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E-Waste Management Trend in Ethiopia: Strategies for Extending Electronics Lifecycles

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Abstract:

The rapid e-waste generation poses a significant environmental challenge, necessitating sustainable approaches to managing electronic product lifecycles. This paper investigates how repair practices in Ethiopia affect the lifespan of electronic devices. It has been observed that, compared to several reference countries, electronics in Ethiopia tend to have slightly longer lifespans, primarily due to extensive repair and reuse practices. In this study, we conducted a lifespan analysis by collecting lifespan data from various maintenance shops. The Weibull distribution method was used to analyze the lifespan of different categories of devices. The data revealed that the average lifespans of LCD TVs, LCD monitors, laptops, and smartphones are 12.0, 11.0, 10.7, and 6.4 years, respectively. The findings highlight the significant role of repair and refurbishment in extending device longevity while also revealing a growing trend in e-waste generation. This study explores the impact of repair practices on extending electronic device lifespans in Ethiopia, considering policy approaches that support repair and reuse. It also shows the need for collaboration among repair practitioners, policymakers, and consumers to strengthen sustainable e-waste management efforts. This research aims to contribute to environmental preservation and sustainable development in the country by fostering a circular economy.

Introduction

The short lifespan of electronic devices significantly contributes to the global e-waste stream driven by rapid technological advancements and consumer demand for newer technology. With most electronics lasting only three to five years, the volume of e-waste is projected to rise from 57.4 million tons in 2021 to 74.7 million tons by 2030, posing severe environmental and health risks due to the hazardous materials it contains (Forti et al., 2020). This rapid and extensive consumption of short-lived electronic products generates not only e-waste but also significant amounts of waste during their production.

The product lifetime, defined as the duration from when a product is first used after manufacturing to when it becomes obsolete (Bakker & Schuit, 2017), plays a crucial role in this issue. The rapidly growing accumulated waste volume highlights the urgent need to extend the lifespan of electronic devices. Strategies such as improved product design, refurbishment, and reuse can help optimize the longevity of electronics, reducing e-waste and promoting sustainability.

Technological advances have contributed to a shorter product lifespan (Khan et al., 2018). Increasing demand for e-products with reduced product lifespan leads to more frequent replacement/renewal of them, resulting in a growing e-waste stream. The urge to protect the planet against this escalating waste generation fits in the 17 Sustainable Development Goals adopted by the United Nations in 2015 (United Nations, n.d.). The extension of a product's lifespan can be regarded as a tool under the goal of

"Responsible Consumption and Production" (Bakker & Schuit, 2017). Extending the lifetime and delaying the obsolescence of e-products can significantly reduce the environmental impacts and contribute to meeting environmental, climate, and sustainability goals.

Various strategies have been proposed to enhance the longevity of electronic products, focusing on design, refurbishment, and media migration. Designing products that can adapt to technological advancements is a key approach to prolonging usability. This includes creating products intended for multiple uses, enabling them to stay relevant even as technology evolves (Park, 2009). Refurbishment and reuse also play a significant role in extending the lifespan of electronic products. Research indicates that refurbished smartphones are becoming increasingly popular, with sales in secondary markets often surpassing those of new devices (Hazelwood & Pecht, 2021). Establishing industry standards for refurbishment can further enhance the reliability and safety of refurbished products, address common consumer concerns, and promote their acceptance.

In Ethiopia, repairing and reusing electronic devices have been common practice for many years (Ali & Akalu, 2022; Getachew et al., 2019). This repair and reuse culture largely stems from economic challenges, as many people cannot afford the latest technological devices. This practice tends to increase life span, reducing e-waste generation and their environmental impact. Repair practices in Ethiopia, while not extensively documented, reflect broader trends observed in similar developing contexts, where repair and refurbishment significantly extend the lifespan of electronic devices. According to Odeyingbo & Baldé (2022), in Nigeria, repair practices extend the lifespan of televisions by an additional 11 years and refrigerators by 9 years (Odeyingbo & Baldé, 2022). These practices are influenced by cultural, economic, and infrastructural factors that shape consumer behavior and repair capabilities (Marikyan & Papagiannidis, 2024; Odeyingbo & Baldé, 2022; Parajuly et al., 2024).

Despite these positive observations, challenges remain, such as limited access to reliable repair services and a lack of consumer confidence in local repair networks. Addressing these barriers is essential for enhancing repair practices and extending the lifespan of electronic materials in Ethiopia. In this study, we present electronic device lifespan extension practices observed in Ethiopia, along with strategies to improve and formalize lifecycle extension approaches.

Data collection for Ethiopia: Methodological aspects

A large-scale data collection exercise conducted across four Ethiopian cities- Addis Ababa, the capital city of Ethiopia, Jimma, Adama, and Asela- revealed key observations about repair and maintenance practices. These cities were chosen as representatives due to the relatively uniform maintenance behavior observed across Ethiopia. Addis Ababa, specifically the Merkato sub-city, was selected as it serves as Ethiopia's central market hub, where many maintenance shops are concentrated, making it an essential location for studying repair trends.

Both quantitative and qualitative data were collected from different sources to calculate the lifespan of the products and the time spent on the market for various device categories. Questionnaires and surveys were used to obtain lifespan data, which included the brand name and manufacturing date of the devices. The electronic maintenance shops considered in this study are mobile phone maintenance shops, television maintenance shops, and computer and laptop maintenance shops. For each equipment category, the brand name and production year of non-repairable devices were registered using a questionnaire as a data collection tool. Using the Weibull equation (Equation 1), an R-script in the R-Studio software was used to calculate the average lifespan, shape, and scale parameters based on collected data concerning end-of-life product ages.

$$P(t) = 1 - exp\left(-\left(\frac{t}{\alpha}\right)^{\beta}\right) \quad \text{.....(1)}$$

where P(t) is the cumulative distribution function, α is the scale parameter (or characteristic Weibull lifespan), t is time in years, and β is the shape parameter. The lifespan profile is defined by an appropriate choice of shape and scale parameters, α and β, respectively. The R script used in estimating the life span uses Maximum Likelihood Estimation (MLE) as the primary method to minimize errors when fitting a Weibull distribution to lifetime data. Specifically, the fitdist function from the fitdistrplus package is employed to estimate the Weibull parameters (shape and scale) by maximizing the likelihood of the observed data under the assumed

distribution. The error minimization process focuses on reducing the negative log-likelihood (NLL), which measures how well the Weibull model fits the data. A lower NLL indicates a better fit (Lastras, 2019). The Weibull distribution has been used since it was experimentally demonstrated that it provides a good fit for the life span of many different types of electronic products (Polák & Drápalová, 2012; Kalmykova et al., 2017). It is a commonly used method for determining the lifespan of products that can help to estimate the amount of WEEE generated (Parajuly et al., 2017).

Data analysis and interpretation

Many maintenance and repair shops face challenges such as limited storage space, which prevents them from keeping old electronic devices for extended periods. These shops typically retain obsolete electronics only when they anticipate an immediate need for spare parts. However, other shops adopt a different approach by storing such devices for longer periods, viewing them as a repository of potential resources that can be harvested in the future. This includes harvesting working components, such as functional screens, circuit boards, or power supplies, which can be used to repair or refurbish other electronic products. This practice not only supports the repair of existing products but also plays a crucial role in extending the lifespan of electronics by reusing valuable parts. This is particularly important in the Ethiopian context, where new spare parts are often unavailable on the market or, when they are, tend to be expensive. Harvesting components from obsolete electronics helps mitigate the impact of these challenges and supports sustainable repair and maintenance practices. Figure 1 shows laptop and mobile phone maintenance shops storing various obsolete devices for spare parts harvesting.

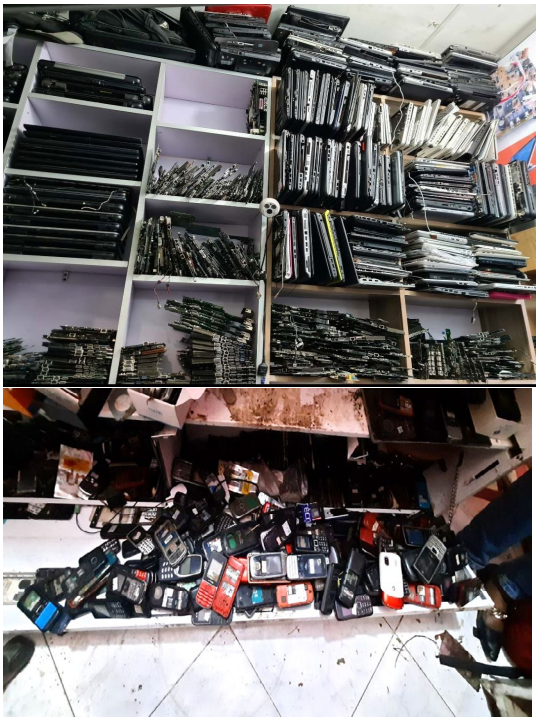

Figure 1. Stored obsolete electronic devices in electronic maintenance shops in Jimma City of Ethiopia. (a) obsolete laptops and (b) obsolete mobile phones.

Table 1: Locations and number of shops where data were collected.

Site	# of shops reached	LCD TVs	Monitors		Laptops	Mobile Phones	
			LCD	CRT		Smartphone	Feature Phone
Addis Ababa	9	32	-	-	7	101	96
Jimma	32	26	363	287	70	326	475
Adama	3	12	-	-	40	44	65
Arsi Asella	3	-	-	-	40	30	71
Total	**47**	**70**	**363**	**287**	**157**	**501**	**707**

Data for 70 LCD TVs, 363 LCD monitors, 287 CRT monitors, 157 laptops, and 501 smartphones, with their brand and production year, were collected and analyzed for lifespan estimation(see Table 1).

Table 2: Weibull life span distribution, shape, and scale parameters for different categories of ICT equipment in an Ethiopian context.

Type of equipment	Mean value	Shape parameter	Scale parameter
Smartphone	6.4	2.9	7.2
Laptop	10.7	3.6	11.9
LCD TV	12.0	3.2	10.0
CRT TV	17.0	4.8	18,3
CRT monitor	18.3	5.0	19.7
LCD monitor	11.0	3.9	12.0

As shown in Table 2 model parameters, such as shape and scale parameters were analysed. In addition, the average lifespan of each category of equipment is calculated, which shows that in Ethiopia, ICT equipment has a relatively long service life compared to different countries for which data are available in the literature. For example, CRT monitors have an average lifespan of 18.3 years, primarily because this figure considers the total lifecycle of the product from production to final abandonment, including storage time. For this category of equipment, the extended lifespan is not attributed to repair or refurbishment but rather to the replacement of CRT monitors with LCD monitors, resulting in their prolonged storage for future disposal or repurposing (see Table 2).

During our survey, we found that CRT monitors were commonly stored in the facilities of major government organizations and NGOs, such as universities and banks. Some of these monitors were still functional and were planned to be donated to educational centers. For other categories of devices, data from maintenance shops indicate that storage times typically range from three to six months, as these devices are either repaired and returned to customers or repurposed to repair other devices.

Another key factor influencing the extended lifespan of electronic devices in Ethiopia is the strong culture of reuse, which plays a crucial role in the continued functionality of mobile phones, televisions, and laptop computers.

Figure 2 compares the lifespan distribution of ICT equipment determined in this study with lifespan data from three different European countries to assess how Ethiopian electronic devices perform in comparison. The graph compares the lifespan of Ethiopian devices to those from France, the Netherlands, and Belgium combined. The European lifespan data are based on research conducted by the International Telecommunication Union (ITU) in 2015 (C.P. Balde et al., 2015). In their study, the lifespan of various electronic waste categories was estimated based on data from the Netherlands and extrapolated to other EU countries. The comparison reveals that the lifespan of ICT equipment in Ethiopia is longer than what is observed in the European countries analyzed. For instance, the estimated average lifespan of a laptop in these countries is estimated to be 4.7 years, while in Ethiopia, based on the collected data, it is estimated to be 10.7 years. In another study, the lifespan of a new desktop computer in Uganda is around 9.0 years (Wasswa & Schluep, 2008), while in Ethiopia this is estimated to be around 10.7 years. Private households tend to hold on to their laptops longer than any other sector by replacing faulty hardware components with new or recovered ones. The lifespan of electronic equipment in Ethiopia largely depends on the availability of spare parts for maintenance: if spare parts are readily available, the lifespan of the device tends to be extended. However, if the device is not maintained properly or the cost of maintenance is not affordable, the device may be considered as a source of spare parts for other devices. From interviews conducted in repair shops, it could be apprehended that for some devices, technicians are trained with as vision that if spare parts are available, there is no end-of-life for any dysfunctional electronic device. They have a saying that goes "No device is ever beyond being repairable". Depending on the willingness to pay of the owner, they either fix a faulty device or use its parts for repairing other similar devices. Another issue we observed is the lack of new spare parts availability; new spare parts are difficult to find in Ethiopia. This is due to the large variety of brands available on the Ethiopian market, which makes it difficult to find the correct spare parts. Also, the high cost of those parts then forms a major hurdle. Mobile phones in Ethiopia have a shorter average lifespan compared to those used for

comparison in Figure 2. This can be attributed to the lack of new spare parts in the

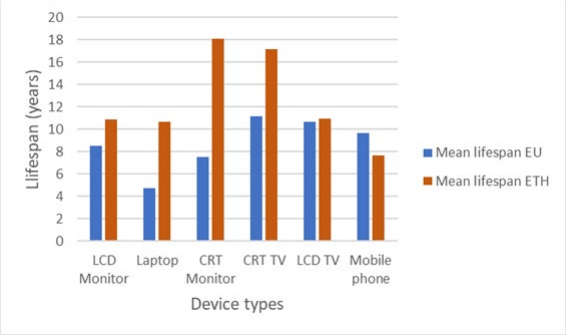

Figure 2. Comparison of life spans from 3 EU countries and Ethiopia.

market, leading to a reliance on components harvested from obsolete devices, which often fail more quickly. Additionally, smartphones' small size, sensitivity to environmental conditions, precise physical tolerances, and fragile electronic components make them difficult to repair or refurbish. The lack of enhanced knowledge through education or training, as well as the absence of appropriate tools to detect failure points further complicate the process (Getachew et al., 2019). Design choices, such as case adhesives, bonded glass displays, non-removable batteries, and soldered components, also contribute to complex refurbishment processes requiring specialized tools and knowledge (N. Proctor, 2020). Building on the earlier comparison of device lifespans in Ethiopia and European countries, another analysis provides additional insights. Ethiopian devices again demonstrate an improved lifespan compared to those in other countries, as shown in Table 2. For example, mobile phones in the Czech Republic are reported to have the longest lifespan at approximately 7.99 years. However, 4.5 years of this period is attributed to storage time after the device has failed (Polák & Drápalová, 2012), resulting in a functional lifespan of 3.5 years. Interestingly, a study by the European Environmental Bureau (EEB) reports a mobile phone lifespan of 3 years in Europe, which contradicts the earlier findings (Francisco et al., 2019). In addition, the lifespan of devices in India is reported to be shorter than in Ethiopia (see Table 3). Limited access to tools and replacement parts poses a significant challenge to maintaining and extending the lifespan of electronic products. Another factor that makes repair difficult and less efficient is the lack of advanced knowledge and tools required for modern electronic devices (John Alake, 2014). As technology becomes more complex, technicians struggle to keep up.

Table 3: Comparison of life spans observed in different countries and Ethiopia.

TV		Computer monitor		Laptops	Mobile phone		Reference	Public. year	Country
LCD	CRT	LCD	CRT		Cellular	Smartphone			
10.0	-	5.0	-	4.0	6.0	-	(Ahmed et al., 2014)	2014	India
6.0	15.0	8.0	12.0	-	-	-	(Kalmykova et al., 2015)	2015	Sweden
-	-	-	-	3.5-5.2	-	-	(Jianxin Yang, 2008)	2008	China
-	-	-	-	-	-	7.9	(Polák & Drápalová, 2012)	2012	Czech Rep.
10.0	15.0	7.0	9.0	-	-	-	(Chancerel et al., 2012)	2012	Germany
5.0	-	5.0		4.0	-	2.0	(Moyen Massa & Archodoulaki, 2023)	2023	Developed countries
-	-	-	-	4.5	-	3.0	(Francisco et al., 2019)	2019	EU
12.0	17.0	11.0	18.3	10.7	7.6	6.4	This work		Ethiopia

Providing training to enhance the skills of repair shop workers can help support a more sustainable repair culture. Additionally, introducing policies that promote and encourage sustainable repair practices is essential for reducing e-waste. One of the limitations of this study is the lack of precise data on the storage (hibernation) phase of electronic devices. While the active lifetime (in-use phase) was determined through repair shop records, obtaining information on how long devices remain unused before final disposal proved challenging. Local shops primarily track functional repairs rather than storage periods, making it difficult to quantify the exact duration of the obsolescence phase. Future research could explore alternative methods, such as household surveys or second-hand market assessments, to better capture this aspect.

Observations and Conclusions

This study allows to conclude that there seems to be potential in the repair culture in Ethiopia for extending the lifespans of electronic devices. However, repairers face several challenges when dealing with more complex devices. Another issue is the lack of spare parts, especially for older or less common devices, which makes it difficult to find the components needed for repairs. Another area of concern is the evolution towards devices that are virtually impossible to take apart without destroying them. Devices such as smartphones and high-tech electronics are often designed with glued parts or non-removable batteries, making disassembly challenging and increasing the risk of inflicting further damage during repair. There is also another issue with the unavailability of important software and firmware, especially on phones where proper working can greatly be based on updates or proper operating system installations. Furthermore, the lack of technical documentation is common, as many repair shops do not have access to manuals or schematics that would allow for efficient troubleshooting and repairs. Lastly, the absence of adequate tooling as well as lack of formal training respectively limit repair capabilities. Many modern electronics require specialized tools, such as precision soldering irons or heat guns for glued components, which may not be available in local shops, hindering the repair process. These challenges make repairing complex devices much more difficult compared to simpler devices, where parts are more accessible, and designs allow for easier disassembly and repair. Generally, the efforts of stakeholders, including the government and maintenance shop owners, to modernize the repair culture could positively impact the emerging e-waste stream.

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