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The Socioeconomic Impacts of E-Waste in Juba: The Case Study of Kator Payam of Juba City, South Sudan

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Abstract

Electronic waste (e-waste), also, commonly referred to as waste from electrical and electronic equipment (WEEE) is a global concern in the contemporary world and poses increasingly significant risks or dangers to the environment and its ecosystem because of the volume being generated, toxic substances in them and the complexity of its poor management in especially, the developing world. South Sudan, like other emerging developing economies, generates a significant volume of e-waste yet, lacks the necessary infrastructure or facilities to recycle e-waste. While e-waste is a business opportunity for the people of Kator Payam and Juba at large, as the valuable materials that can be recovered can earn them incomes while the industry opens up opportunities for job creation, there is a huge concern on the levels of informal practices when it comes to disposal. This study looks into critical analysis of the socioeconomic impacts of e-waste resulting from the management mechanisms in place through the application of the "Social-ecological model" and its conceptual framework and the "Integrated Economic Impact Model (IEIM)" to analyze data and identify potential impacts of management approaches from both upstream (primary and secondary e-waste generation) and down-stream on e-waste management by recycling among others on the society and the economy at large.

Keywords: E-waste, WEEE, toxicants, refurbishers, recycling, policy framework, regulations, legislation, treaties

INTRODUCTION

The Republic of South Sudan is the youngest African country. It got its independence in 2011. The country has a population of 14.7 million and a land area of 644,329 sq. Km, CPI of USD 50 and GDP of 38Bn, with Juba as its capital city (NBS, 2023). Juba city is located in Juba County in Central Equatoria State. The JCC is comprised of three Payams of three Payams of Munuki, Juba Town and Kator. CES has a population of 1,408,411 (NBS, 2023), while Juba City has an estimated population of 403,000 people which is about 15% of the urban population in South Sudan within a land area of 168 Km2 and a population density of 3,990 persons / km2 and 4.2 growth rate, (UN-Habitat, 2023). South Sudan inherited a weak system from the Sudan and has been struggling with its stability from recurring internal conflicts that could not allow it to establish effectively functional systems. The city faces various problems with regard to providing basic services such as education, public health, waste management, public hygiene and sanitation, water supply, infrastructure development, electricity and communications among others

(Agwanda, & Asal, 2020).

Since 1990s to date, due to rapid economic development, advanced technologies and frequently updating or upgrading electronic products. In 2014, the global quantities of e-waste generated annually have grown from 41.8 million tons (Mt) to 44.7 million tons (Mt) in 2016. This further grew to 53.6 million tons (Mt) in 2019 (Forti et al. 2020). This e-waste growth trend is estimated to keep increasing to 74.7 million tons by 2030 (Baldé et al. 2017; Forti et al. 2020). In 2019 about 53.6 Mt of E-waste were generated globally into the environment have increased significantly, it is further estimated to reach 74-76 Mt by 2030 (Murthy, & Ramakrishna, 2022). This has made e-waste one of the most rapidly growing pollution problems globally. The current trend of electronic devices such as mobile phones replacement frequency is less than 2 years in developed countries and less than 3 years in developing countries (Prabhu & Majhi, 2023). In 2015, the Global estimates of mobile device users worldwide is over sixteen (16) billion as of 2023 (Fowler, et al., 2023) from five (5) billion in 2019 (Atanassov, & Chowdhury, 2021) while over 400 million waste mobile phones produced each year globally since 2012 (Huang, CL et al., (2016). This calls for effective measures by governments and stakeholders in controlling e-waste pollution.

In most developing countries, the urban authorities, such as municipalities are charged with the responsibility of waste management among other tasks related to safety and welfare of City dwellers. "Waste management is one of the most visible urban services whose effectiveness serves as an indicator for good local governance, sound municipal management and successful urban reforms. (Makando, & Muguba, 2023)", these emerging cities like Juba use trucks to collect waste from random sources or pick-points on daily basis and dispose them in designated waste dumps sites or recycling facilities. Land filling has become the immediate most possible way of managing electronic waste in the case of South Sudan. Due to high prevalence of 'un-demarcated' and 'un-developed' waste dumping sites and non-existing recycling sites or facilities, the Payam authorities that primarily bear the responsibility to clean up the cities, towns and residential areas find it easier and time saving to randomly collect the waste and dump in the poorly designated locations as landfill rather than sorting out the electronic wastes for recycling and proper disposal mechanisms. This has been very common in the case of Juba City.

Today, as one of the rapidly growing economies, South Sudan is experiencing a large production of waste from electronics and electrical equipment which is increasing in an over-burdening phase in the major cities and towns. As the population grows, industrialization increases and agriculture gets mechanized, WEEE rapidly increases. For example, in the ICT sector, mobile phones are produced each year due to high demand and consumption and rapidly growing innovation that generates new technologies prompting the abandoning of old technologies for a new one almost every year by users. In the context of South Sudan, almost every youth has more than one mobile phone and these are often changed after one or two years. The old ones are kept in housed unused and later dumped as a play tool for children that later ends up in the streets. Other examples include toner for printers, phone batteries, vehicle batteries, printer rollers, and other electrical accessories that often end-up in streets. These materials are later eroded or carried by rain water into streams and the Nile River (Juba city case) where the inhabitants in the city get their drinking water. These electronics and electrical contain many harmful substances and these substances will be released to the environment and damages it or contaminates the food people eat.

The hypothesis of this analysis aim to investigate, examine and explain the socioeconomic impacts associated with e-waste in Juba with a particular attention to Kator Payam of JCC. The Researcher sought to establish these by examining the sources and driving factors of e-waste generation, economic impacts of e-waste on the society and environment, roles of stakeholders on e-waste management, and the gaps

related to e-waste management in the area to draw conclusions and workable recommendations that can practicably be used to reduce the negative impacts of e-waste on the social and economic lives of the people in Kator Payam of Juba City.

Definition of e-waste or WEEE

Electronic Waste (E-waste) or Waste from Electrical and Electronic Equipment (WEEE) refers to "electronic and electrical products which are nearing the end of their lifespan or just discarded due to the availability of new and advanced products in the market" (Bel, et al., 2020). This can also mean all light and heavy electrically chargeable and electronically usable materials for personal or industrial purposes.

E-Waste in the Global Context

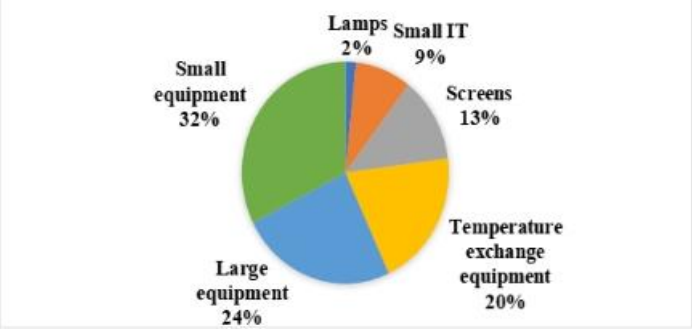
Globally, millions of e-waste are discarded every year when they break or become obsolete. These discarded devices fall into various categories of e-waste including recyclable (repairable) reusable, and disposable. The rapidly growing volumes of global and national WEEE result from several long-term pushes in the global economic space and subsequent competition, technological advancement, and high demand for modern technologies across the globe. "Population growth, increasing prosperity, and changing consumer habits globally are increasing demand for consumer electronics" (Avis, 2022). Equally, the advancement in technology, automation of production, and increasing industrialization have made WEEE grow in contemporary societies, where these advancements and modernization play a critical role in households to maintain and enhance living standards (Sakhuja, et al., 2022). On the other hand, at the consumer level, higher disposable income, urbanization, and changing consumer habits and preferences on technologies, such as more frequent purchases of new tech devices and equipment, either to update or access more efficiency have led to more widespread uptake of technology leading to increasing frequency in disposable devices hence, WEEE (Tanveer, et al., 2022).; Shi, et al., 2021). Also, on the economy, high demands pushed for increased production of such devices, and competition among manufacturers boosted the zeal to keep researching and producing more advanced technologies to attract more customers/clients and make high bottom-line and return on their investments. This again contributed to the massive influx of advanced technologies, and increased disposable EEE. All these three scenarios or factors mentioned above contributed to an exponential rise in e-waste generation in countries, more especially developing ones with limited capacity to recycle or reuse these WEEE.

E-waste is a global challenge of increasing significance because of the volume being generated and complexity of this waste in terms of management. E-waste contributes a large portion, an estimate of 53.6 million tonnes, in environmental pollution in the global context, yet, only 17.4% was documented as formally collected and recycled (WHO, 2023), South Sudan inclusive in this data. Due to increasing population, and high consumption of EEE, huge volumes of WEEE are generated into the water contaminating the rivers and lakes causing health issues resulting from consuming the contaminated water especially in the case of South Sudan, most health conscious and high income earning people rely on consuming bottled water instead of water taken directly from the river. The WEEE consumption and generation estimations keeps increasing almost every day in the developing world and dumping on streets of e-waste grows damaging the environment and contributing to the negative global climate change causing unusual droughts and floods in most parts of the world. In Thailand, mobile phones has the highest toxic generation i.e. importing approximately 21 million units of new mobile phones every year, equivalent to 262 million (Budnard, & Khaodhiar, 2022). This has put humans and animal at enormous

health risks and displacements. In 2020, the International Labor Organization estimated about 16.5 million children globally working in the industrial sector, of which waste processing is a subsector (ILO, 2021), but, there were unclear data on how many child labourers participate in informal e-waste recycling sector. However, E-waste exposure may be linked to "adverse neonatal outcomes, including increased rates of stillbirth and premature birth; neurodevelopment, learning and behaviour outcomes, especially associated with lead released through informal e-waste recycling activities; and reduced lung and respiratory function and increased asthma incidence, which may be linked to high levels of contaminated air pollution that characterize many e-waste recycling sites" in pregnant mothers, infants and children; (ILO, 2014).

In 2014, the global quantities of e-waste generated annually have grown from 41.8 million tons (Mt) to 44.7 million tons (Mt) in 2016 (Baldé et al. 2017). This further continue to grow to 53.6 million tons (Mt) in 2019. This e-waste growth trend is estimated to keep increasing to 74.7 million tons by 2030 (Forti et al. 2020). The concern is arguably with the disposal challenge. The ultimate fate (disposal) of these EEE where recycling and reuse rates are not matching with the generation of e-waste quantities is quite worrying. "In 2016, only 20% (8.9 Mt) of the total e- waste was recycled through proper channels globally, 4% (1.7 Mt) was thrown in with residual waste that was subsequently sent to landfill or incinerated, while the destination of the remaining 76% (34.1 Mt) was reported as unidentified (Baldé et al. 2017)". Moreover, in 2019, only 17.4% (9.3 Mt) was documented to be collected and recycled

Global E-Waste Category 2019



Source: Forti et al. (2020)

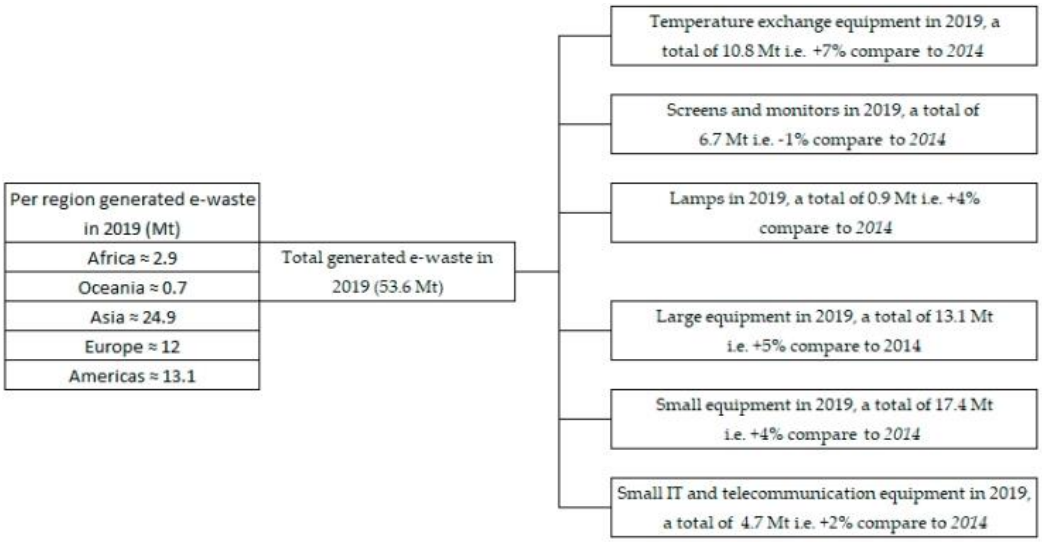
through appropriate formal processes, while 82.6% (44.4 Mt) were undocumented (Forti et al. 2020). Out of the total undocumented e-waste, about 8% was discarded with municipal waste in high-income countries, 7% to 20% was probably exported to developing countries as second-hand equipment or e-waste and the whereabouts of the rest remains undisclosed, maybe dumped, traded or recycled informally (Ilankoon et al. 2018 and Lee, D et al. 2018). The unfortunate situation is that e-waste in most developing countries is managed using informal, unstandardized methods that have negative impact on the environment and the health of e-waste recycling workers, people living near e-waste recycling facilities or dumping sites (true in the case of South Sudan), the local community and wider society (Khan, MU, Besis & Malik 2019; Soetrisno & Delgado-Saborit 2020). The Figure above shows the percentage of each category of total e-waste generated globally based on the estimated physical weight.

Other studies conducted by Sanga et al. discovered rich literature on the global trend of e-waste. their studies looked in to several years starting with 2014 citing historical works of numerous researchers on the same. "For the years 2014, 2016 and 2019. They show that amount of e-waste in the year 2014 was

about 42 Mt (Balde et al., 2015) whereas the estimate of e-waste in the year 2016 was about 45 Mt (Balde et al, 2017). In 2019, e-waste was estimated at about 54 million tons (Mt) (Forti et al., 2020). That means, globally, e-waste had increased by about 107% from 2014 to 2016 and increased by 120% from 2016 to 2019 and increased by 129% from 2014 to 2019" (Sanga et al., 2023) while, a recently published study by Moyen G., & V. M. (2023) also confirmed global e-waste generation to the tune of 53.6 Mt in 2019 with temperature exchange equipment, screens and monitors as well as large equipment leads by 22.5 Mt of the total e-waste generation in 2019.

Global e-waste generation, 2019

Source: Moyen & Archodoulaki, (2023).



Inter-continental Overview of E-waste Generation and Management

In the struggle to bridge the digital divide by governments, most African countries have become recipients of used EEE. The demand for EEE keeps rising on the continent due to consumer demand for new products some of which are reconditioned creating high chances of rapid e-waste generation on the continent. The volumes of e-waste generated and collected for recycling at the continental levels as presented in the Table below show Africa amongst the highest e-waste generating continents in the world i.e. Africa, Asia, Americas, and Europe. However, Asia is leading the four, followed by the Americas and Europe as shown in 'bolded' data in the table . Africa is the least contributing continent to e-waste. Asia generates 24.9 Mt (annually in 2019) or 46.5% of global e-waste, making it the largest producer of e-waste (Baldé et al. 2017; Forti et al. 2020). Asia is a multifaceted continent, characterized by a range of developing and developed economies, with varying levels of incomes and therefore, very diverse levels of EEE production and usage, as well as a broad range of e-waste management systems. Specifically, as Baldé et al. (2015) pronounced in their studies, "the rise in consumption of electrical and electronic equipment is more rapid in developing countries than in the developed countries". Moreover, out of the total e-waste produced in Asia, only 11.7% or 2.9 Mt are documented to be formerly collected and recycled through standard procedures. This collection and recycling rate naturally varies by country, depending on the national legislation of each Asian country. Looking at the data, China generated 10.1 Mt on e-waste or WEEE in 2019,

E-waste generation and collection per continent

Indicators	Africa	Americas	Asia	Europe
Countries in the region (analyzed)	49	34	46	39
Population in the region (millions)	1,152	984	4,445	740
E-waste generated (kg/inhabitant)	2.5	13.3	5.6	16.2
E-waste generated (Mt)	2.9	13.1	24.9	12.0
Documented to be recycled (Mt)	0.03	1.2	2.9	5.1
Formal recycling / collection rate (in the region)	0.9%	9.4%	11.7%	42.5%
Informal recycling /Undocumented (est. - Mt)	2.87	11.9	22	6.9
Informal recycling/Undocumented (est. -.%)	99.1%	90.6%	88.3%	57.5%

Source: Forti et al. (2020)

leading the continent as the major producer of e-waste in Asia as well as in the world. This quantity keeps on increasing almost annually, Baldé et al and Zeng et al. projected the increase to 27 Mt by 2030 (Baldé et al. 2017). This increase is because China is the most populous country in the world with close to 1.4 Billion people. This translates to being the leading country globally in terms of growing local demand for EEE, and it also enjoys a relatively high per capita income where its population has the purchasing power of these EEE like laptops, mobile phones, Table ts, headphones among others. The propelling factor or booster of this growth in the use of technology, Asia is modernity and technological advancement and uptake (supported by high and increasing literacy rates). The continent especially South-East and East Asia has become one of the global hubs for manufacturing and assembling of electrical and electronic equipment, which is not just for local consumption, but for global use as well (Baldé et al. 2015). Apart from manufacturing, China and India among other Asian continent countries play an important role in the renewal, reuse and recycle of e-waste generated locally and imported from developed countries (Baldé et al. 2017). India and Pakistan, being the 4th and 26th largest producers of e-waste globally according to studies of Abid, Zulfiqar & Raza among other scholars/researchers also are recipients of e-waste from OECD countries (Abid, Zulfiqar & Raza 2019; Baldé et al. 2017). As a result, the volume of discarded electronics in East and South-East Asia has risen by almost two-thirds, while studies show it is more than double in China between 2010 and 2015, and this rise in e-waste generation is outpacing the population growth (Honda, Khetriwal & Kuehr 2016). It is estimated that developing countries in Asia, Africa, Latin America are likely to discard twice as much e-waste as the developed countries by 2030 due to high local demand and consumption of EEE as well as illegal inflow of e-waste from developed countries dumped into this highly demanding, low-income developing countries (Wu, Qihang et al. 2015).

The second leading continent on e-waste generation after Asia is the Americas, which is recorded as producing 13.1 Mt (annually in 2019), about 24.4% of the worldwide e-waste generation, but with a collection and recycling rate of only 9.4% or 1.2 Mt (Forti et al. 2020). The African continent generates close to 3Mt of e-waste making it the least generating continent globally in 2019. However, the Americas put in place some general measures and regulations to reduce e-waste at the federal level (Resource, Conservation and Recovery Act – RCRA) to limit the adverse effects of improper disposal and recycling, which also includes Responsible Recycling (R2) or Stewardship Standards. Unfortunately, Guibrunet that despite all measures and regulations put in place, there is still growing number of formal e-waste facilities in the region, including Latin America, Mexico, etc where very large quantities are still processed through informal methods and or exported to other developing countries (Guibrunet 2019). Digging deeper on the continental measures on e-waste management, the Americas still lag behind compared to Europe. The European continent (region) has already established tight legislation that covers the European Union (Baldé et al. 2017), including the (EU) WEEE Directive that provides for the design, production, collection, disposal and treatment of e-waste. this is why it can be evident that Europe has high collection and recycling rates (42.5% or 5.1 Mt) compared to other regions in this study.

Continental Context (Africa)

Africa was estimated to have generated approximately 2.9 million tons of e-waste annually and e-waste materials sourced from Africa amounted to about $3.2 billion USD in 2019 (Maes, & Preston, 2022). The trans-boundary movement of used EEE and or e-waste into Africa has resulted in an increase in growth of informal economic sector despite its adverse consequences. “Used EEE, and repairable EEE, have permitted individuals and companies to buy inexpensive and vital electronics or IT equipment helping socioeconomic development” (Maes, & Preston, 2022). The informal e-waste practices including collection and recycling processes provides a major source of livelihood for many poor urban people especially in major cities and towns where e-waste generation is high. In South Africa, studies found that the informal sector contributes to job creation for about 10,000-20,000 workforce of low-income population amounting to 25% of the e-waste recycling in 2013 (Maes, & Preston, 2022). While in Ghana, e-waste activities generated US$105–268 million and creating employment for at least 200,000 people nationwide in 2014. In general, e-waste activities about 4000—6000 direct jobs and supporting strong entrepreneurship and economic opportunities through the development of community-based collection, recovery, and recycling businesses in sub-Saharan Africa (Maes, & Preston, 2022). However, e-waste also contains valuable materials such as gold, copper, and other rare elements, trading and repairing e-waste can be of enormous economic benefits for individuals in Africa despite the significant amount of economic value lost due to inadequate recycling practices. Also, poor e-waste disposal incurs health costs for both the environment and humans in terms of land, water, and air contamination resulting from toxins from e-waste.

The E-waste management dynamics in Africa are impacted by rapidly growing informal sector collectors and refurbishers in most countries; these informal sector players are not organized as such in a manner that trackable systems are set in place nor have license provisions for sorting, dismantling, and refurbishing e-waste. Most of the e-waste collected by these players ends up being burned in nearby landfills thereby polluting the environment. There is low Government control of the sector and inefficiencies are enormous in the handling of e-waste. Studies by Maphosa, & Maphosa (2020) indicate that a lot of developing countries’ e-waste handlers use undeveloped or traditional means of processing e-waste through cremating

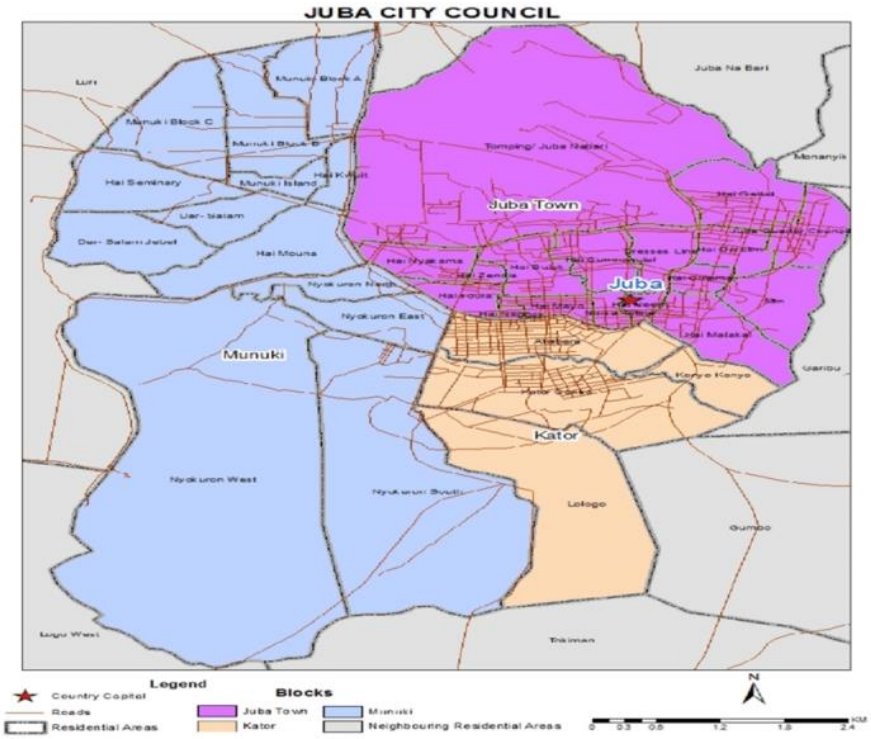
or open burning in dumpsites around household or office compounds (premise) or designated dumping sites far from residential areas. The studies further identified the illegal e-waste workers who use rudimentary means, with no appropriate tools, the general public who reside near informal recycling dumpsites, children, and pregnant women as the most affected and vulnerable groups to e-waste toxic substances (Maphosa, & Maphosa, 2020).

Kator Payam (South Sudan) Contextual Overview

Kator Payam is one of the three semi-autonomous Juba City Council's (JCC) Payams in the Central Equatoria State. The JCC was established in March 2011 with three Payams Councils namely; Juba-Town, Kator, and Munuki. The Department of Environment & Sanitation of JCC was established to take charge of Solid Waste Management (SWM) including e-waste in the city of Juba. One of the mandates of the JCC resulted from the growing mixed wastes generated the City streets by the residents and Institutions without any proper disposal mechanisms in place. JCC is made responsible for collecting these wastes and disposing of them in Controlled dumping sites that is managed by Rejaf Payam along Yei Road and Juba-Nimule Road. However, with the dwindling security situation in the country, and financial challenges caused by internal political instability and poor management mechanisms, Waste management by the JCC increasingly deteriorates. Illegal dumping and burning are common within residential areas and organization compounds. There is already an illegal dumping site created along Nimule Road near the city where wastes are dumped and burnt. As a result, environmental pollution and the spread of diseases become some of the major socioeconomic challenges the city people face everyday. Central Equatoria State has a growing population, today, the population of the State is estimated at 1,103,557 people while Juba county has an estimated population of nearly 370,000 (2008 Census), 700,000 (NBS-PES, 2021) and 523,000 (UNOCHA, 2022). The city itself has an estimated population of 130,507 people within a land area of 52 square kilometers and a population density of 2,510 persons / km2 with Kator Payam hosting considerable number of the population in the City. It is understandable that Juba City is South Sudan's major economic, administrative, and cultural center and also among the undeveloped but

Source: Abdullatif Sleibi (2023)

fastest-growing cities in East Africa. The City attracts huge number of business people from the region and beyond. The EAC region has an estimated population of over 300 million people as of 2022 and these economies looks at South Sudan as a potential business place with enormous opportunities (Moses, 2022). Juba City, as one of the EAC cities, is undergoing rapid urbanization that is causing a high generation of wastes including electronic wastes resulting from industrialization picking up and high consumption levels. Therefore, the huge generation of e-waste pose a health and environmental threats to the people living in the city and especially within the limits of Juba City Council. These threats risks social and economic well-being of the people as their health and that of the environment where they depend on shall be damaged or affected by the toxic substances from these WEEE that are poorly disposed within residential areas. The map below shows the three Bocks or Payams of JCC.



Source: Moses et al. (2018)

The situation of electronic waste management in Juba City can therefore be generalized as a representation of the waste management situations in other municipalities throughout South Sudan. However, this study is only limited to Kator Payam of Juba City Council but its outcomes can be borrowed to be used in other municipalities in South Sudan as the situation might be similar due to almost similar cultural orientation, awareness issues, knowledge and resource limitations, literacy issues and proximity. As one of the Payams of the JCC Payams, Kator Payam faces rapid population growth, high Block's high consumption of EEE resulting from the expansion of the city contributes to the increasing generation of e-waste within the area. General waste generation within JCC was estimated at about 1,337 tons/day (2017). The rate of generation was about 0.65 kg/person/day. While Waste collection amount to 34.3 tons/day and the collection rate was 2.6%. There are no clear data on the composition of the waste, especially e-waste (JICA, 2019). Recycling is provided for in the National Environmental Bill and in the National Environment Policy 2015-2025. However, minimal recycling activities exist. Self-disposal at generation source (open burning) predominates. The only landfill site that is controlled (fenced and treated) for Dumping was established

along Yei Road in 2012 has an area of 25 ha. It is managed by Rejaf Payam, and JCC pays disposal costs to Rejaf Payam. However, the present state of the landfill or disposal site is no longer controlled due to the fact that the fence around the site is removed and treatment is lacking, roads are not passable due to rains and yet, people are intruding into it turning it into the residential area.

As one of JCC's Payams, Kator Payam gets its waste management revenues mainly from three sources, namely (1) waste collection fees, (2) issuing permits to sewerage tankers and waste collection vehicles, and (3) fines and penalties. "Most of the revenue comes from the waste collection fees, with the fees collection from markets accounting for 62% of the total. Markets: SSP 11,159,276 Hotels: SSP 2,070,000 Institutions: SSP 492,000 Issuing Permission to Sewerage Tanker: SSP 3,298,000 Issuing Permission to Waste Collection Vehicles: SSP 576,000 Fines and Penalties: SSP 500,000 Grand Total: SSP 18,095,276 Expenditure: The total expenditure amount of the Department of Environment and Sanitation of JCC in FY2016/17 was about SSP 18 million" (JICA, 2019). this is a very small amount to run waste management in the City. The JCC relies on its resource generation with very little supplementary support from the State Finance Ministry or National government to finance its budget. Waste management cost represents 30% of the city's annual budget which is indeed a huge burden for the JCC finances to effectively and sufficiently fund much-needed projects including recycling and other infrastructure developments for segregated waste management including e-waste. Also, within Kator Payam of Juba City, individuals, and households actively participate in waste generation as well as management; they contribute to waste generation through their daily activities and consumption patterns and manage waste by engaging in practices such as waste segregation, recycling, disposal, composting, waste reduction, etc. What is unclear is data on e-waste, the e-waste is being mixed together with other normal municipal solid waste. There are no sorting or segregation mechanisms in place to establish the quantity of e-waste being generated, recycled and disposed in the area. The Kator Payam Council do not have substantive data records on e-waste either.

THE SOCIOECONOMIC IMPACTS OF E-WASTE

E-waste contributes to climate change as a result of substances contained in the electronics such as copper, aluminum, and iron including polybrominated diphenyl ethers (PBDE) which when burnt, accumulate and pollute the air and later with rains, release toxicants into soil and water damaging coral-reef on water surfaces or contaminates the soil killing vegetation altering rain patterns causing droughts and floods (Tom Musili, 2022). Also, another problem with e-waste is at the level of management in terms of repair (recycling), reuse, and disposal. There are limited regulations in most developing countries on e-waste management, the few with regulations, the regulations are not sufficient enough, and yet enforcement is the challenge. This makes e-waste a major threat to human and animal health including the environment causing lots of mitigation or treatment costs on the economy. The global "monetary worth of e-waste raw materials is estimated to be $57.0 billion. However, only $10.0 billion worth of e-waste is recycled and recovered sustainably, offsetting 15.0 million tons (Mt) of CO2" (Uddin, et al., 2023). Globally, the economic contribution of e-waste management practices is about USD 28 billion worth of metals being turned into secondary use in 2022. However, the overall impact of e-waste management represents a net cost of about USD 37 billion in the same period, especially in the form of health and environmental costs arising from poorly managed hazardous substances and discharges of greenhouse gases. The total value of the metals contained in e-waste was estimated at USD 91 billion, USD 19 billion for secondary e-waste raw materials, USD 15 billion for gold, and USD 16 billion for iron. (Baldé, et al., 2024).

"…" The externalized costs of e-waste:
USD 36 billion in long-term socio-economic and environmental costs arising from the emission of the greenhouse gases that drive climate change (see Box 5 for an example of gender dynamics); USD 22 billion representing the cost of illnesses and decreases in human capital (productivity and wages) and the average monetized value of working lives caused by mercury emissions; USD 19 billion arising from the release of plastic waste into the environment; Less than USD 1 billion arises from the release of lead into the environment and its effects on wildlife and humans.
Source: Baldé, et al., (2024).

Electrical and Electronic Equipment (EEE) contain various toxic substances including Lead, Mercury, Cadmium, Polybrominated Flame Retardants (PFRs), Marium, Lithium, Dioxins, Polychlorinated Biphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs), Nickel, Copper, Chromium, Arsenic and Cadmium. These substances are harmful to lives and the environment in the sense that they can cause damage to the human central and peripheral nervous system, blood system, endocrine system, reproductive system and kidney and can cause cancer, e.g. the health impact of Lead, Polychlorinated Biphenyls, Dioxins and Mercury; they can cause cancer that targets human cardiovascular, renal, gastrointestinal, neurological, reproductive and respiratory systems e.g. the health impact of Cadmium; they can badly affect the endocrine, thyroid and immune system of humans e.g. the health impact of Polybrominated Flame Retardants (PFRs) (Tom Musili, 2022); they can cause brain swelling, muscle weakness, heart, liver and spleen damage, cataracts and jaundice e.g. the health impact of Barium and Polycyclic Aromatic Hydrocarbons (PAHs); they can cause air and water pollution exposing the environment to harmful Lithium substance especially when burnt or landfilled which later affects humans through products of the land consumed including the air, water and food; they can lead to a prolonged impairment of human immune system; they can cause pulmonary and skin disease, respiratory issues due to the heavy metals found in Nickel, Copper, Chromium, Arsenic and Cadmium that are consumed from water, food or air (Zhuang, 2019).

INTERNATIONAL TREATIES ON E-WASTE

Several international treaties or conventions, including the Basel Convention, Bamako Convention, and Waigani Convention, were established to control waste, including e-waste, and to protect the environment from harmful substances (waste).

The Basel Convention; this is one of the great conventions which is concerned with controls of trans-boundary movement of hazardous wastes and their disposal that may have an adverse impact on the environment of the recipient country (Lebbie, et al., 2021). Adopted on March 22, 1989, by the Conference of Plenipotentiaries in Basel, Switzerland, it became a great global environmental agreement that aims to tackle issues surrounding hazardous wastes, including e-waste and its management. The treaty was established in response to a public outcry following the discovery, in the 1980s, of toxic waste deposits in Africa and other parts of the developing world that had been imported from abroad, leading to environmental and health concerns on the continent. In 2019, an amendment to the Agreement i.e. the Ban Amendment to the Basel Convention entered into force limiting the movement of hazardous wastes,

including e-waste, from countries of the Organization for Economic Co-operation and Development (OECD), the European Commission countries and Liechtenstein to other states that are party to the Convention. The Basel Convention runs programs and workshops to develop and deliver guidance on environmentally sound management of e-waste. It also provides states with guidelines to distinguish between waste and non-waste and the trans-boundary movement of e-waste. Primarily, the objective of the treaty was to protect human health and the environment against the adverse effects of hazardous wastes with aims of Reduction of hazardous waste generation and promotion of environmentally sound management of hazardous wastes, regardless of the place of disposal, Restriction of trans-boundary movements of hazardous wastes, except where it aligns with environmentally sound management principles and Establishment of a regulatory system for permissible trans-boundary movements. In this treaty, member states are required to establish relevant policies and observe the fundamental principles of environmentally sound waste management, Prohibit and prevent the export and importation of hazardous wastes, establish bilateral or multilateral agreements on hazardous waste management with other parties or non-parties, provided they are "no less environmentally sound" than the Basel Convention (Faga, et al., 2016).

The Bamako Convention; the Basel Treaty allowed member states to establish or adopt similar Agreements aimed at managing hazardous waste. The Bamako Convention which came to existence was coined by 12 African member states of the African Union in Bamako, Mali in January 1991 and came into force in 1998, is one of the great treaties which is more a continental Agreement for African nations, aimed at prohibiting the import of hazardous and radioactive waste into the continent (Lebbie, et al., 2021). the key points of establishing this African-based treaty which is almost related to the international Basel Convention include a customized need, in the context of Africa, to Prohibit the import of all hazardous and radioactive wastes into Africa for any reason, Minimize and control trans-boundary intra-Africa movements of hazardous wastes within the continent, Prohibit ocean and inland water dumping or incineration of hazardous wastes, Ensure that disposal of wastes is conducted in an "environmentally sound manner" that promotes greener production over the pursuit of permissible emissions based on assimilation capacity assumptions and Establishment of protective principles (Faga, et al., 2016). This Africa Treaty covers extensively on more other wastes compared to the Basel Convention. It covers beyond radioactive wastes but also considers other waste with a listed hazardous characteristic or a listed constituent as hazardous waste that a domestically defined by member countries as hazardous.

The Waigani Convention; the Waigani Convention, which is more like the Bamako Treaty, it is one of the regional treaties extending the Basel Convention to the Island and South Pacific countries, came into existence on October 21, 2001, with membership of Australia, Fiji, New Zealand, Papua New Guinea, Samoa, and the United States (into force Secretariat, O. E., 2013). The broader purpose of establishing the Waigani Treaty was to prohibit the Importation into Foreign Island Countries and the South Pacific region of Hazardous and Radioactive Wastes and to Control the Trans-boundary Movement and Management of Hazardous Wastes within the Region. In particular, the Convention's objectives were to Reduce and eliminate trans-boundary movements of hazardous and radioactive waste, Minimize the production of hazardous and toxic wastes in the Pacific region, and ensure that waste disposal within the Convention area is managed through an environmentally sound manner. The Waigani Convention also covers radioactive wastes within a territorial coverage extending to each Party's Exclusive Economic Zone (EEZ) (200 nautical miles), rather than just the outer boundary of each Party's territorial sea (12 nautical miles) as under Basel. It is closely linked to the London Convention, which is concerned with the prevention of

marine pollution by dumping of wastes (Kulsoom, et al., 2021).

Other Related Treaties; more customized continental or regional protocols on e-waste or environmental protection related regulations established include "The London Convention" or Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters of 1972 established in London by the International Maritime Organization (IMO) aimed to prevent pollution by dumping of wastes to sea; "The Montevideo Program" also known as Progressive Development of Environmental Law's Work of 1982, created in Montevideo, Uruguay by the United Nations Environment Program with aim to promote and safeguard sustainable development, legal assistance, and training to strengthen the countries to implement environmental law; "The Barcelona Convention of 1995 in Barcelona, Spain by United Nations Environment Program" which replaced the "Mediterranean Action Plan of 1975" on Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean extending to address illegal dumping of wastes into Mediterranean Sea; "The Rotterdam Convention" of 1998 in Rotterdam, the Netherlands established by the United Nation Environment Program and FAO to respond to promoting Responsibilities while importing of hazardous chemicals; and "The Stockholm Convention on Persistent Organic Pollutants" of 2001 in Stockholm, Switzerland coined by the United Nation Environment Program and FAO to limit or reduce production and use of persistent organic pollutants (Antony, et al., 2020).

E-WASTE GENERATION STATUS, LEGISLATION, AND POLICY FRAMEWORKS IN THE EAST AFRICAN (EAC) REGION

The East Africa Community (EAC) composing Tanzania, Rwanda, Uganda, Burundi, Kenya, and South Sudan including the recently accepted members i.e. DRC and Somalia, through the East Africa Communication Organization (EACO), has adopted a regional e-waste strategy to achieve a sustainable e-waste management system (EACO, 2017). The strategy prioritizes several issues related to e-waste management including strengthening the policy, legal, and regulatory framework for sustainable resourcing of e-waste management; putting in place the requisite e-waste management infrastructure; establishing mechanisms for comprehensive and sustainable mobilization for e-waste management resources; strengthening e-waste coordination structures at regional and national levels; and promoting research and innovation in e-waste management. This long-term EACO strategy is being developed in harmony with regional and national policies and legislation. However, EACO is also engaging with the relevant Authorities to harmonize national legislation and policy frameworks within the region so that the regional statistics parameters and status derived from each EAC member state are the same. The level of e-waste generation is high in Eastern Africa compared to the other African regions with Ethiopia and Kenya leading with 88 million kilograms of total 470 million kilograms of e-waste generated followed by Tanzania with 61 million Kilograms in 2022 (EACO, 2022); the next African region is Central Africa with a total of 190 million kgs of e-waste, Angola leading the region with 150 million kgs of e-waste; Northern Africa generates a total of 260 million kgs of e-waste with Egypt leading by 690 million kgs; Southern Africa generates 68 million kgs with South Africa leading by 530 million kgs; and Western Africa generates a total of 420 million kgs of e-waste, Nigeria leading the region by 500 million kgs. This makes Eastern Africa leading the continent in WEEE generation followed by West Africa and North Africa respectively, while, the highest generating countries in Africa are Egypt (690million kgs) followed by South Africa (530million kgs) and Nigeria (500million kgs) respectively (Baldé, et al., 2020).

Kenya's E-waste Generation status, Legislation and Policy frameworks; it was established that Kenya

generates approximately 51.3 metric tons (mt) of e-waste annually. Out of this amount of WEEE generation, only 1% is formally recycled annually and only 10% of e-waste generated are properly managed. The remaining 99% (52,000 tons) of e-waste are thrown into dumpsites within neighborhoods or compounds or nearby rivers or streams and burnt exposing people to the risks of WEEE toxic substances (Moyen & Archodoulaki, 2023). There is poor management of e-waste in Kenya, lack of public awareness and poor coordination structures on e-waste management (Otieno, & Omwenga, 2015). The legal structure indicated in Table below face effective enforcement and enhancement mechanisms. In the past Decade; UNEP estimated 11,000 tons of e-waste generated annually in Kenya from refrigerators i.e. 2,800 tons from TVs, 2,500 tons from personal computers, 500 tons from printers and 150 tons from mobile phones in 2010; this trend has been increasing in Kenya (Tocho, & Waema, 2013). Also the study estimated total e-waste generated from computers, monitors and printers alone to approximately 3,000 tons per year. (Otieno, & Omwenga, 2015). Despite the fact that Kenya is signatory to most of the international conventions on e-waste, the country lacks sufficient legal and or regulatory frameworks to effectively manage WEEE at the local level. Moreover, existing regulations are not enforced very well and e-waste infrastructure is yet to be enhanced.

Kenyan policy and legal framework on e-waste management

Legislation	Description
Environment Management and Co-Ordination (Extended Producer Responsibility) Draft Regulations.	Under development since 2020, the regulations provide extended producer responsibility for all products and packaging in all phases of their life cycle to enhance environmental sustainability.
Environment Management and Co-Ordination (E-Waste Management) Draft Regulations.	Under development since 2013, the regulations will provide an appropriate legal and institutional framework and mechanisms for the management of e-waste handling, collection, transportation, recycling and safe disposal.
National E-waste Draft Strategy, 2019.	The strategy guides stakeholders in the concerted efforts in sustainable management of E-waste in the country and hence build synergy among the various players.
E-Waste Management Guidelines, 2010.	The guidelines apply to the handling and management of the various categories and elements of e-waste in Kenya. The guidelines provide a clear mechanism for the management of e-waste at various stages in the supply chain, the objective being to ensure the integrity of the environment is assured against the potential impacts of e-waste and its elements.
National Sustainable Waste Management Policy, 2021.	The policy requests the adoption of 5-year waste management plans and the adoption of green public procurement measures around waste.
The Waste Management Regulations, 2006	these regulations provide detailed guidelines for waste management practices in Kenya. They outline the responsibilities of waste generators, waste transporters, and waste management facilities. The regulations

	specify waste classification, collection, storage, transportation, treatment, and disposal requirements.

Source: (ITU, SCYCLE & UNITARSCYCLE, 2023) & (ISPR, 2023)

Uganda's E-waste Generation status, Legislation, and Policy frameworks; in Uganda, e-waste emission is estimated at 14.9 kilotons (Kt) annually. Most of the e-waste are not collected as applied in many other East African countries. The legislation are weak and enforcement has been a challenge. Recycling facilities are lacking and public awareness on dangers of e-waste is limited and low exposing public to risks of e-waste toxic substances ignorantly. The country established a long-term e-waste management plan (five Year strategy) that started in 2019 to 2024, however, many of the provisions in the strategy are not achieved due to resource challenges, poor enforcement of regulations on e-waste and lack of WEEE infrastructure. The Global E-waste Monitor Report of 2020 estimated that Uganda generated 17,000 tons of e-waste in 2018, and a projected an average annual e-waste generation of 4,500 tons from end user ICT devices from the Year 2018 to 2022 (Baldé, 2020).

Table 5: Uganda's policy and legal framework on e-waste management

Policy/Legislation	Description
National Electronic Waste management Policy, 2012.	Presents the vision of Uganda in e-waste. It also elaborates the mission, goal, policy objectives and strategies in considerable detail. It includes an institutional framework, as well as a monitoring and evaluation arrangement for its implementation.
National E-waste Strategy, 2014.	The strategy provides an all-encompassing plan for implementing the e-waste policy, detailing the costs, time frames, targets, outputs and outcomes, and refers to EPR.

Source: (ITU, SCYCLE & UNITARSCYCLE, 2023; Ministry of ICT, 2016; & NITA, 2016)

Rwanda's E-waste Generation, Legislation and Policy Frameworks; Rwanda generates approximately 7kt of e-waste annually (Forti et al., 2020). The country, as highlighted earlier, is one of the strictest countries in East Africa when it comes to waste management. The country is seen to be a model for municipal waste management in the region, most countries in the region including South Sudan conducted benchmarks with Rwandan Authorities on waste management practices and models. Rwanda generated approximately 18,834 tons of e-waste in 2020. (Twagirayezu, et al., 2021). These WEEE are imported from other developing and advanced countries in the region and beyond by individuals, businesses and public entities as "good to re-use or reconditioned equipment". The most interesting part of it all is that the projected annual increase in the inflow of EEE into Rwanda was close to 6% following trends of the previous year's i.e. in 2014 and 2020, 8,790,255.66 kg, 12,432,416.6kg of e-waste was generated from 33,449,623.04 kg and 47309164.3 kg of EEE respectively. Future projections for the Years 2025, 2030 and 2050 are alarming for this East African Country as it was estimated that Rwanda will be generating 16,596,528.74 kg, 22,155,368.07 Kg, 70,359,994.68 kg for e-waste respectively that are produced from 63,154,890.07 kg, 84,307,981.33 kg, and 26,7741,393.3 kg of EEE within these predicted years respectively (Twagirayezu, et al., 2021). Below are the policy/legislative frameworks of Rwanda.

Rwanda's policy and legal framework on e-waste management

#	Policy/Legislation	Description
1	Regulation on Governing E-waste Management in Rwanda, 2018.	The regulation covers the licensing of e-waste management companies and the EPR obligations of EEE producers.
2	National E-waste Policy, 2015.	The policy provides comprehensive guidance for the efficient and effective management of e-waste through appropriate legal, regulatory instruments, which promote green growth and ensure a sustainable economic development for the country.

Source: (ITU, SCYCLE & UNITARSCYCLE, 2023)

Rwanda has one of the best public policy approaches to managing and or controlling e-waste in the East African region. There are numerous public Institutions given oversight mandates on e-waste management as listed in the table below.

Rwanda's public Institutions' duties and responsibilities on e-waste oversight

Institutions	Duties and responsibilities
Ministry in charge of Information and Communications Technology (ICT)	Lead e-waste policy and strategic plan development for e-waste management. Monitor the implementation of the E-waste strategic plan in coordination with the Ministry in charge of Trade and Industry
Ministry in charge of Trade and Industry	Management of e-waste facilities, processes, and sustainable consulting framework. E-waste management funding system, such as advanced recycling fee, e-waste operating and management procedures.
Ministry in charge of Health	The Health Ministry will establish health and safety standards related to e-waste management policies.
Ministry in charge of Education	The Ministry responsible for education establish and incorporate e-waste management processes within curricula. The Ministry will concentrate on developing the requisite skills for the proper management of waste, including recycling, at local and national level.
Ministry in charge of State Assets	State assets ministry will develop spotless procedures for e-waste Management facilities before the decommissioning of EEE.
Authority in charge of the Protection of the Environment	vanguard e-waste mainstreaming in current environmental policy, strategy, regulatory and legal tools. be involved in the informative contemplation on e-waste as baseline surveys, etc. Control implementation of e-waste-management environmental programs.
ICT Regulatory Authority	These policies are enforced by the ICT Regulatory Authority: Providing regulations guiding e-waste management in Rwanda.

	Providing e-waste management and disposal technical guidance. impose the licensing scheme for the organization's deals with EEE collection, transport, removal, restoration and recycling.
Authority in charge of Standards	inform member states of the World trade organization on instigated EEE standards, regulations, and policies that harm the imported quality into the country. Developing standards for e-waste management. develop an E-Waste Management Standards Auditing and Monitoring mechanism.
Authority in charge of Imports Inspection	The import inspection authority shall ensure that all electrical and electronic equipment imported are complied with by specified specifications at the time of entry.
Authority in charge of Customs and Revenues	Both EEE produced in Rwanda and imports will remain registered with the customs and revenue authority.
Private sector	the private sector shall introduce E-waste management policies and strategic plans Via planning and establishment of e-waste collection, transport, disposal, and recycling facilities. In addition, the private sector shall also be in charge of developing, maintaining, and funding the entire E-waste chain.
EEE Users	Distinct e-waste from others to enable the collection, recycling, and treatment. Emplace generated e-waste to licensed centers and drop-off points. be moderated with the suggested methods or procedures for disposal, particularly the expiry or end of the product usage period.

Source: Twagirayezu, et al., 2021

However, despite all the established policy frameworks and legislation on e-waste management and its leading position in the region in terms of waste management in general, some of the policy frameworks and legal mechanisms established in place including public players on environmental protection and especially e-waste control as highlighted faces poor enforcement and enhancement including effective coordination mechanism from the oversight bodies. E-waste handling has been still poor, there is lack of segregation of e-waste from the other municipal wastes. This still exposes collectors to risks of WEEE toxic substances during collection. Atleast, in 2022 and 2023, the ITU and the UNEP has launched the #GreenRwanda campaign initiative in Rwanda to Educate and mobilize the public to return e-waste to official collection points, create buy-in across private and public sectors, raise awareness about the dangers of improper device disposal, including environmental contamination and exposure to toxins. This initiative has improved the waste management somehow and help boost the country's goal to move toward a circular economy for electronics.

Tanzania's E-waste Generation, Legislation and Policy frameworks; Tanzania is one of the East African economies with a stable and steady growth over a period of time, atleast in the last decade; its economy has been growing at about 7% and population at about 6% annually; The country's households have 36% average purchasing capacity of EEE, this has increased the use of EEE in production of goods and services (Nelson, et al., n.d). In 2021, the country is estimated to generate over 50 kilotons (kt) of e-

waste annually (Forti et al., 2020). Minimal recycling and re-use technologies for refurbishing WEEE are available in the country with a number of vendors (companies), under the umbrella of the "Tanzania Recyclers Association (TARA) - an organization that aims at identifying, coordinating and supporting relevant dealers in the waste management and recycling" - dealing with WEEE recycling business, yet, the e-waste is not reduced, only 35% of the total WEEE generation within the city is cycled. Studies indicates rapid growth of EEE e.g. the proportion of households having a mobile phone raised from 25 % in 2007 to 78% in 2018 while television ownership by households in Tanzania raised from 8% to 24% the same period (Nelson, et al., n.d).

Tanzania's policy and legal framework on e-waste management

Policy/Legislation	Description
Solid Waste Management Regulations, 2009.	The regulations provide the general regulatory framework around solid waste in the country and refer to the principle of EPR.
Hazardous Waste Control and Management Regulations, 2008.	The regulations apply to all categories of hazardous waste and to the storage and disposal of hazardous waste and their movement into and out of Tanzania and refer to EPR.
Electronic and Postal Communications Electronic Communications Equipment Standards and E-waste Management) Regulations, Government Notice No. 919, 2020.	The regulations apply to electronic communications equipment imported or manufactured for use for connection to any electronic communications network for the purpose of receiving or transmitting electronic communication signals.
Guidelines for Hazardous Waste Management, 2013.	The guidelines cover hazardous waste management hierarchy, a brief overview of hazardous waste management practices in the country, legal framework as well as roles and responsibilities of different stakeholders; guidelines on management of hazardous waste during segregation, storage, packaging, labelling, transportation, treatment and disposal; and administrative procedures for trans-boundary movements of hazardous waste.

Source: (ITU, SCYCLE & UNITARSCYCLE, 2023)

Other Tanzanian policy frameworks related to e-waste management

Policy	Policy objectives	Relevancy to e-waste management
The Sustainable Industrial Development Policy (1996- 2020).	To achieve sustainable industrial development.	Promotes industrial development with less Pollution. Promotes efficient use of resources and recycling activities.
National Environmental Policy (1997).	To ensure, sustainability, security, and equiTable use of resources to meet the basic needs of the present population	Promotes health-related programs including food hygiene, separation of toxic or hazardous wastes, and pollution control.

	without compromising those of the future generations without degrading the environment or risking health or safety.	Proper e-waste management reduces pollution load to the environment and reduces risks to human health.
National Water Policy (2002).	To ensure that beneficiaries participate fully in the planning, construction, operation, maintenance, and management of community-based domestic water supply schemes.	Promotes prevention of pollution of water resources. An efficient e-waste management system prevents pollution of water bodies
National Energy Policy (2003).	To ensure the availability of reliable and affordable energy supplies and their use rationally and sustainably to support national development goals.	Promotes the use of energy-efficient Equipment. Promotes the use of EEE and hence contributes to e-waste generation.
National Trade Policy (2003).	To raise efficiency, widen linkages in domestic production, and building of a diversified competitive export sector as the means of stimulating higher rates of growth and development.	Promotes trade development, Recovery of valuable fractions in e-waste could contribute to this policy
National Health Policy (2007).	To improve the health of all Tanzanians, particularly those at high risk.	Encourages safe disposal of hazardous waste from health services including medical Equipment and devices. E-waste contains hazardous substances
National ICT Policy (2003).	To provide a national framework that will enable ICT to contribute towards achieving the national development goals; and to transform Tanzania into a knowledge-based society through the application of ICT.	Promotes investments in ICT Promotes competitive development and production of ICT products and services Promotes establishment of direct relationships with manufacturers and designers of ICT resources. E-waste recycling activities could lead to the establishment of relationships with manufacturers and designers of ICT Equipment.

Source: NBS & UNU, ViE – SCYCLE. (2019).

Burundi's E-waste Generation, Legislation and Policy Frameworks; Burundi generates 5.3kilotons (kt) on e-waste in 2019, the least among most of the East African countries except South Sudan whose

data are blurry (unclear or untapped). (De Marchi, 2013). Burundi also faces similar challenges of poor e-waste management, domination of informal sector, weak e-waste legislation and low awareness of the people about the risks associated to exposure to e-waste intoxicant.

Burundi's policy and legal framework on e-waste management

#	Policy/Legislation	Description
1	La Politique Nationale de Gestion des Déchets d'Equipements lectriques et Electroniques au Burundi.	A draft national policy on WEEE management is under development since spring 2022. The first part of the policy argues in favor of its utility and explains its methodology. The second part describes the initiatives existing in Burundi linked to e-waste management. The third part traces the main vision and mission and the goals of the policy. These elements are phrased as goals and call for the implementation of an institutional framework around e-waste management within the country. The custodian and implementing authorities are both within the Ministry of Environment of Burundi.

Source: (ITU, SCYCLE & UNITARSCYCLE, 2023)

South Sudan's E-waste Generation, Legislation and Policy Frameworks; in South Sudan, the management of electronic waste (e-waste) is a growing concern. E-waste has been mixed up together with other solid waste making distinction quite difficult for collectors. There has never been a comprehensive study on e-waste in South Sudan, therefore, no proper data can be found about South Sudan's e-waste generation trends since its Independence from the Sudan in 2011. However, a partial survey was conducted by the National Communication Authority (NCA), the ICT sector regulatory body of the Republic of South Sudan, covering a few Government Agencies, International and National Non-governmental Agencies and private companies within Juba City. This particular study in Juba City presented 85% of the respondents confirming various WEEE in their offices waiting for disposal, 78% of respondents said to be aware of e-waste collection by third parties involved in recycling and disposal, 47% of the respondents acknowledged poor management of e-waste in the city. Among the e-waste categories listed in the study, the reported leading (high) e-wase generation within the city includes 76% desktop computers, 72% printers, 52% air conditioners, 57% laptop computers. (NCA, 2023). A study by JICA has indicated that a total of 262 $(ton/day)^2$ of un-categorized solid waste i.e. mixed with e-waste are generated within the jurisdiction of JCC areas comprising of Munuki Block, Kator Payamand Juba-town Block. Kator Payam of Juba generates 65 $(ton/day)^2$ of the total waste. (JCC, 2019).

South Sudan, like other East African and African emerging economies faces challenges related to e-waste pollution and management. Issues of poor e-waste collection, recycle and disposal are common. Formal e-waste collection, sorting and proper disposal handling is lacking in the country. Waste facilities are non-existing and informal practices dominates e-waste collection, storage and dumping/incineration in nearby dump sites, land surfaces or in water bodies. "Inadequate waste disposal practices lead to pollution of land, water bodies, and air, negatively impacting ecosystems, and biodiversity" (UNEP, 2018)

South Sudan's policy and legal framework on e-waste management

Policy/Legislation	Description
The Waste Management Policy of South Sudan, 2014	The policy focus provides a framework for sustainable waste management practices across the country. It emphasizes waste reduction, recycling, and environmentally sound disposal methods. It also considers public awareness, community participation, and collaboration among stakeholders on waste management.
The Juba City Council has developed a Strategic Plan for the Development of Juba City (2019-2023)	The strategy underscores explicit objectives, strategies, and actions to improve waste collection, segregation, and disposal practices in Juba city. It further stresses the need for public-private partnerships, community involvement, and capacity building to enhance waste management in Juba City including addressing concerns of waste recycling, establishing waste treatment facilities, and adopting sustainable waste management technologies.
The Environmental Management Bill of South Sudan, 2013	The Bill provides a legal framework for environmental protection, including waste management by creating regulations for waste handling, storage, transportation, and disposal. It further outlines penalties for non-compliance with waste management regulations.

Source: The Institute of Social Policy and Research (ISPR), (2023)

FINDINGS:

The types of e-waste, disposal driving factors and economic impacts in Kator Payam:-

- Most disposed WEEE are "electronics and electrical accessories" such as Mobile phones, switches and power extensions, Radio, music instrument, audio set, video recorder, speakers and other accessories, and bulb/lightnings equipment (72% - 95% range), There is high e-waste collection charges that are combined with other municipal normal wastes on the households, small businesses or vendors in the markets, yet, the general economic situation is dwindling. 79% of the household respondents and 73% of the organizations spends atleast between SSP 10,100 to SSP 50,000 and SSP 100,000 and SSP 500,000 respectively per month on municipal waste collection which include e-waste. This, along with other unnecessary charges on small businesses is contributing to killing the informal sector due to the fact that many business people hinted closing down shops due to too many charges different by local government.
- Most of the key informants (63%) are worried of the elderly people, women and children's exposure to 'toxicants' contained in e-waste in regards to their future health. Others (21%) expressed concern over the current health condition of people and rampant deaths occurring nowadays unlike in the past, blaming it on some of the substance of e-waste dumped in the river and within residential areas that pollute the water and food people eat causing financial costs on treatments.
- 55% of the KII respondents spent between SSP 50,000 and SSP 300,000 on doctor visits and hygiene related sickness treatments monthly depending on size of household. Some of the diseases being treated include respiratory issues, recurring flue and congestion, stomach/abdominal pain and disorders, skin wearings/rashes, eye issues among others that are commonly and recurring affecting them and their households.
- 75% of the respondents believed there are no firms dealing in e-waste purchase from sources

(households/communities, businesses and organizations) except the Kator Payam Council who do not buy but collects them together with other solid wastes.

- 32% of 22 respondents interviewed believed e-waste is source of income making or jobs creation for them as many people look for these e-waste to either resell them to informal repairers and they fix them and sell them again. Others say, without the e-waste they shall have no job or income. They make living (money) from informal e-waste recycling.
- 59% of the KII respondents complained of soil damage and loss of crops such as paw-paw, fashion fruits, etc that used to be mostly grown in the area but now they plant them but either die before bearing fruit or give contaminated fruit that can not mature or not even edible. They the soil contain toxic substances that makes some crops or fruit trees not to survive making their other sources of incomes lost, adding that fruits like paw-paw, passion fruit commonly known as 'batunda' develops some whitish elements on them and fall immature.
- Others (36%) believed the rampant e-waste in the area has made them loose control of their children who they could not afford to educate due to high tuition fees. The children end-up in the streets collecting wastes including and mostly e-waste to resell to make money after which they use the money in the town without returning home. Children grew uncontrollable and unproductive to the household.

Driving factors for e-waste generation in Juba (Kator Payam in particular) as an emerging economy in the region:-

- There is rampant disposal of e-waste together with other normal solid waste within residential areas and burning of these waste at business centers by vendors
- There is insufficiently controlled sale (auctions) and donations of used EEE by organizations especially UN Agencies and foreign Missions (Embassies) of which some of these used EEE have shorter useful time and others are already waste. These Agencies wants to dispose the e-waste by mixing them with some of the short-time use EEE during auctions or donations.
- Lack of awareness on dangers of e-waste and its improper disposal in the area increased the ignorance of people to dispose e-waste unnecessarily. Majority (51%) of respondents are ignorant on risks of e-waste.
- There is no existing e-waste cantonment and recycling facility or center in Juba where all e-waste can be assembled, sorted and re-exported for recycling or republishing and others incinerated properly after sorting/segregating within the facility.
- The high consumption of used products of limited lifetime purchased or donated by organizations increased e-waste generation in the area as some of these used EEE have small useful time while others are already sold as e-waste as well as the issue of no Policy and legislation/regulations known to public on e-waste spurred the e-waste generation uncontrollably in the area. Switches (96%), mobile phones (95%), power extension units (83%), bulbs/lightnings (80%), power-bank (74%), and external drives (69%) forms the highly consumed EEE in which most of them were purchased as "second-hand (used) product".

Roles played by institutions of government, non-governmental actors, private sector and individuals in communities in e-waste management to reduce socioeconomic costs in Kator Payam of Juba City:-

- There is insufficient partnership and coordination on e-waste management by stakeholders. Only JICA plays a great role on generate waste management support to the local authorities of Juba city.
- Most (82%) of the respondents believed that to address some of the adverse socioeconomic impacts

of e-waste, stakeholders must work together to engage communities by providing collection tools, training and facilities and incentivized community collectors, create more awareness initiatives on e-waste, establish recycling facilities and other infrastructure for e-waste collection including Trucks, regulate import/sale of used euipment including quality of EEE and establish partnership with private sector and other actors to reduce e-waste collection fees which is a burden on people.

- Most organizations reached (82%) do not have policy on e-waste or regulation on useful life of EEE and how to dispose them. This contribute to high sales or donations of used EEE in the market or to other smaller organizations as a way of disposing or getting rid of them once these EEE malfunction or gets older.
- Limited financial resources or funding for the Kator Payam Council to dedicate efforts to segregate e-waste from other municipal solid waste. E-waste management requires good funding to provide leveled disposal facilities or containers and conduct rigorous awareness campaigns in the area. The Block Council is not generating enough to offer the required facilities and tools for managing e-waste. There is limited or insufficient support from budgets to even fully finance its overheads and operations. Yet, there are no recycling plant that can buy some of the waste for the Block Council to earn revenues out of it.
- Policy statements issued by local authorities on waste management are not very clear on e-waste, yet, there is little compliance to those policy statements. 76% of the respondents there is poor compliance to those policy statements on waste including e-waste control.

E-waste impacts and management systems, practices, policies, and mechanisms for effective management of e-waste in Kator Payam of Juba City:-

- There are limited formal refurbishing facilities in the area. Only informal refurbishers operating a kiosk or mini-shops fixing phones, radios and TV sets, refrigerators, fans, vehicles, among others EEE who are not formally supported to grow their business into a regular one that can be advanced to a legal recycling firm in the future. Literally, they are only making ends-meal or survival out of the business.
- 73% of KII respondents believed the poor road infrastructure and sanitation issues increased poor disposal practices as waste collection trucks could not access other areas/places. Also that the poor sanitation monitoring by the KBC allowed bushes near business and residential areas that are used as damping sites for e-waste along with other normal solid waste in the area.
- There are policies and strategies on environmental protection and waste management, however, elements of e-waste are not well captured in these policies and legislation e.g. the Waste Management Policy of South Sudan, 2014, the Juba City Council has developed a Strategic Plan for the Development of Juba City (2019-2023) and the Environmental Management Bill of South Sudan, 2013. these policies,strategies and legislation covered little on e-waste management especially regulations on collection and to disposal procedures and its enforcement mechanisms.
- Many people (41%) are unaware of any legislation or policy and regulations on e-waste in the area, this tells the level of ignorance or leeway for poor and traditional practices on e-waste disposal. 75% of the respondents do not know of any formal firm dealing in e-waste purchase of recycling. Meaning, e-waste from the area can be disposed without extreme care on its dangers. This calls for an increased awareness and improvement on the legislation and policies to clearly capture issues and management of e-waste.
- Most of the organizations (29%) earns between SSP 101,000 to 500,000 and yet (35%) of them spends

the same amount on e-waste similarly to those earning less than SSP 100,000 where 41% and 41% earns and spends on e-waste management or collection including related charges. This is too much on them.

- Over 60% of the respondents believed that e-waste causes environmental damage causing climate change (floods/drought resulting from destroying vegetation and reef-cover on water bodies) and poor productivity, human and animal health problems e.g. high costs on treatment and poor productivity or loss of job, damaging soil discouraging agriculture hence, high costs on food, and contaminate water sources destroying aquatic lives that are livelihood sources e.g loss of food and income. This calls for deliberate program, policy, and regulations on e-waste disposal that can promote positive socioeconomic impact of dealing with e-waste in the area.
- The Kator Payam Council faces challenges of finances to be able to engage in e-waste management including massive awareness campaigns in the area to control the traditional disposal, exposure to e-waste toxic substances and reduce negative impacts resulting from the exposure or pollution. This can be done by deliberate allocation of funds to the JCC to manage e-waste as well as engaging partners in the civil and private sectors to support technically and with resources (finances and tools/materials) they can afford to boost performance of the Block Council in delivering on e-waste management in the area.

DISCUSSIONS

In consideration of the experimentation of e-waste exposure, there is a positive relationship between e-waste generation and impacts and management systems including policies, regulations, disposal practices, job creation, income generation, health ad environmental damages among others. When it comes to e-waste disposal, there is a strong relationship with equipment type, its lifetime, technology and model, level of education of user, average income of user, awareness etc.

The e-waste generation has beed influenced by a number of determining variables (factors) including level of education, per capita income, technology etc.

WEEE disposal = $El_t + Y_t + nT_t + ndM + Ur_t + + eC + eLav_t + e_t$

Where:

El = Education level

Y = Per capita Income level

nT = new Technology emergence

ndM = new device Model

Ur = Unemployment rate\ ` ` `

eC = equipment Cost

eLav = Average Lifespan of equipment

e = Error term (other constant variables)

t = time period

In a nutshell, there is a combined positive effect of effective e-waste management on environmental conservation and economic performance. With the help of the Integrated Economic Impacts Model (IEIM) conceptual framework, the data presented shows both positive and negative impacts of e-waste which can be attributed to several factors including toxic substances contained in the e-waste. With the growing generation of e-waste and traditional disposal (coupled with poor economic conditions, vulnerable people including children and women including elderly are at high risk of infections from e-

waste as they engage in collection and resale of e-waste materials. The low literacy rate and low awareness and education on e-waste contributed to increasing e-waste generation as many people do not value device benefit compared to costs but interested on new models regardless of costs, others do not bother to repair in case of fault or malfunction and go for a new one. The e-waste produced can be disposed of in landfills, be dumped, and be repaired for reuse or recycled (formally and informally), however, the informal practices are more prevalent that formal processes. It should be noted that associated financial costs on e-waste management by individuals and organizations in the area are combined in a sense that it includes costs on collection of other solid wastes in the area. There are no mechanisms in place to segregate e-waste from other wastes to establish volumes generated and associated costs on handling.

The highest environmental and human health impact is by direct disposal in surrounding bushes or landfills and burning the WEEE which exposes people and environment (ecosystem) to harm and contributing to global warming i.e. if they are burnt often into the air, it emits hydrocarbon in to the atmosphere which pollute the air, "hydrocarbons can contribute to the greenhouse gas effect, which many scientists thing is a leading contributor to global warming" (Tom Musili, 2022). Recycling and refurbishing including incineration are good management mechanisms which falls under the tertiary intervention (downstream sector), which are the responses to already a problem i.e. growing e-waste generation which in this case is traditionally practiced by informal players in the private sector. Informal refurbishing recovers some material with highly considerable impact in the area as some of the remains are either returned to owners, burnt within the premise or disposed together with normal solid waste in the area. Therefore, despite high exposure to informal players and disposal at surroundings of Kator Payam, formal recycling and establishment of e-waste centers are recommendable because these facilities are designed to "safeguard occupational and environmental health" (Ceballos & Dong 2016). More formal recycling facilities are needed to be established and "automation" is required in the formal recycling practices to protect workers and the environment (Julander et al. 2014) and ensure efficiency and effectiveness of the processes from e-waste collection to disposal.

However, focusing on the downstream sector or the tertiary intervention by establishing and or improving formal recycling centers or facilities shall be a short-term solutions to e-waste adverse impacts in the area. It simply does not stop the increasing e-waste generation as consumers of EEE continuous to ignorantly use and dispose these equipment with less knowledge on its impacts, but considering the upstream sectors including the primary and secondary responses shall yield a better solution to the growing e-waste in the area. Measures that help reduce the consequence of high EEE acquisition and consumption, especially of imported used products or low and outdated quality products regardless being new or recondition including awareness initiatives on e-waste, can reduce the e-waste generation levels. Policy and regulations including law on e-waste and its enforcement is a primary tool for effective management, while public education and awareness on on e-waste among others are essential tools in controlling negative impacts of e-waste on society and the ecosystem (environment) and reducing WEEE generation.

CONCLUSION

E-waste could be a danger or economic opportunity to the society. It has got both positive and negative socioeconomic impacts including jobs creation in the collection, sorting, recycling and disposal processes, income generation from resale of restored devices etc and damaging of environment including soil, air and water by its toxic substances that are lifeline for animals, humans and plants causing health problems, loss of crop yield, poverty, displacement (resulting from unproductive land) including high costs on

treatment of diseases like lung cancer, respiratory issues etc caused by exposure to the toxicants, disintegration of family especially children who end-up in streets collecting e-waste to make living and left home.

RECOMMENDATIONS

- First, there is an urgent need to establish "an e-waste cantonment Hub" at the national level to ensure all e-waste generated from all States and Administrative Areas of South Sudan including Kator Payam is collected and delivered to the main e-waste hub for further segregation and management. Similarly, each county including the JCC and Payams including the Kator Payam Council needs to establish "an e-waste center" within their jurisdictions to help households and businesses dispose of WEEE at these centers for further collection and delivery to the "national e-waste Hub".
- Kator Payam Administration need to establish formal recycling facilities for most common e-waste generated in the country that can be put up at the capacity of Kator Payam Council or the JCC including developing infrastructure that shall allow effective sorting, processing, and recycling of reusable EEE that are almost considered e-waste.
- Provide support to informal repubishers by incentivizing their operation by either low taxes and license fee to enable them grow and formalize their operations and integration into formal sector, increase creation of green jobs, and enforcing regulations while eliminating practices which are harmful to human and environmental health.
- Reduce e-waste collection charges or introduce routine free e-waste collectors to promote willingness to dispose e-waste to designated facilities/containers without being thrown away or burnt to lessen quantity highly chargeable by collectors.
- Control e-waste generation by regulating importation of used EEE and establishing organized management systems and structures aided or led by private sector. Reducing e-waste generation from first entry into country or manufacture of products enables users to enjoy long lifetime or the product, save unnecessary costs associated with repairs, waste collection, transportation, and disposal in landfills and those associated with its adverse impacts such as infections and treatment costs.
- Public Awareness and Education: intensify public awareness campaigns and education initiatives on e-waste to educate residents of Kator payam about the importance of responsible and accounTable waste management practices, e-waste reduction, and the benefits of recycling. This has to be done through the conduct of periodic workshops, seminars, and school programs to raise awareness and engage the community. Example: The "keep Juba clean campaigns" by the JCC with occasional participation of many organizations including UN Agencies, UN forces, Youth Unions etc" raised awareness about proper waste disposal and sanitation through public exercises on waste collection with help of mass media. This is critical for Kator Payam considering the limited knowledge and involvement of the public, including households and individuals and stakeholders in the proper disposal and management of e-waste in the area.
- Community Participation and Engagement: Involve the community (area leaders, youth leaders, women representatives, disabled groups etc) in waste management decision-making processes and encourage active participation in e-waste management initiatives. This can be done by establishing community-led e-waste management committees that shall be trained, provided tools and incentivised to engage in e-waste collection, sorting and other relevant activities.

- Monitoring and Evaluation of level of e-waste exposure and disposal practices in the area i.e. establish a comprehensive monitoring and evaluation framework that can assess the effectiveness of waste management strategies, track progress, and identify areas for improvement. Periodically monitor waste management indicators such as waste diversion rates, recycling rates, and landfill volumes, disposal trends, etc to improve on e-waste management practices, reduce environmental pollution, promote resource recovery, and create a cleaner and healthier living environment for Kator Payam residents.
- Ensuring e-waste regulations and or legislation account manufacturers and importers of EEE or quality of supply products that are recyclable and provide for collection and disposal standards, systems and finances to make them accounTable and responsible in the entire life-cycle of the EEE products from production to disposal mechanisms in mind learning from the Chinese approach (Schnoor, JL et al., 2016). While establishing and enforcing e-waste disposal procedures for the public.
- Improved e-waste collection practices by the Kator Payam Council by enhancing the waste collection systems through establishing collection points or e-waste cantonment sites in key locations, ensuring regular and reliable collection schedules, and employing appropriately designed e-waste collection vehicles. This will help improve e-waste collection efficiency and prevent illegal dumping and exposure to toxic substances.
- Strengthening Institutional Capacity i.e. Building the capacity of waste management agencies and government institutions responsible for waste management including the environment management department of Kator Payam Council through training programs, technical support, and study-tour initiatives to neighboring countries to get exposed to practical skills on e-waste management.
- Distribute and ensure access to disposal containers by opening up roads, improving health sector capacity to manage and prevent potential risks (health issues) caused by e-waste exposure as well as facilitate monitoring of children and other vulnerable people exposure to e-waste and intervene to protect public health.
- Promote Public-Private Partnerships on e-waste management i.e. the local government or JCC including Kator Payam Council need to engage the private sector including academia closely through partnership agreements or MoUs to leverage their expertise, resources, and investment in e-waste management. Encourage collaboration with waste management companies, recycling enterprises, Universities and other relevant organizations to enhance workable e-waste management practices to Kator Payam condition.
- Ensure all organizations operating within jurisdiction of JCC including Kator Payam establish e-waste policies respectively in compliance with established legislation or regulations of the local government to provide for consistency and effective coordination on e-waste management.
- Implementation of e-waste sorting or segregation from generation and disposal pointe by educating residents on the importance of separating recyclable and non-recyclable e-waste materials and or devices. If resources could support, provide households and businesses with separate waste bins or bags for easy segregation or partner with a firm to manufacture these bags or bins and make it mandatory for households and businesses to purchase at a low cost.
- Strictly ban burning of e-waste in residential areas and office premises to prevent absolute exposure to inhalation of chemical intoxicants contained in these WEEE which are severely harmful to human and animal lives causing respiratory issues including cancer among other dangers.
- Promote re-export of WEEE by engaging foreign recycling facilities (especially in the region e.g. Kenya) or manufacturers and re-export e-waste for recycling if the option of establishing large and

complex recycling facilities could not be afforded by the JCC or investors are not willing to establish one in the country. This could be a better and immediate viable approach to managing e-waste effectively. Such re-exported WEEE can be re-imported once rehabilitated or reproduced into new products at a low cost depending on agreements established with the recycling firm or manufacturer.

- Establishing and or improving legal and regulatory frameworks by developing new or enhance the existing waste management or environmental protection legislation to comprehensively cover e-waste management regulations and policies that addresses e-waste collection, sorting, recycling, and disposal approaches. This frameworks should be developed in an inclusive space where stakeholders including public, interest groups, community and organizations including private sector participate. Later, after development of these policy and legal frameworks or regulations, the Kator Payam must enforce compliance with through regular monitoring and penalties for non-compliance.
- Ratification or adoption of protocols from international treaties such as the Basel Convention on controls the trans-boundary movement of hazardous wastes and their disposal, the Bamako Treaty and Waigani Convention to limit the movement of hazardous wastes, including e-waste in South Sudan to reduce influx of e-waste in the study area.
- Prosecution of punishment of defaulters of regulations and standards on controls of e-waste especially importation of sub-standard and or obsolete EEE into the country, unregulated e-waste disposal practices among others so that the policy or regulations are complied to by users and businesses including organizations.
- Introducing extra tax on EEE that has got adverse environmental impacts after its lifetime and whose disposal into the soil, water and or air is harmful and expensive to manage. This is what Ghana legislators did to generate more revenues from the taxes to finance environmental management.
- Establishing community and market committees who are e-waste collectors and incentivize their work as well as provide the necessary capacity-building and tools/materials to be able to do the job effectively with dedication.
- Ensure any organization including UN Agencies, Foreign Embassies and large companies wanting to dispose EEE secure clearance from the respective entities such as the National Communication Authority (on ICT equipment), Electricity Ministry (on electrical equipment) etc. This shall regulate out-floor of e-waste into open and unregulated spaces resulting from auctioning of WEEE and EEE whose useful time is less than 6 months or so (depending on disposal procedures or regulations), and those that are already obsolete in terms of technology or efficiency, radiation effect etc regardless of being new or functional.
- There is a greater opportunity in creating jobs and improving livelihoods from e-waste. Local authorities including Kator Payam Council need to grab the space by lobbying for finances to establish the e-waste centers, employ youth and later earn incomes from PIT either of the employees or licence fees from firms engaged in e-waste management business such as refurbishing, recycling and resale including reexporting of e-waste.

Further Research

Further research needs to be conducted to investigate the volume of e-waste generated and disposed by the local authorities and the monetary expenditure or costs on management in Kator Payam. The data gathered from literature are generic on waste generation not particular on e-waste, yet, relevant institutions are unsure (due to lack of proper records) and unwilling to release such information, therefore, are not

sufficient enough to predict or draw on the potential expenditures on e-waste management in Kator Payam and Juba city in general.

REFERENCES:

1. Abid, M, Zulfiqar, F & Raza, M 2019, 'Managing electronic waste pollution: policy options and challenges', in MZ Hashmi & A Varma (eds), Electronic Waste Pollution: Environmental Occurrence and Treatment Technologies, Springer International Publishing, Cham, pp. 329-45, DOI 10.1007/978-3030-26615-8_21, <https://doi.org/10.1007/978-3-030-26615-8_21>.
2. Atanassov, N., & Chowdhury, M. M. (2021, May). Mobile device threat: Malware. In 2021 IEEE International Conference on Electro Information Technology (EIT) (pp. 007-013). IEEE.
3. Agwanda, B., & Asal, U. Y. (2020). State fragility and post-conflict state-building: An analysis of South Sudan Conflict (2013-2019). Güvenlik Bilimleri Dergisi, 9(1), 125-146.
4. Abdullatif Sleibi. (2023). HSS 2022: Data summary from Central Equatoria State, South Sudan. https://protectionofcivilians.org/infographic/hss-2022-data-summary-from-central-equatoria-state-south-sudan/
5. Antony, S., Reshmy, R., Sindhu, R., Binod, P., & Pandey, A. (2020). Possible Strategies for Hazardous Waste Management and Legality.
6. Andeobu, L., Wibowo, S., & Grandhi, S. (2023). Informal E-waste recycling practices and environmental pollution in Africa: What is the way forward?. International journal of hygiene and environmental health, 252, 114192.
7. Avis, W. (2022). Responsible E-Waste Value Chains in Africa.
8. Avis, W. (2021). Drivers, barriers and opportunities of e-waste management in Africa (No. 1074). K4D Helpdesk Report.
9. Budnard, J., & Khaodhiar, S. (2022). Estimating the Generation of Discarded Mobile Phones and Highlighting Areas for Recycling Precious Metals from Printed Circuit Boards in Thailand. Sustainability, 14(24), 17025.
10. Baldé, et al., (2024). The global e-waste monitor. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna, 1-109.
11. Baldé, CP, Forti, V, Gray, V, Kuehr, R & Stegmann, P. (2017). The global e-waste monitor 2017:
12. quantities, flows, and resources, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna.
13. Baldé, CP, Wang, F & Kuehr, R. (2016) Transboundary movements of used and waste electronic and electrical equipment, United Nations University, Vice Rectorate in Europe – Sustainable Cycles Programme (SCYCLE), Bonn, Germany.
14. Baldé, CP, Wang, F, Kuehr, R & Huisman, J. (2015). The global e-waste monitor – 2014, United Nations University, IAS – SCYCLE, Tokyo, Japan & Bonn, Germany.
15. Bimir, M. N. (2020). Revisiting e-waste management practices in selected African countries. Journal of the Air & Waste Management Association, 70(7), 659-669.
16. Cao, J, Lu, B, Chen, Y, Zhang, X, Zhai, G, Zhou, G, Jiang, B & Schnoor, JL 2016, 'Extended producer responsibility system in China improves e-waste recycling: government policies, enterprise, and public awareness', Renewable and Sustainable Energy Reviews, vol. 62, no. Supplement C, pp. 882-94

17. De Marchi, A. (2013). Burundi.
18. EACO. (2022). Regional E-waste Management Strategy 2022 – 2027
19. Faga, E., Reynolds, J. L., & Jafroudi, M. M. (2016). The Transboundary Movement of Hazardous Wastes: a Comparison between the Basel and the Bamako Conventions. International and European Law thesis, Tilburg University.
20. Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The global e-waste monitor 2020. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam, 120.
21. Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The global e-waste monitor 2020. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam, 120.
22. Gómez, M., Grimes, S., Qian, Y., Feng, Y., & Fowler, G. (2023). Critical and strategic metals in mobile phones: A detailed characterisation of multigenerational waste mobile phones and the economic drivers for recovery of metal value. Journal of Cleaner Production, 419, 138099.
23. Guibrunet, L (2019). 'What is “informal” in informal waste management? Insights from the case of waste collection in the Tepito neighbourhood, Mexico City', Waste Management, vol. 86, pp. 13-22.
24. Haseena, M., Malik, M. F., Javed, A., Arshad, S., Asif, N., Zulfiqar, S., & Hanif, J. (2017). Water pollution and human health. Environmental Risk Assessment and Remediation, 1(3).
25. Honda, S, Khetriwal, DS & Kuehr, R 2016, Regional e-waste monitor: east and southeast Asia, United Nations University, ViE – SCYCLE, Bonn, Germany.
26. Huang, C-L, Bao, L-J, Luo, P, Wang, Z-Y, Li, S-M & Zeng, EY. (2016). 'Potential health risk for residents around a typical e-waste recycling zone via inhalation of size-fractionated particle-bound heavy metals', Journal of Hazardous Materials, vol. 317, pp. 449-56.
27. Haghani, M, Shabani, M & Moazzami, K 2013, 'Maternal mobile phone exposure adversely affects the electrophysiological properties of Purkinje neurons in rat offspring', Neuroscience, vol. 250, pp. 588-98.
28. Into force Secretariat, O. E. (2013). Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region (Waigani Convention). In Yearbook of International Cooperation on Environment and Development 1999-2000 (pp. 119-120). Routledge.
29. Ilankoon, IMSK, Ghorbani, Y, Chong, MN, Herath, G, Moyo, T & Petersen, J 2018, 'E-waste in the international context – a review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery', Waste Management, vol. 82, pp. 258-75.
30. International Labour Organization. (202). Child labour: global estimates 2020, trends and the road forward. Geneva. https://www.ilo.org/ipec/ChildlabourstatisticsSIMPOC/lang--en/index.htm.
31. International Labour Organization. (2014). Tackling informality in e-waste management: the potential of cooperative enterprises. Geneva. https://www.ilo.org/sector/Resources/publications/WCMS_315228/lang--en/index.htm
32. International Telecommunication Union (ITU) and United Nations Institute for Research and Training Sustainable SCYCLE Programme (UNITARSCYCLE). Towards the Harmonization of Data Collection – A Baseline Study for E-waste in Africa. Geneva/Bonn 2023.
33. Juba City Council. (2019). Strategic Plan for the Development of Juba City 2019-2023
34. JICA. (2021). Solid Waste Management Master Plan in Juba City 2021-2030

35. JICA .(2019). Report."Data collection survey on solid waste management in Juba".
36. Khan, MU, Besis, A & Malik, RN. (2019). 'Environmental and health effects: exposure to e-waste pollution', in MZ Hashmi & A Varma (eds), Electronic Waste Pollution: Environmental Occurrence and Treatment Technologies, Springer International Publishing, Cham, pp. 111-37, DOI 10.1007/978-3-03026615-8_8, <https://doi.org/10.1007/978-3-030-26615-8_8>.
37. Kulsoom, M., Shukla, V., & Kumar, N. (2021). International Legislation for Containment of Persistent Organic Pollutants and Hazardous Chemicals. In Persistent Organic Pollutants in the Environment (pp. 319-338). CRC Press.
38. Ladu, John & Athiba, Andrew & Lako, Stanislaus & Lomoro, Moses. (2018). Investigation on the Impact of Water Pollution on Human Health in Juba County, Republic of South Sudan. Journal of Environment Pollution and Human Health. 6. 89-95. 10.12691/jephh-6-3-2.
39. Lebbie, T. S., Moyebi, O. D., Asante, K. A., Fobil, J., Brune-Drisse, M. N., Suk, W. A., ... & Carpenter, D. O. (2021). E-waste in Africa: a serious threat to the health of children. International Journal of Environmental Research and Public Health, 18(16), 8488.
40. Lebbie, T. S., Moyebi, O. D., Asante, K. A., Fobil, J., Brune-Drisse, M. N., Suk, W. A., ... & Carpenter, D. O. (2021). E-waste in Africa: a serious threat to the health of children. International Journal of Environmental Research and Public Health, 18(16), 8488.
41. Maphosa, V., & Maphosa, M. (2020). E-waste management in Sub-Saharan Africa: A systematic literature review. Cogent Business & Management, 7(1), 1814503.
42. Martin, R., Mwakatoga, J. D., Madaha, R. M., Babili, I. H., Kibonde, S. F., & Sanga, C. A. (2023). Exploring Electronic Waste Situation in Africa: A review. Journal of Applied Sciences and Environmental Management, 27(12), 2743-2750.
43. Moyen Massa, G., & Archodoulaki, V. M. (2023). Electrical and electronic waste management problems in Africa: Deficits and solution approach. Environments, 10(3), 44.
44. Maes, T., & Preston-Whyte, F. (2022). E-waste it wisely: lessons from Africa. SN Applied Sciences, 4(3), 72.
45. Moyen Massa, G., & Archodoulaki, V. M. (2023). Electrical and electronic waste management problems in Africa: Deficits and solution approach. Environments, 10(3), 44.
46. Moses, M. (2022). admission of Democratic Republic of Congo (DRC) in the East African Community (EAC): are there opportunities for Kenya?. International Journal of Innovative Technologies in Social Science, (3 (35)).
47. Murthy, V., & Ramakrishna, S. (2022). A review on global E-waste management: urban mining towards a sustainable future and circular economy. Sustainability, 14(2), 647.
48. Makando, D. D., & Muguba, S. E. (2023). The Plastic Waste And its Management in Tanzania: A Case of Arusha Municipality. The Accountancy and Business Review, 15(1), 43-54.
49. Ministry of Information and Communications Technology (2016), Guidelines for EWaste Management in Uganda, published by UNDP.
50. National Information Technology Authority Uganda (2016), National Information Technology Authority 2016 Statistical Abstract. Published by National Information Technology Authority-Uganda (NITA-U)
51. NBS. (2023). South Sudan Population Projections, 2020-2024
52. Nelson, N., Dongjie, N., Mwamlima, P., & Mwitalemi, S. Assessment of Dealers' Contribution in Current and Future E-waste Management Trends Within Dar es Salaam, Tanzania.

53. National Bureau of Statistics and United Nations University, ViE – SCYCLE. (2019). National E-Waste Statistics Report 2019. National Bureau Statistics, Dodoma, Tanzania, United Nations University, ViE – SCYCLE, Bonn, Germany.
54. Otieno, I., & Omwenga, E. (2015). E-waste management in Kenya: challenges and opportunities. Journal of Emerging Trends in Computing and Information Sciences, 6(12), 661-666.
55. Pahari, A. K., & Dubey, B. K. (2019). Waste from electrical and electronics equipment. In Plastics to Energy (pp. 443-468). William Andrew Publishing.
56. Prabhu N, S., & Majhi, R. (2023). Disposal of obsolete mobile phones: A review on replacement, disposal methods, in-use lifespan, reuse and recycling. Waste Management & Research, 41(1), 18-36.
57. Soetrisno, FN & Delgado-Saborit, JM. (2020). 'Chronic exposure to heavy metals from informal e-waste recycling plants and children's attention, executive function and academic performance', Science of the Total Environment, vol. 717, p. 137099.
58. Shahabuddin, M., Uddin, M. N., Chowdhury, J. I., Ahmed, S. F., Uddin, M. N., Mofijur, M., & Uddin, M. A. (2023). A review of the recent development, challenges, and opportunities of electronic waste (e-waste). International Journal of Environmental Science and Technology, 20(4), 4513-4520.
59. Sakhuja, D., Ghai, H., Bhatia, R. K., & Bhatt, A. K. (2022). Management of e-Waste: technological challenges and opportunities. Handbook of Solid Waste Management: Sustainability through Circular Economy, 1523-1557.
60. Shi, L., Liu, J., Wang, Y., & Chiu, A. (2021). Cleaner production progress in developing and transition countries. Journal of Cleaner Production, 278, 123763.
61. Tocho, J. A., & Waema, T. M. (2013). Towards an e-waste management framework in Kenya. Info-The journal of policy, regulation and strategy for telecommunications, 15(5), 99-113.
62. Tom Musili. (2022). e-Waste. Electronic Waste Explained. Bluemark Holdings Limited
63. Thakur, P., & Kumar, S. (2022). Evaluation of e-waste status, management strategies, and legislations. International Journal of Environmental Science and Technology, 19(7), 6957-6966.
64. Twagirayezu, G., Irumva, O., Uwimana, A., Nizeyimana, J. C., & Nkundabose, J. P. (2021). Current status of e-waste and future perspective in developing countries: Benchmark Rwanda. Energy and Environmental Engineering, 8(1), 1-12.
65. Tanveer, M., Khan, S. A. R., Umar, M., Yu, Z., Sajid, M. J., & Haq, I. U. (2022). Waste management and green technology: future trends in circular economy leading towards environmental sustainability. Environmental Science and Pollution Research, 29(53), 80161-80178.
66. UNITARSCYCLE. (2022). E-waste management in East Africa. Retrieved from (Eastern-africa - 2022 - E-waste statistics (globalewaste.org)
67. United Nations Environment Programme (UNEP). (2018). Solid Waste Management in Juba.
68. UN-Habitat. (2023). Juba Strategic Plan
69. Wu, Q, Leung, JYS, Geng, X, Chen, S, Huang, X, Li, H, Huang, Z, Zhu, L, Chen, J & Lu, Y 2015, 'Heavy metal contamination of soil and water in the vicinity of an abandoned e-waste recycling site: Implications for dissemination of heavy metals', Science of the Total Environment, vol. 506-507, pp. 21725.
70. Xu, C., Zhang, W., He, W., Li, G., & Huang, J. (2016). The situation of waste mobile phone management in developed countries and development status in China. Waste management, 58, 341-347.
71. Zhuang, X. (2019). Chemical Hazards Associated With Treatment of Waste Electrical and Electronic

Equipment. In Electronic waste management and treatment technology (pp. 311-334). Butterworth-Heinemann.