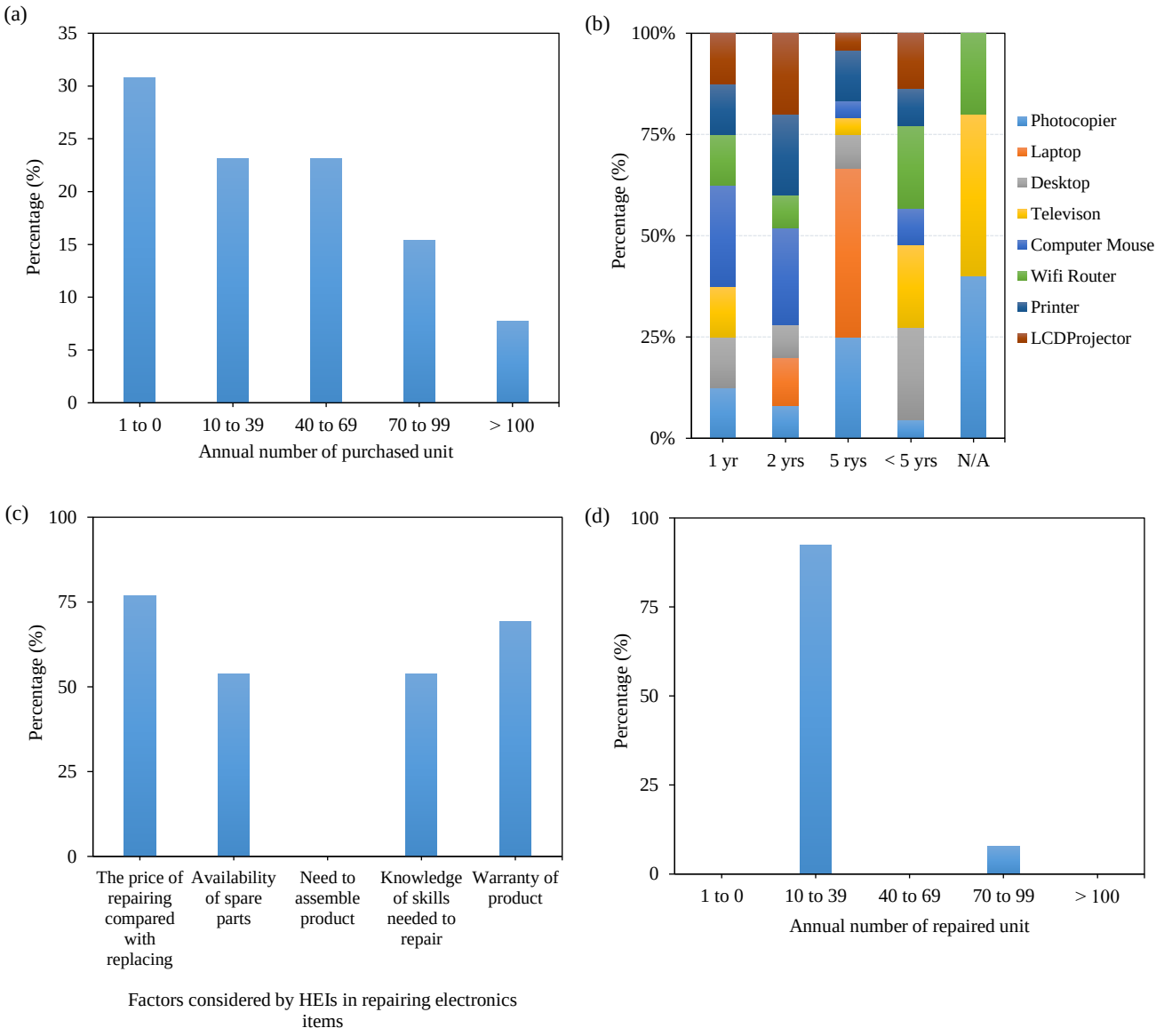

Figure 2. (a) HEIs number of units purchased yearly, (b) perceived life span of electronic equipment, (c) factors considered by HEIs in repairing electronics items, and (d) number of electronic and electrical equipment repaired yearly

3.2 Management practices for both functional and damaged electronic items

With the number of electronic and electrical equipment repaired annually and having reached their useful life, they become part of e-waste because they are working but are outdated, or damaged/unusable. It was found out that most of the workingelectronic and electrical devices that are no longer used by the HEIs for obsolete electronic items end up in any of these routes: storage room, other agencies/offices/ schools through donation, or sold as a second-hand product which is brought to a local recycling centre or stripped for spare parts (Figure 3(a)). The majority of HEIs, both private and public colleges and universities end up putting their electronic and electrical devices into storage followed by stripping for spare parts or materials. This is consistent with extant studies suggesting that placing in storage is one of the practised modes of disposal for e-wastes (Agamuthu et al., 2015; Alam, 2016; Kitila and Woldemikael, 2019). In the absence of precise directives for its management, e-wastes are typically stored for a

certain period due to a perceived value but eventually run through other phases such as reuse, recycling, and the landfill (Peralta and Fontanos, 2006; Oteng-Ababio, 2012).

Dismantling of out-modelled or obsolete electronic devices ranked as the second most adapted management option for e-wastes. Electronic items usually consist of spare parts and assemblies that have economic value, and these functional components are often recovered by recyclers. Through recycling, natural resource depletion and reducing greenhouse gases can be addressed (Ko et al., 2021). Through a process known as cannibalization, functional components of discarded computers and laptops are stripped and are used to create a new unit, subsequently sold at second-hand markets (Carisma, 2009) and the recovery of waste materials (reuse and recycle) is the technique to reach the goal of using everything and nothing left (Ko et al., 2021).

The results reveal that few of HEIs donate working electronic equipment because of an existing protocol among government learning institutions: obsolete electronic devices must be turned over to General Services Offices (GSO) or property officers. Accordingly, only private tertiary schools can perform other disposal modes-the doling out or selling off obsolete electronics as second-hand products, and taking them to local recycling centres- due to the prevailing audit procedures and regulations for public HEIs.

While Figure 3(b) presents non-working and damaged/unusable electronic and electrical devices as practised by surveyed HEIs, disposal methods for unusable electronics are largely like those working but obsolete devices, with storing and stripping for spare parts as the topmost responses. Damaged electronics are temporarily kept for a short time until they are picked up by garbage collectors or scavengers. Other discarded devices are also dismantled to recover useful subassemblies and components that can be utilized for other purposes. Despite its relative advantages, recycling and/or selling discarded devices are placed only by private institutions. Recycling is deemed as an effective yet underutilized e-waste management alternative (Kitila and Woldemikael, 2019), rendering several positive implications including pollution prevention; avoiding the need to extract limited resources; reducing energy used in manufacturing new products. As elicited from the KII, most of the selected tertiary schools do not practice recycling, stemming from the absence of definite e-waste disposal policies and regulations, facilities and the established audit procedure and resolution for government-administered HEIs.

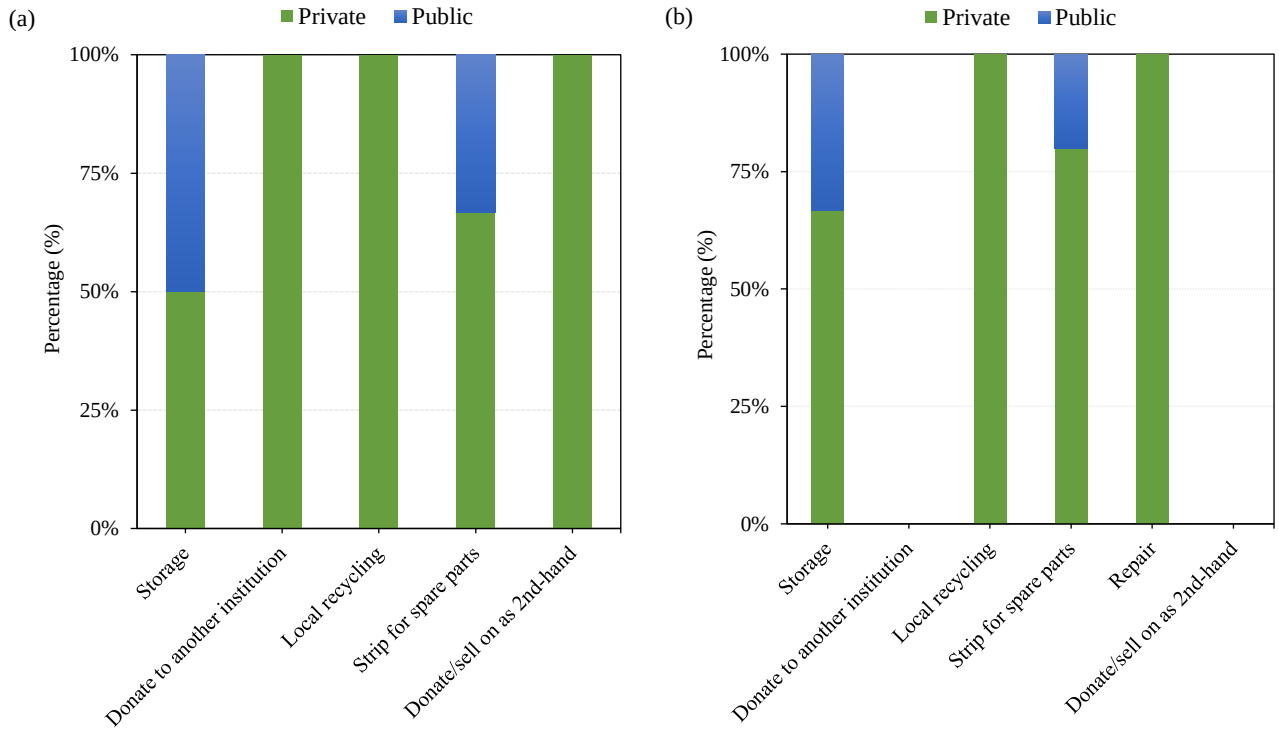

Figure 3. (a) Management of working electrical/electronic devices and (b) management of non-working and damaged electronic devices

The management practice differs according to the devices, the most common management alternatives for both functional but out-outdated devices and non-working items are recycling and dismantling/stripping of usable assemblies or spare parts are the topmost response (Figure 4(a)). Since repairing is also an integral management option for HEIs, cost, warranty validity and availability of spare parts as prime considerations. Disposing of trash is common for computer mice and computer wires while laptop and desktop computers are for donating to civic organizations or schools. Only a few engaged in selling and sorting electronic and electrical devices.

Among the salient findings of the present study is solid waste including e-wastes disposal practices of colleges and universities in South Central Mindanao (Figure 4(b)). Solid wastes generated by HEIs primarily ended-up in either of these routes: landfills (53.8%), informal e-waste sectors such as junk shops (23.1%) and returned to GSO for audit purposes (7.7%). Remarkably, a sizeable proportion (15.4%) also expressed that they completely lack solid waste disposal procedures in their institution. In the absence of e-waste regulations and clear policies, discarding e-wastes through local garbage collection offers the simplest option for HEIs.

This observation is congruent with other studies indicating that landfilling remains the most practised means of disposal for various types of wastes, including e-waste (Lundgren, 2012; Agamuthu et al., 2015; Rosete and Valdez, 2018). Despite its practicality, discarding of e-waste in the general waste stream has critical setbacks: possible leaching of highly toxic elements such as Ba, Cd, Ar, Se, Cu, Pb, Hg and Li, and contamination of soil and water bodies (Tiwari and Dhawan, 2014; Ponghiran et al., 2021), and shortage of landfill space (Rosete and Valdez, 2018).

Public awareness has an imperative role in addressing issues and challenges associated with e-waste; hence this aspect was also explored in the present study. Only 46.2% (Figure 4(c)) of the respondents expressed awareness of the notion of e-waste management, suggesting that adoption of this concept among HEIs in South-Central Mindanao is flimsy. Lundgren (2012) remarked that public awareness about e-waste management is generally low, with cognizance of the hazardous nature of e-waste and the crude waste management methods in developing nations as the weakest facets. Rautela et al. (2021) noted that setbacks in e-waste management are attributed to various factors including lack of technical skills, weak financial support, shortage of infrastructure and facilities, and poor community engagement.

HEIs' low level of awareness about e-waste management is further reflected by their low engagement in activities relevant to this concept (Figure 4(d)). Most of the surveyed learning institutions do not spearhead endeavours related to the disposal and processing of e-waste. As deduced from the survey, volunteer activities, recycling events and e-waste collection drives are mostly conducted by private tertiary schools, hence, HEIs in South Central Mindanao have generally low participation in e-waste management initiatives.

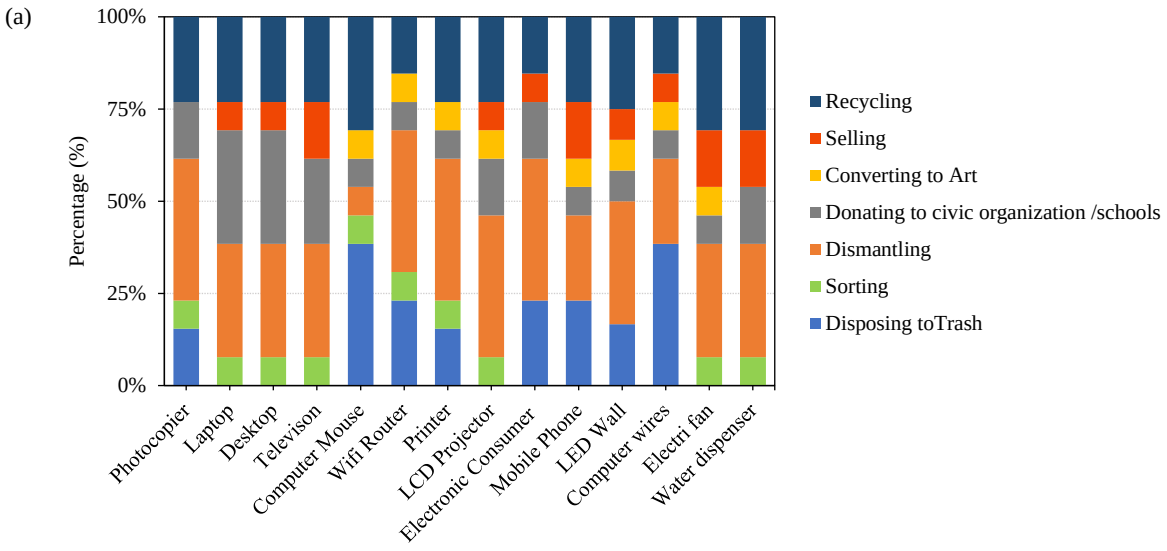

Figure 4. (a) Management practices for functional and nonworking items, (b) solid waste disposal practices of HEIs, (c) HEIs sponsored activities relating to e-waste management, and (d) awareness about e-waste management among HEIs

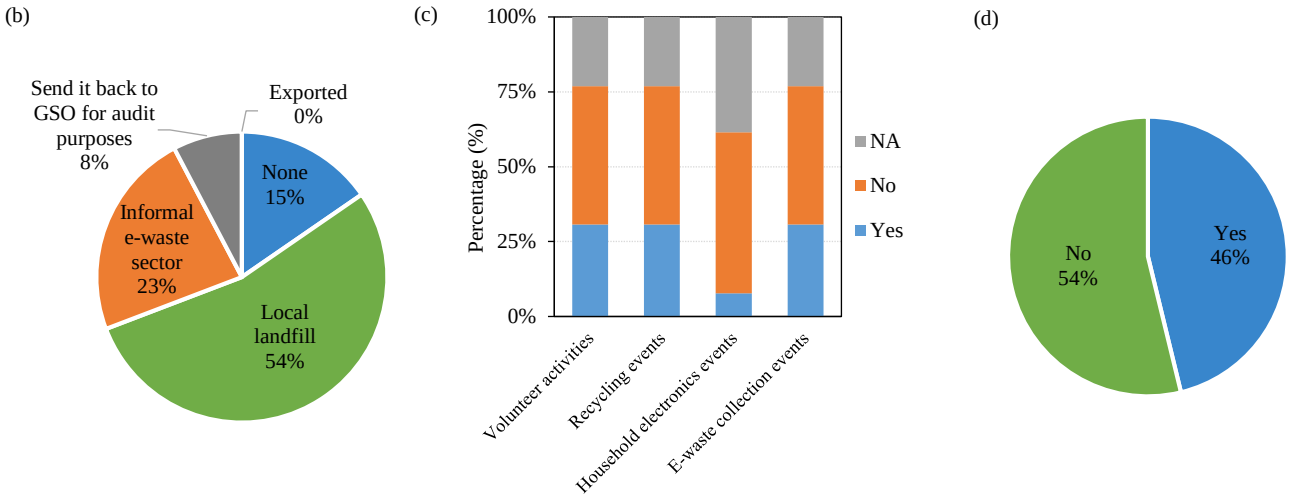

Figure 4. (a) Management practices for functional and nonworking items, (b) solid waste disposal practices of HEIs, (c) HEIs sponsored activities relating to e-waste management, and (d) awareness about e-waste management among HEIs (cont.)

HEI representatives were also asked about their perception of e-waste as a problem. Whilst the perceived intensity of the e-waste problem varied for each respondent, e-waste is largely viewed as a problem by HEIs in South Central Mindanao, with 38.5% considering it as an extremely serious dilemma (Figure 5). Despite their high level of cognizance of the challenges associated with e-waste, all surveyed HEIs do not have comprehensive e-waste management rules and regulations. Moreover, discussion about e-waste management is not integrated into their regular operations. Collaboration and partnership with other stakeholders/sectors do not exist. As deduced from the KII, only 7.7% of the HEIs indicated that they work in partnership with their respective Local Government Unit- Municipal Environmental and Natural Resources Office (LGU-MENRO). E-waste has been considered an escalating concern due to its environmental and human health problems (Raghupathy et al., 2010; Rautela et al., 2021). Considering its impacts, proper administration of generated e-waste must be incorporated into the management plan of HEIs and other concerned agencies.

3.3 E-waste management framework of HEIs in South Central Mindanao

Following our findings, a framework showing the e-waste management of learning institutions in South Central Mindanao was developed (Figure 6). It also shows that HEIs' sources of electronic devices are brand new with the annual number of purchases made and the budget allotted for ICT equipment and electronic devices. Because of the life span of the acquired items and management processes, it compounded the number of discarded electronic and electrical devices, thus HEIs necessitate in managing e-waste. The management alternatives for both functional but outdated devices and non-working items are namely: storing, donating, selling, recycling, dismantling, and disposing of landfills. The most common practices for e-waste disposal in HEIs are storing and dismantling/stripping usable assemblies or components. HEIs have no other options but to store discarded electronic and electrical devices due to audit procedures, including lack of awareness, facilities, guidelines, priorities, and non-existent e-waste management. Also, recycling, donating, and selling were influenced by audit procedures and warranty, thus discarded items were stored for some time.

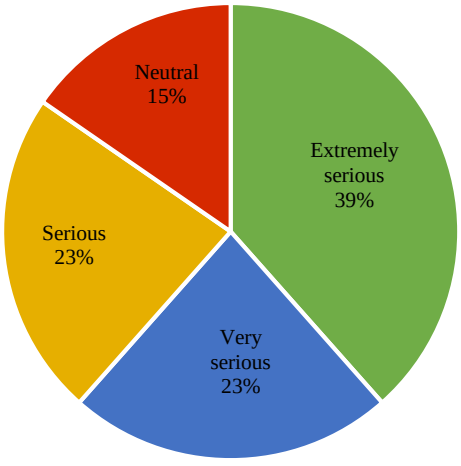

Figure 5. HEIs' perception of e-waste as a problem

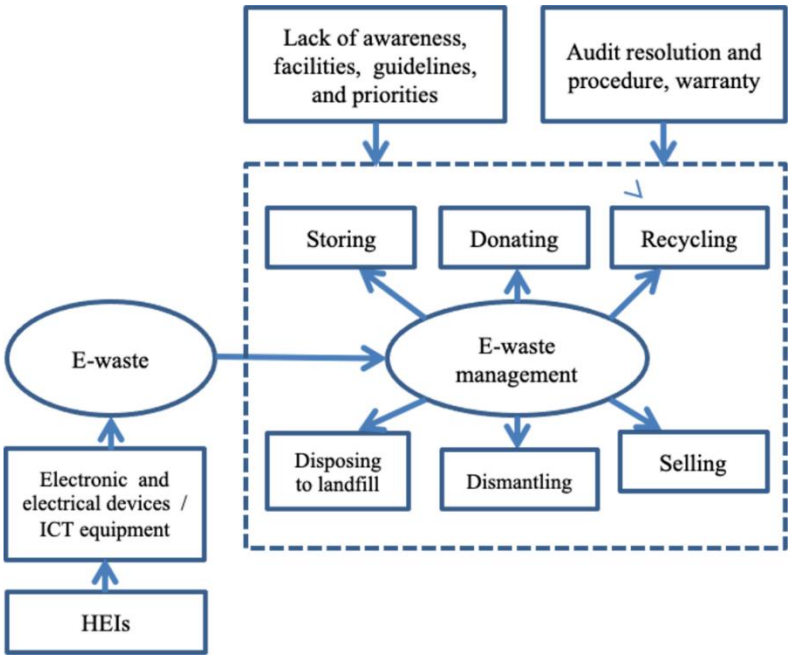

Figure 6. E-waste management framework of HEIs in South Central Mindanao

3.4 Recommendations

The Department of Environmental and Natural Resources (DENR) categorized e-wastes as a new class of miscellaneous waste through Administrative Order No. 2013-22, yet a comprehensive legal framework and mechanism for e-waste are non-existent in universities and colleges. The government should revisit the audit procedure and resolutions to address the compounded e-waste product in the storage area of HEIs. Formulating appropriate legislation and laws that need to be implemented by the government HEIs based on scientific evidence. It is important to provide recycling facilities for e-waste and technical support and capacity-building programs to the recyclers. There must be personnel assigned to this area to closely monitor the volume of e-waste generated in the schools. Annual inventory of equipment issued among faculty and personnel must be incorporated into the e-waste management plan.

Because of the low level of awareness among HEIs regarding e-waste and the adverse effect on human health and the environment, dissemination and information should be done. Also, include in the awareness program the disposal and accredited e-waste TSD facilities. Part of the awareness activities is to conduct recycling events and e-waste collection drives. The HEIs should provide repair services to salvage some damaged electronics devices to reduce stored e-waste products, ensure after-sale services of the supplier and encourage extended producer responsibility (EPR). When the life span of equipment has reached end-of-life and becomes non-functional, the supplier will collect and be responsible for disposing of their product. The HEIs should formulate policy and guidelines on e-waste management because the majority of HEIs are highly reliant on ICT equipment and electronic devices. Furthermore, every HEI should give utmost priority to e-waste disposal.

4. CONCLUSION

The present study has evaluated the e-waste management in higher learning institutions of South-Central Mindanao, Philippines and substantial findings were obtained from the current work. Although only 13 out of 30 HEIs responded, the sample consisted of a mix of private and public universities/colleges, small and large populations, and proximity to major municipalities. Also, the large number of repeated responses across the sampled universities/colleges suggests that a similar situation holds in other universities. The sizeable contribution of educational institutions in generating e-waste has been documented and attributed to various reasons including increasing demand for more advances, innovative designs and features, impairment of devices and rapid obsolescence rate of electronic products. Remarkably, the adoption of recycling, deemed as the most efficient management alternative, is ineffective. The major setback affecting e-waste management in HEIs may be associated with the administrative aspect-public schools that are not able

to implement other disposal options such as donating, selling, and recycling due to audit procedures and regulations. The solid waste disposal of HEIs is also flimsy, with most of the generated wastes ending up in the landfill. Being the foundation of education and development, institutional policy on handling e-waste should be integrated into the management plan of all universities, colleges, and other concerned agencies. Furthermore, policymakers can also make a better strategy on how to mainstream the increasing e-waste management problems based on the baseline information provided in this study.

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REFERENCES

Agamuthu P, Kasapo P, Nordin NA. E-waste flow among selected institutions of higher learning using material flow analysis model. Resources, Conservation and Recycling 2015;105: 177-85.

Alam ZF. The assessment of the e-waste management generated from cellular phones, laptops, and personal computers in the Philippines. Manila Journal of Science 2016;9:27-42.

Carisma B. Drivers of and Barriers to E-Waste Management in the Philippines [dissertation]. Sweden: Lund University; 2009.

Celestial RG, Mauricio ED, Tan LB, Gumaru JC, Mondragon RO. E-waste management in the Philippines. Agro-Industrial Waste Management 2018;5(1):1-2.

Cucchiella F, D'Adamo I, Koh SL, Rosa P. Recycling of WEEEs: An economic assessment of present and future e-waste streams. Renewable and Sustainable Energy Reviews 2015; 51:263-72.

Gutierrez R, Agarrado G. New age trade agreements and their possible contribution to toxic trade. Environmental Law Network International 2011;2:Article No. 46.

Islam MT, Dias P, Huda N. Young consumers'e-waste awareness, consumption, disposal, and recycling behavior: A case study of university students in Sydney, Australia. Journal of Cleaner Production 2021;282:1-18.

Kiddee P, Naidu R, Wong MH. Electronic waste management approaches: An overview. Waste Management 2013;33(5): 1237-50.

Kitila AW, Woldemikael SM. Waste electrical and electronic equipment management in the educational institutions and governmental sector offices of Addis Ababa, Ethiopia. Waste Management 2019;85:30-41.

Ko CO, Tun Y, Lwin NH, Moe T, Eaindray J. Estimation of the recyclable waste amount collected by informal recycling shops: Case study in Nay Pyi Taw, Myanmar. Environment and Natural Resources Journal 2021;19(2):103-11.

Lundgren K. The Global Impact of E-Waste: Addressing the Challenge. Geneva, Switzerland: International Labour Organization; 2012.

Oteng-Ababio M. Electronic waste management in Ghana-issues and practices. In: Curkovic S, editor. Sustainable Development-Authoritative and Leading-Edge Content for Environmental Management. IntechOpen; 2012. p. 149-66.

Peralta GL, Fontanos PM. E-waste issues and measures in the Philippines. Journal of Material Cycles and Waste Management 2006;8(1):34-9.

Ponghiran W, Charoensaeng A, Khaodhiar S. The environmental impact assessment of gold extraction processes for discarded computer RAM: A comparative study of two leaching chemicals. Journal of Material Cycles and Waste Management 2021;23(4):1412-22.

Raghupathy L, Krüger C, Chaturvedi A, Arora R, Henzler MP. E-waste recycling in India: Bridging the gap between the informal and formal sector. Hamburg, Germany: International Solid Waste Association, World Congress; 2010.

Rautela R, Arya S, Vishwakarma S, Lee J, Kim KH, Kumar S. E-waste management and its effects on the environment and human health. Science of the Total Environment 2021; 773:Article No. 145623.

Robinson BH. E-waste: An assessment of global production and environmental impacts. Science of the Total Environment 2009;408(2):183-91.

Rosete MA, Valdez KG. Assessing the level of awareness of electronic waste among the business economics majors of the University of Santo Tomas College of Commerce and Business Administration. Review of Integrative Business and Economics Research 2018;7(4):216-37.

Sasaki S. The effects on Thailand of China's import restrictions on waste: Measures and challenges related to the international recycling of waste plastic and e-waste. Journal of Material Cycles and Waste Management 2021;23(1):77-83.

Tiwari D, Dhawan NG. E-waste management: An emerging challenge to manage and recover valuable resources. International Journal of Environmental Research and Development 2014;4(3):253-60.

Williams E, Kahhat R, Allenby B, Kavazanjian E, Kim J, Xu M. Environmental, social, and economic implications of global reuse and recycling of personal computers. Environmental Science and Technology 2008;42(17):6446-54.