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Development Sector

National E-waste Monitor

Botswana

2024

STATISTICS BOTSWANA

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United Nations Institute for Training and Research
Sustainable Cycles (SCYCLE) Programme

ITU

National E-waste Monitor

Botswana

2024

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General disclaimers

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Foreword

We are pleased to present the first national publication about e-waste in Botswana, representing a positive stride towards developing sustained e-waste monitoring for the country.

This publication is expected to catalyse discussion on e-waste management and infrastructure development around e-waste in the country. It also aims to raise awareness regarding the quantities of e-waste generated as a result of electrical and electronic equipment placed on the market, as well as possible negative impacts on the environment and human health. Simultaneously, this publication highlights the benefits of adopting a circular economy within the e-waste sector.

As a next step, it is also envisaged that Statistics Botswana will build a national database to be updated on an annual basis.

To this end, considerable effort will be dedicated by Statistics Botswana to engage with various stakeholders to expand knowledge through research and surveys, while also leveraging existing surveys and censuses.

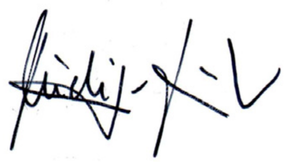
The use of international definitions and methodology in this National E-waste Monitor allows for international context and comparability. In addition, it is acknowledged that this Monitor has identified data gaps that need attention and improvement to enhance e-waste data in Botswana.

Building on the partnership on measuring ICT for development, in 2017, the International Telecommunication Union (ITU) and the United Nations Institute for Training and Research (UNITAR), joined forces to create the Global E-waste Statistics Partnership as a way of addressing the challenges associated with managing e-waste. The partnership helps countries enhance their understanding and interpretation of e-waste data and improve the quality of e-waste statistics by guiding stakeholders and building capacity through e-waste statistics trainings. All data is made publicly available via its open-source global e-waste database, www.globalewaste.org. Since its creation, the partnership has made substantial efforts by expanding national and regional capacity on e-waste statistics in various countries.

Timely, accurate, and relevant statistics are key to monitor e-waste management and guide policy on generation, collection and disposal of e-waste.

The collaboration among the partners in producing this report has been pivotal and we look forward to the continued partnership. We trust that users will find this publication informative and valuable for monitoring and decision making on this significant environmental issue.

Dr Cosmas Luckyson Zavazava
Director Telecommunication Development Bureau,
International Telecommunication Union (ITU)



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Executive summary

This report examines the overall statistics of electronic and electrical equipment (EEE) placed on the market (POM) and e-waste generation in Botswana. The main findings indicate that 21 097 tonnes of EEE were placed on the market in Botswana in 2020 generated by demand from households and businesses. In 2020, 13 494 tonnes of EEE became e-waste. The highest EEE POM recorded in the last 20 years rose to 24 742 tonnes in 2011. This may be attributed to a boom in construction and refurbishment of sporting facilities ignited by the 2010 World Cup hosted by neighbouring South Africa. In contrast, 2002 had the lowest recorded level of EEE POM. The main reason for the dip in this year is not yet known but it should be highlighted that the year 2002 saw the introduction of the use of the local Pula (BWP) currency from the previous South African Rand (ZAR) currency. The temperature exchange equipment category had the highest share for both POM and E-waste.

POM was calculated from imports and exports trade data on EEE, excluding domestic production as such data was not readily available. In the future, other waste flows should be included in calculations (e.g. amount of e-waste collected) to enable an assessment of the national collection rate e.g. through consulting e-waste collection and recycling actors in the country.

Once discarded, an EEE product becomes e-waste and due to the weak waste management infrastructure in Botswana, this e-waste ends up with the municipal solid waste or is collected by the informal sector. It is very likely that most of the e-waste is not managed in an environmentally sound manner. This poses a risk to the environment and to the safety of workers, as e-waste contains hazardous materials that need to be separately and adequately managed.

The statistical data can be used to support e-waste management, such as planning the number and the capacity of e-waste collection points and e-waste pre-treatment facilities, and the setting of national collection targets to ensure that all e-waste will be properly managed. The statistical data can also be used for international reporting such for indicator 12.4.2 on hazardous waste management and for indicator 12.5.1 on national recycling rates under Sustainable Development Goal 12 on sustainable consumption and production, both of which contain sub-indicators for e-waste.

Abbreviations and acronyms

EEE	Electrical and electronic equipment
EEE POM	Electrical and electronic equipment placed on the market
ESM	Environmentally sound management
EU	European Union
e-waste	Electronic waste
ICT	Information and communication technology
kg/inh	kilograms per inhabitant
ITU	International Telecommunication Union
kt	(metric) kiloton, or 1 million kilograms
Mt	(metric) megaton, or 1 billion kilograms
POM	placed on the market
SCYCLE	Sustainable cycles programme
SDGs	Sustainable Development Goals
t	(metric) ton, or 1 000 kilograms
UNITAR	United Nations Institute for Training and Research
UNU-VIE	United Nations University Vice-Rectorate in Europe
UNU-KEY	product-based classification distinguishing 54 products, used to measure e-waste statistics
WEEE	waste electrical and electronic equipment

1 Introduction

1.1 Background to the report

Technical capacity building was requested for the assessment of baseline data on volumes of e-waste generated, including types, routes and flows as Botswana lacked the capacity to monitor e-waste quantities. This makes the e-waste problem largely unknown and hampers the setting and assessment of targets in transitioning to a more sustainable and circular economy.

The project was positively welcomed and supported by the Botswana Communication Regulatory Authority (BOCRA), Statistics Botswana, and the Ministry of Environment, Natural Resource Conservation and Tourism. A capacity building workshop was held in May 2021 and was attended by stakeholder groups from BOCRA, Statistics Botswana, Botswana Unified Revenue Service, Ministry of Environment, Natural Resources Conservation and Tourism and Ministry of Local Government and Rural Development. The capacity building workshop was conducted by UNITAR Sustainable Cycles Programme (SCYCLE) and ITU, with the purpose of training the participants on UNITAR methodology for e-waste quantification, and on the main e-waste statistics indicators. The workshop was delivered in cooperation with the Ugandan Statistics Office, allowing for experiences in conducting national e-waste quantitative assessments to be shared.

The present report summarizes the outcomes obtained from the application of the international framework to measure e-waste statistics, and from the use of the e-waste tools delivered by SCYCLE. Quantifying e-waste stocks and flows in a country helps to identify best practices in policies, to set and evaluate appropriate targets, develop better management programs, achieve some of the SDGs, and assess progress over time.

The development of a National E-waste Monitor for Botswana constitutes the first step of this process and will ensure an updated baseline where to start improving the capacity of the country in effectively managing the sector. Comprehensive collection of e-waste data provides a basis for Botswana to implement policies, recycling infrastructure, and regulatory instruments more efficiently. In addition, data will help Botswana set their own national targets for e-waste collection and recycling.

The International Telecommunication Union (ITU) is also providing technical assistance to Botswana in the development of national strategy on the management of e-waste.

1.2 What is EEE and e-waste

Electric and Electronic Equipment (EEE) is dependent on electric currents or electromagnetic fields in order to function, and equipment for the generation, transfer and measurements of such currents and fields. The production and use of EEE continues to rise significantly worldwide due to a rapid increase in the adoption of information and communication technology and its incorporation into other products. As individuals accumulate multiple sets of mobile phones, accessories, television sets, radios, computers, printers, and various other devices, the amount of outdated and end-of-life equipment in the economy increases, resulting in a larger pool of equipment that can be collected and recycled. This is leading to an increase in the amount of waste electrical and electronic equipment (WEEE).

Also known as e-waste, WEEE is all items of EEE and its parts which are discarded as waste without the intent of re-use. Currently, there is inadequate handling, recycling and disposal of e-waste in Botswana, which is leading to challenges in the adoption of a circular economy for EEE.

1.3 E-waste classification

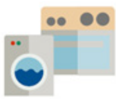
Electric and electronic equipment (EEE) and e-waste can be classified according to several possible systems. For statistical purposes, however, in this report EEE will be classified following the internationally accepted and adopted UNU-KEYs system, which consists of 54 different product-centric categories, and it is described in the *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition*[1]. The UNU-KEYs group the EEE by similar function, comparable material composition, average weight, and similar end-of-life attributes. The full list of UNU-KEYs can be viewed in Annex A of this report.

The 54 EEE product categories are then grouped into six general categories that correspond closely to their waste management characteristics. The six categories are:

I  **Temperature exchange equipment**, including refrigerators, freezers, air conditioners and heat pumps.

II  **Screens and monitors**, comprising liquid crystal displays (LCDs) and light-emitting diodes (LEDs) used in televisions, monitors, laptops and tablets.

III  **Lamps**, including LED lamps, high intensity discharge lamps, compact fluorescent lamps and straight tube fluorescent lamps.

IV  **Large equipment**, including dishwashers, washing machines, ovens, central heating systems, large printing systems and photovoltaic panels.

V  **Small equipment**, comprising microwaves, grills, toasters, personal care products, speakers, cameras, audio sets, headphones, toys, household tools, medical equipment and monitoring systems.

VI 

Small information technology (IT) and telecommunication equipment, including desktop personal computers, printers, mobile telephones, cordless telephones, keyboards, routers and consoles.

Currently, the six categories of classification is compliant with both the EU Directive 2012/19/EU on waste electrical and electronic equipment, known as the WEEE Directive, and the internationally recognized framework for e waste statistics described in *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition*.

[1] http://collections.unu.edu/eserv/UNU:6477/RZ_EWaste_Guidelines_LoRes.pdf

1.4 E-waste: rising quantities, issues and opportunities

First initiated by SCYCLE in 2014, three *Global E-waste Monitors* (GEMs) have been published thus far (2014, 2017, and 2020). The GEMs introduce the wider public to the global e-waste challenge, explaining how it currently fits into international efforts to reach UN Sustainable Development Goals (SDGs) and discussing how to create a circular economy and sustainable societies. In 2017, the Global E-waste Statistics Partnership (GESP), funded by the International Telecommunication Union (ITU), SCYCLE, and the International Solid Waste Association (ISWA), co-published the *Global E-waste Monitor 2017* which, in its third edition (2020), shows a continued global growth in the generation of e-waste.

The *Global E-waste Monitor 2020* highlighted that a record 53.6 million metric tonnes (Mt) of e-waste was generated in 2019, equal to 7.3 kg/inh, up by 21 per cent since 2014. Out of this amount, only 17.4% (9.3 Mt) is documented to be collected and recycled. It has been estimated that e-waste is increasing at an alarming rate of almost 2 Mt per year and will increase 74.7 Mt by 2030. These quantities show that the management and recycling of e-waste is not keeping pace with the global growth of the sector. Along with that, the majority of the e-waste generated in 2019 (82.6%, 44.3 Mt) has an undocumented fate outside the official system, and it is either dumped, recycled with substandard techniques, traded (also illegally) or mixed with the other municipal waste.

For Africa in 2019, the *Global E-waste Monitor 2020* estimated that 2.9 Mt (2.5 kg/inh) of e-waste was generated and only 0.03 Mt (0.9%) was documented to be collected and properly recycled.[2] Currently, limited information is available on the amount of e-waste collected and recycled by the formal sector in Africa, and therefore that figure could also be only partially representative.

Managing e-waste requires specific legislation and collection infrastructure. In general, e-waste is, unfortunately, poorly regulated and enforced at a global level. In fact, less than half of all counties (78 out of 193) is currently covered by a legislation, policy or regulation on e-waste. In addition, in most cases, policies are neither legally binding nor appropriately supported financially, which reduces the likelihood of ensuring their implementation and compliance. In Africa, only a handful of countries have enacted e-waste specific policies and legislation. Recycling activities are dominated by the informal sectors, with related inefficient resources recovery and environmental and health problems[3].

In many countries globally, including Botswana, e-waste statistics are not maintained, and the flows are not systematically monitored. At present, only 21% of countries (41 out of 193) collect data about indicators such as e-waste generation and collection, and this clearly results as a global gap in the quantification of waste arising from discarded EEE, ICT products and other electronics. To improve data collection, there is a need to improve the quality and quantity of municipal data, further build capacity and data infrastructure, and improve collaboration and coordination between key institutions.

E-waste also contains hazardous substances and the improper management, including inadequacies in recycling and disposing of, can result not only as loss of valuable content, but also as potential hazards to human health and to the environment in Botswana. EEE and e-waste contain, for instance, heavy metals (e.g. cadmium and mercury), chlorofluorocarbons, and flame retardants. Great care must be taken to prevent unsafe exposure of the workers during

2 https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf
3 https://www.nbs.go.tz/nbs/takwimu/Environment/EWASTE-REPORT-TZ-2019.pdf

treatment and recycling operations, and to prevent contamination and pollution problems for the environment for instance from landfills leaches or incineration ashes.

Currently there is little clarity nor direction on the valorisation process and the actual recycling of valuable waste fractions in Botswana. A similar lack of clarity and understanding also applies to the management of non-valuable and potentially hazardous waste fractions, which results in the poor disposal of toxic waste. Therefore, there is a need in Botswana to handle such disposal of e-waste in a responsible manner and in line with emerging global best practices and standards.

The complexity of this waste stream and its cross-cutting nature, intersecting environmental policy, product policy and industrial policy necessitates a targeted and dedicated approach to e-waste management in Botswana.

1.5 E-waste and the Sustainable Development Goals

E-waste also constitutes an opportunity to move towards the achievement of the Sustainable Development Goals (SDGs). In 2015, United Nations member States adopted the 2030 Agenda for Sustainable Development. This included the 17 Sustainable Development Goals (SDGs) and 169 targets for ending poverty, protecting the planet and ensuring prosperity. Increasing levels of e-waste, improper and unsafe treatment, and disposal through incineration or in landfills pose significant challenges to the environment and human health, and to the achievement of the SGDs. A better understanding and more data on e-waste will contribute to measuring progress towards achievement of several SDGs. In particular, e-waste can contribute to SDG 11 "make cities and human settlement inclusive, safe, resilient and sustainable" and to SDG 12 "ensure sustainable consumption and production patterns". E-waste statistics are relevant for monitoring progress of SDG indicators 12.4.2 on "Treatment of waste, generation of hazardous waste, and hazardous waste management, by type of treatment" and 12.5.1 "National recycling rate and tons of material recycled (e-waste sub-indicator)".

Indicator 12.5.1 is defined as:

Equation 1

$$\textbf{\textit{Sub indicator}}\ \mathbf{12.5.1} = \frac{\textbf{Total e} - \textbf{waste recycled}}{\textbf{Total e} - \textbf{waste generated}}$$

The numerator is equivalent to the amount of e-waste which is collected as such by the formal system of a country, usually under the requirements of a national e-waste legislation. The final destination of this e-waste is in a treatment facility, where the valuable content is recovered in an environmentally responsible way. The denominator equates the amount of discarded EEE within a national territory, in a given reporting year, prior to any collection, reuse, treatment or export.

The custodian agencies of the indicator, the United Nations Environment Programme (UNEP) and the United Nation Statistics Division (UNSD), and UNITAR as co-custodian for delivering e-waste datasets, which are developed by SCYCLE, based on methodologies developed by Global E-waste Statistics Partnership, and the Partnership Measuring ICT for Development.

Next to the specific sub-indicator on e-waste, management of e-waste is closely linked to several other goals of the 2030 Agenda for Sustainable Development. In fact, health risks posed by inadequate disposal of e-waste include contamination of water sources, air, and soil, which harm people's health due to direct contact with harmful materials or inhalation of toxic fumes.

Moreover, dismantling processes that do not utilize adequate means, facilities, and trained personnel pose additional threats to people and the planet.

SDGs Goal	SDGs Targets
3 GOOD HEALTH AND WELL-BEING	Target 3.9 refers to the reduction of the number of deaths and illnesses caused by hazardous chemicals and air, water, and soil pollution and contamination.
6 CLEAN WATER AND SANITATION	Target 6.1 seeks to achieve universal and equitable access to safe and affordable drinking water for all; and Target 6.3 aims at reducing pollution, eliminate dumping, and minimize release of hazardous chemicals and materials.
8 DECENT WORK AND ECONOMIC GROWTH	Target 8.3 aims to promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity, and innovation, and to encourage the formalization and growth of micro, small, and medium-sized enterprises. Target 8.8 calls for the protection of labour rights and promotes safe and secure working environments for all workers, including migrant workers, particularly women migrants, and those in precarious employment. *The sound management of e-waste can create new employment and contribute to economic growth in the recycling and refurbishing sector. Now, e-waste is often processed in the informal sector, and many e-waste disposal and recycling jobs are unsafe and not protected by formal regulation (Brett et al. 2009; Leung, et al. 2008).* *It is therefore necessary to formalize the environmentally sound management of e-waste and to take advantage of the business opportunities it offers.*
11 SUSTAINABLE CITIES AND COMMUNITIES	Target 11.6 aims to reduce the adverse per capita environmental impact of cities, by paying special attention to air quality and to municipal and other waste management. *Since over half of the world's population lives in cities, rapid urbanization requires new solutions to address rising environmental and human health risks, especially in densely populated areas. Most e-waste will be generated in cities and it is particularly important to properly manage e-waste in urban areas, improve collection and recycling rates, and to reduce the amount of e-waste that ends up in dumpsites. The move towards smart cities and the use of ICTs for waste management offer new and exciting opportunities.*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Target 12.4 aims to achieve the environmentally sound management of chemicals and all waste throughout the life cycle, in accordance with agreed international frameworks, and to significantly reduce their release into air, water, and soil in order to minimize their adverse impacts on human health and the environment. Target 12.5 aims to substantially reduce waste generation through prevention, reduction, repair, recycling, and reuse. An increasing number of people on the planet are consuming growing amounts of goods, and it is critical to make production and consumption more sustainable by raising awareness levels of producers and consumers, specifically in the area of electrical and electronic equipment.

(continued)

SDGs Goal	SDGs Targets
	Target 14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Target 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

2 E-waste in the national context

2.1 E-waste policies and legislation in Botswana

The Department of Waste Management and Pollution Control under the Ministry of Environment, Natural Resources Conservation is the government entity that is mandated under the Waste Management Act (1998) to regulate the waste management sector in Botswana through policy formulation, to provide of technical guidelines, licensing of waste management facilities, waste carriers and generally coordinate sector activities and programmes. BOCRA also plays a critical regulatory role for the telecommunication sector, which is one of the major producers of e-waste in the country.

Botswana is currently making efforts to improve the regulatory framework regarding e-waste since there is no specific regulatory instrument dealing with e-waste management in the country. The Department for Waste Management and Pollution Control has produced an Integrated Waste Management Policy (September 2021), which will facilitate the sound management of all types of waste streams in the country, including e-waste. A situational analysis within this policy identified e-waste as one of the fastest growing waste streams in Botswana. In addition, the following issues and challenges regarding e-waste in Botswana were identified by the situation analysis:

- No specific legislation for e-waste management in Botswana.
- No infrastructure for the formal collection and recycling of e-waste.
- General lack of awareness among consumers and industry stakeholders on the potential hazards posed by exposure to e-waste.
- The informal sector in the e-waste value chain is not well organized which might lead to health hazard exposure.
- A lack of separation of waste at source which means that e-waste is collected with domestic waste destined for landfill disposal.
- Lack of e-waste recycling infrastructure results in e-waste being transported to neighbouring countries for recycling. Basel Convention protocols on Prior Notification are applied in dealing with Trans boundary Movement of Hazardous Waste and their Disposal.
- No data to show quantities of e-waste.
- A lack of expertise on e-waste management.

This emerging issue requires a specific regulatory framework for its safe and proper management. E-waste needs to be supported by a management system able to recognize the waste as an additional value and a resource, which differs from the current practice of collection and disposal at the landfills. The principle of extended producer responsibility (EPR) is also covered in the Integrated Waste Management Policy and, for the future, Botswana hopes to fully establish an EPR system. The EPR will place a legal obligation on retailers and distributers of EEE to introduce take back schemes for end of use and obsolete equipment. To operationalize the implementation of the Integrated Waste Management Policy, an Integrated Waste Management Bill is now under draft phase, which offers an opportunity to incorporate regulatory requirements for e-waste management, and the whole legislative package is due to be presented at Parliament for consideration and approval.

2.2 International and regional conventions

Botswana has ratified several international and regional conventions and agreements related to the environmentally responsible management of hazardous chemicals and waste, which are also of relevance to e-waste. Table 1 summarizes all the international agreements related to e-waste that have been signed and ratified by Botswana.

Although Botswana is a signatory to several international and regional treaties/conventions, there remains a challenge to translate some of these international obligations into domestic laws. However, efforts are on-going to address this identified gap.

In 1998, Botswana ratified and entered into force the Basel Convention on Control of Trans-boundary Movement of Hazardous Waste and their Disposal. One significant milestone achieved is the recognition of the Basel Convention on the Trans boundary Movement of Hazardous Waste and their disposal under the Waste Management Act (1998). Botswana prohibits the import of hazardous waste, including e-waste, since it does not have specific hazardous treatment or disposal sites. The environmentally responsible management of e-waste is also covered by the requirements of this Convention.

Botswana has also ratified and entered into force the Stockholm Convention on Persistent Organic Pollutants in October 2002, and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade in February 2008. Botswana ratified and became a party to the Minamata Convention on Mercury 2016, but the agreement has not yet entered into force.

However, Botswana is not a Party to one of the main environmental agreements for the African continent, the Bamako Convention on Ban of the Import into Africa and Control of Transboundary Movement and Management of Hazardous Waste within Africa.[4]

Accession of Botswana to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone occurred in 1991, which aims to phase out ozone depleting substances such as chlorofluorocarbons and hydrochlorofluorocarbon as refrigerants which is relevant to EEE such as fridges, freezers, and air conditioners.

4 https://www.informea.org/en/treaties/bamako-convention/treaty-parties

Table 1: Multilateral Environmental Agreement status

Agreement	Signature	Accession/Ratification	Entry into force
Basel Convention[5]		20 May 1998	18 August 1998
Rotterdam Convention[6]		5 February 2008	5 May 2008
Stockholm Convention[7]	22 May 2002	28 October 2002	17 May 2004
Minamata Convention[8]		3 June 2016	
Bamako Convention	n/a	n/a	n/a
Vienna Convention[9]		4 December 1991	
Montreal Protocol[10]		4 December 1991	

2.3 E-waste stakeholders mapping

E-waste is a global challenge, not only because of its increasing generation worldwide, but also because proper treatment and generation prevention requires the active engagement of a diverse set of actors at country level, and sometimes also going beyond the national borders.

The stakeholders that must be involved to improve e-waste quantification in Botswana are summarized in Table 2, which also presents an overview of the expected responsibilities.

Table 2: List of stakeholders and responsibilities involved in e-waste data and statistics

Stakeholder	Responsibility
Statistics Botswana (SB)	• SB to gather and process statistical data and experiment with the harmonized methodology. • SB, BOCRA and MoE to coordinate and lead the national quantitative assessment report writing. • SB, BOCRA and MoE to produce internal work descriptions so that the work can be replicated.
Ministry of Environment, Natural Resource Conservation and Tourism (MoE)	
Botswana Communications Regulatory Authority (BOCRA)	

5 http://www.basel.int/?tabid=4499
6 http://www.pic.int/Countries/Statusofratification/PartiesandSignatories/tabid/1072/language/en-US/Default.aspx
7 http://www.pops.int/Countries/StatusofRatifications/PartiesandSignatoires/tabid/4500/Default.aspx
8 http://www.mercuryconvention.org/Countries/Parties/tabid/3428/language/en-US/Default.aspx
9 https://ozone.unep.org/all-ratifications
10 https://ozone.unep.org/all-ratifications

Table 2: List of stakeholders and responsibilities involved in e-waste data and statistics (continued)

<table>
<tr><th>Stakeholder</th><th>Responsibility</th></tr>
<tr><td>Customs & Excise Division of Botswana Unified Revenue Service</td><td rowspan="2">• Contribute to the expectations highlighted above.
• Ensure consistency and quality in data production.
• Ensure relevance of data to the work of the ministries and its integration in the policy cycle.</td></tr>
<tr><td>Ministry of Transport and Communications</td></tr>
<tr><td>Ministry of Finance and Economic Development</td><td></td></tr>
<tr><td>Ministry of Investment, Trade and Industry</td><td></td></tr>
<tr><td>City Councils</td><td rowspan="2">• Provision of data and information for regular updates of the National E-waste Monitor.
• Provide the experience as actors on the ground so to orient the work in addressing also the challenges faced in the sector.</td></tr>
<tr><td>E-waste producers (including importers, retailers, distributors and manufacturers)</td></tr>
<tr><td>E-waste managers (including collectors, dismantlers and recyclers)</td><td></td></tr>
</table>

2.4 E-waste management infrastructure and refurbishment facilities

There is very little awareness from consumers on how to handle e-waste in Botswana. Botswana has some companies actively dealing with e-waste, but the available infrastructure is insufficient to handle e-waste. There are twelve licensed companies that deal with e-waste, but they are not specialized in this sector and mainly export the waste for treatment. Many of these companies only take care of e-waste collection and transport. They are mainly involved in the dismantling of electronic appliances to extract valuable and precious materials and for transport of e-waste across borders (mainly to South Africa) handing it over to more established companies that have the infrastructure available for end-of-life management.

In addition, there are no available data on the quantities of e-waste collected by those companies, and on what is exported internationally. There are many outlets in towns and cities across Botswana for the repair and reconditioning of EEE such as computers, mobile phones and general electronic equipment. Refurbishment operations are involved in the purchase of obsolete EEE for reuse, extracting spare parts, and repairing and selling equipment. As the Government of Botswana is one of the largest procurement entities of computers, the Government Computer Refurbishment Centre for the reclamation and restoration of used/obsolete ICT equipment from government institutions was established. Some refurbished computers under this project used to be supplied to schools around the country. However, this is no longer practiced as the refurbished equipment has limited lifespan and accumulates in schools at the end of use creating disposal challenges.

3 Methodology

To improve comparability in time and between countries, it is highly desirable to have a sound measurement framework that can integrate the harmonized existing data and can serve as the basis for e-waste statistics and e-waste indicators.

The statistical methodology used in this study to quantify the main e-waste indicators follows the principles set out in the internationally harmonized framework, which was developed jointly through the Partnership on Measuring ICT for Development initiative by UNU, ITU, United Nations Environment Programme (UNEP), Eurostat, the Organization for Economic Cooperation and Development and other United Nations agencies. These principles are described in the *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition*.[11]

3.1 International framework

The measurement framework of e-waste statistics follows a mass balance approach over the entire life cycle of EEE. This covers the manufacturing phase, the EEE placed on the market (EEE POM), the use phase and then the e-waste generated phase. Then, different flows should be distinguished to determine the amount of e-waste, which is formally collected and recycled, and the amount which undergoes other activities such as uncontrolled picking, disposal, illegal export etc (Figure 1).

As a first step, the framework quantifies the amount of EEE placed on market, which covers any product supplied to the national market for consumption and use by households, businesses and public authorities.

The UNU-KEYs classification system can allow several operations from a statistical point of view. First, UNU-KEYs are correlated to other e-waste classifications, so they can be converted, for instance, to the six categories of the European Union (EU) WEEE Directive (see Annex A). Secondly, it can be used to collect statistical data on EEE placed on the market, through the link with the Harmonized Commodity Description and Coding System (HS codes) and convert the data in number of units to weight by applying the specific average weights of the UNU-KEYs. The lifetimes of the UNU-KEYs are also homogeneous, which enables the amount of e-waste generated per year to be determined. In fact, the e-waste generated is based on a dataset of EEE placed on the market over a time series and the average lifetime of a product. Since the composition of the products within the same UNU-KEYs are homogeneous, the classification is also suitable for material flow analysis of the raw material components in EEE and e-waste.

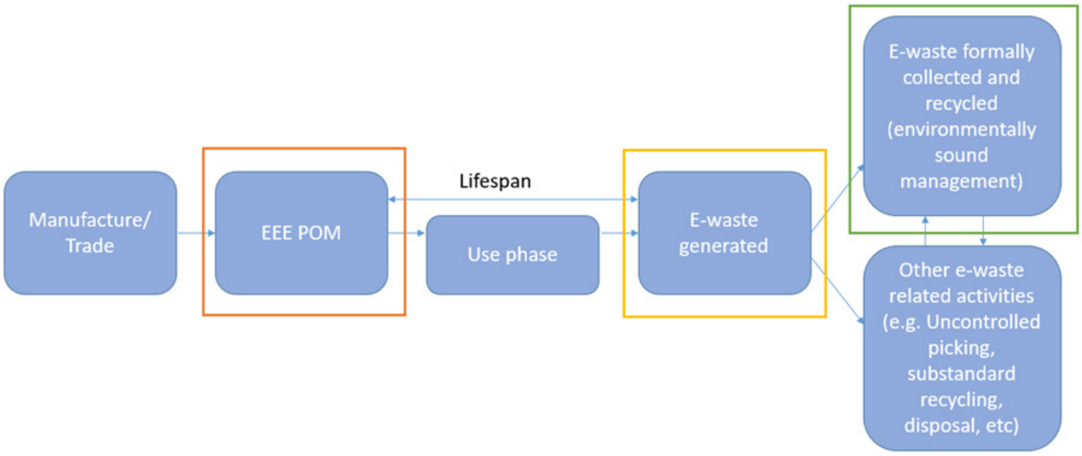
To capture the most important dynamics of e-waste, the following indicators are defined for SDGs and e-waste international guidelines:

- Indicator 1: EEE POM
- Indicator 2: E-waste generated
- Indicator 3: E-waste managed in an environmentally responsible manner (also referred to as e-waste formally collected) - under e-waste legislation
- Indicator 4: E-waste collection rate (indicator 3 divided by indicator 2)

[11] https://www.itu.int/en/ITU-D/Environment/Pages/Toolbox/Guidelines.aspx

The performance of the entire e-waste management is expressed using the e-waste collection rate, defined as indicator 4, which is expressed as a percentage. The collection rate can be an indication of the progress made by the country towards achieving a proper management of the e-waste sector.

Figure 1: Harmonized framework for e-waste statistics



The EEE POM can be calculated though a variety of data sources. The easiest methodology is using the apparent consumption methodology, according to which EEE POM can be obtained with equation 2:

Equation 2

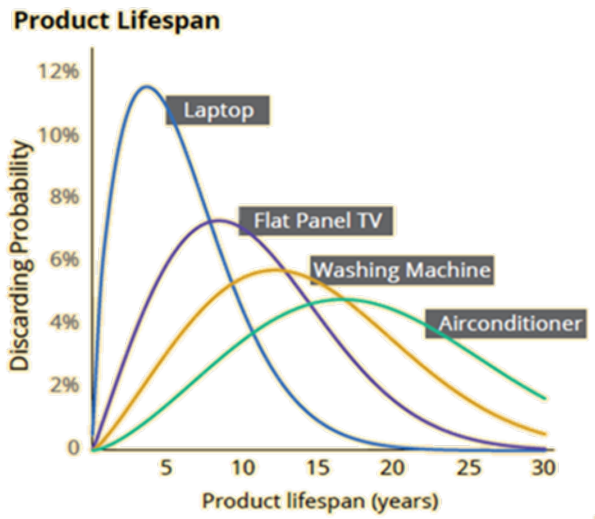
$$POM = Import - Export + Domestic\ Production$$

The EEE POM is calculated for each UNU-KEY, from preferably 1980 (or earliest year available) to present day and should include imports of both new and used-EEE, in addition to all EEE domestically produced (manufactured new EEE and used-EEE for reuse). Since trade statistics and domestic production data can be expressed in weight or units, if required, the tool performs a unit to weight conversion factor. Each UNU-KEY is calculated and applied to obtain the amount of EEE POM in mass if weight data is not available. In this study, weight data from trade statistics was used.

After a product has been placed on the market, it stays in use, or at the household, or business or governmental institute until it is discarded. The lifespan of a product is the period from when the product has been POM until it becomes e-waste. This includes the hibernation phase, such as the storing/stockpiling of the equipment until POM or the hoarding time of the equipment prior to actual discarding at end of life, as well as the passing on of the equipment from one owner to another (reuse). The lifespan of EEE is expressed as a Weibull function that varies per UNU-KEY (Figure 2), with the shape and scale parameters associated to the average lifespan for each UNU-KEY individually.

The time series of EEE POM and lifespans are then used to calculate e-waste generated for each UNU-KEY. The mathematical description of e-waste generated is explained in Annex E. E-waste generated in a country refers to the total weight of all types of EEE (and its parts) that have been discarded by the owner as waste without the intention of re-use, and that resulted from EEE, which had been POM of that country, prior to any other activity such as collection, preparation for reuse, treatment, or recovery, including recycling and export[12].

Figure 2: Lifespans of product



In general, waste management involves the collection, transportation, storage, the disposal of waste, including after-care of disposal sites. It is of vital importance that e-waste undergoes depollution, hazardous fractions are disposed of in an environmentally responsible manner, and recyclable components are properly recycled. This is typically, but not exclusively, performed under the requirements of national e-waste legislation. Therefore, this flow is referred to as "e-waste formally collected" in the context of this report and the *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition*.

Waste management can be undertaken within a legal framework, but there is also informal waste picking or illegal waste-handling. In this context, "waste management", and "other waste related activities", as proposed by the Waste Statistics Framework from the United Nations Economic Commission for Europe[13] is defined as the set of lawful activities carried out by economic units of the formal sector, both public and private for the purpose of the collection, transportation, and treatment of waste, including final disposal and after-care of disposal sites. The "other waste related activities" includes waste dumping, waste picking, disposal, etc., and may include the informal sector[14].

E-waste can also be managed in such a way that it can cause damage to the environment if hazardous substances are not treated. One such example of inferior treatment is when e-waste is mixed with residual waste and also ends up landfill as it had not been separated at source. It can also be mixed with other waste, for instance, metal scrap, and recycled together with metal scrap. Not all recyclable parts are recycled, and hazardous components of e-waste are left untreated. Thus, this waste management is not accounted for in the environmentally responsible e-waste management flow.

12 https://ec.europa.eu/environment/waste/weee/pdf/16.%20Final%20report_approved.pdf
13 https://unece.org/sites/default/files/2021-03/04_WasteStatistics_forConsultation_0.pdf
14 ILO definition of informal sector: A group of production units comprised of unincorporated enterprises owned by households, including informal own-account enterprises and enterprises of informal employers (typically small and non-registered enterprises). See ILO (2017) section 4.5 on informal economy workers.

For e-waste, "other waste-related activities" may involve the selective dismantling of the valuable parts, recovery of some metals, or dumping at uncontrolled landfills. The hazardous components of e-waste are untreated, this is typically done by informal waste operators. The activities performed by the informal sector usually do not imply minimum safety requirements, environmental standards and depollution techniques.

Import and exports can occur for used-EEE and e-waste. This is called transboundary movement. Transboundary movement of e-waste occurs with whole products, or parts / components. It needs to be distinguished whether the exported e-waste is according to the criteria in the national legislation, thus managed by e-waste certified recyclers in the receiving countries, or not. Then the amounts of exported e-waste have to be added to the environmentally responsible management of e-waste, otherwise, it should be added to other e-waste management. Imports of e-waste, however, do not have to be added to the national totals of e-waste formally collected and recycled, but should be recorded separately. Imported used-EEE has to be added to the EEE POM, and the exported used-EEE can be defined as a flow to measure[15].

3.2 Data sources

At present, Botswana does not have a methodology established for the quantification of EEE POM and e-waste generated. There is also no information available concerning EEE possession rate and lifetime. Therefore, several data sources have been used and compared to start quantifying the main statistics indicators.

Statistical data on EEE POM and e-waste generated were obtained from the estimations provided by SCYCLE that were obtained by the UN Comtrade International Trade Statistics Database[16]. All the data on import and export of EEE for Botswana were downloaded. To obtain a longer time series, a statistical regression was applied to get data starting from 1980. The dataset is then cleaned through a statistical validation procedure to identify eventual outliers and data gaps and obtain the EEE POM dataset. From the complete dataset of EEE POM and information on the lifespan of products, it was then possible to quantify also the e-waste generated.

Statistics Botswana improved the estimation provided by SCYCLE on the amount of EEE POM and e-waste generated in the country, using the national data and information available within the agency. Data on EEE import and export were obtained for the years from 2002 to 2020. POM was based on trade data from the Trade Statistics Unit. Domestic production data is hard to come by; it is being compiled and data is available from 2017 to 2020 but has been excluded from the analysis in this report.

A fundamental instrument to perform the calculations of the e-waste statistics indicators of the harmonized framework was the use of the E-waste Toolkit provided by SCYCLE. The E-waste Toolkit consists of two Excel files, two user manuals on the operational use of the Excel files, and the *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition*.

15 https://ewastemonitor.info/wp-content/uploads/2021/12/REM_2021_ARAB_web_final_nov_30.pdf
16 https://comtrade.un.org/

3.3 Data processing

Data processing is a series of actions or operations that convert data into useful information. For this study, the data processing to obtain the first two e-waste indicators was possible using the E-waste Tools provided by SCYCLE.

The E-waste Tools are two excel files which are programmed to help the user in start calculating the amount of EEE POM and e-waste generated in a country. The E-waste Generated Tool uses the outcomes of the EEE Placed on the Market Tool, which is the data on the EEE placed on the market, per UNU-KEY and per year, and allows the amount of e-waste generated to be calculated (per UNU-KEY and per year). The EEE Placed on Market Tool helps the user to prepare, adjust and convert the available country data on EEE POM prior to inserting it in the E-waste Generated Tool. The E-waste generated Tool calculates the amount of e-waste generated and it is pre-populated already with SCYCLE estimations of EEE Placed on Market data per country obtained through the UN Comtrade import/export data and elaborated through the methodology described above.

This study combined validation techniques based on the experience and knowledge of trends of EEE in Botswana performed by Statistics Botswana, and SCYCLE methodology on e-waste statistics. In this context, raw data from Statistics Botswana were harmonized as EEE datasets according to HS codes as per the *E-waste Statistics Guidelines on Classification Reporting and Indicators – Second Edition* and following the procedure explained in the manuals on the EEE Placed on Market Tool and the E-waste Generated Tool. The main steps conducted were:

1. Gathering and sorting the data on importation and exportation of EEE using the relevant codes that describe EEE in the Harmonized Commodity Description and Coding System (HS code). The data on importation of EEE was in a time series format, covering the period of 2002-2020.
2. Linking the HS codes data to the UNU-KEYs classification system and converting the units to weight using the average weight data per EEE appliance type which is available at UNU-Key level using EEE Placed on Market Tool.
3. Undertake data validation and adjusting for outliers. During validation data gaps and extreme figures or outliers were noted and adjusted.
4. Computation of e-waste generated in the country using the E-waste Generated Tool, which uses the EEE POM dataset and the lifespan distributions.

4 Results

4.1 EEE POM

From the applied methodology, it was possible to determine a complete dataset of EEE POM in Botswana for the years 1995 to 2020. The dataset can be consulted in Annex C of this report.

Figure 3 shows that 2011 had the highest EEE POM at 24 742 tonnes. Out of this, the temperature exchange equipment category accounts for approximately 33 per cent of POM in that year. This is followed by the small equipment category, which accounts for about 31 per cent. This pattern is also observed in 2020 (Figure 4) where 21 097 tonnes of EEE was POM, with approximately 40 per cent being accounted for by temperature exchange equipment, and 26 per cent from small equipment. This is based on the EU-6 Classification discussed in the methodology section above. According to the UNU-Keys and HS Codes the temperature exchange equipment category includes refrigerators, freezers, and air-conditioner items. The small equipment category includes electric blankets, alarm clocks, ceiling fans, electric motor (<125-watt), personal weighing machines, baby and household scales, headphones, microphones among others. The observation above is further illustrated in Figure 5, which shows a fluctuating trend although generally increasing over the years.

Figure 6 shows EEE POM per 100 inhabitants from 2011 to 2020, with 1 222 POM kg/inh being the highest recorded in 2011, in line with the trend of the total quantities of EEE POM shown in Figure 3. The year 2002 had the lowest EEE POM. It is not yet known what led to the dip in that year. It is however worth noting that the year 2002 saw the introduction of the use of the local Pula (BWP) currency from the previous South African Rand (ZAR) currency.

Figure 3: The amount of EEE POM in Botswana (EU6), 1995 – 2020, weight in tonnes

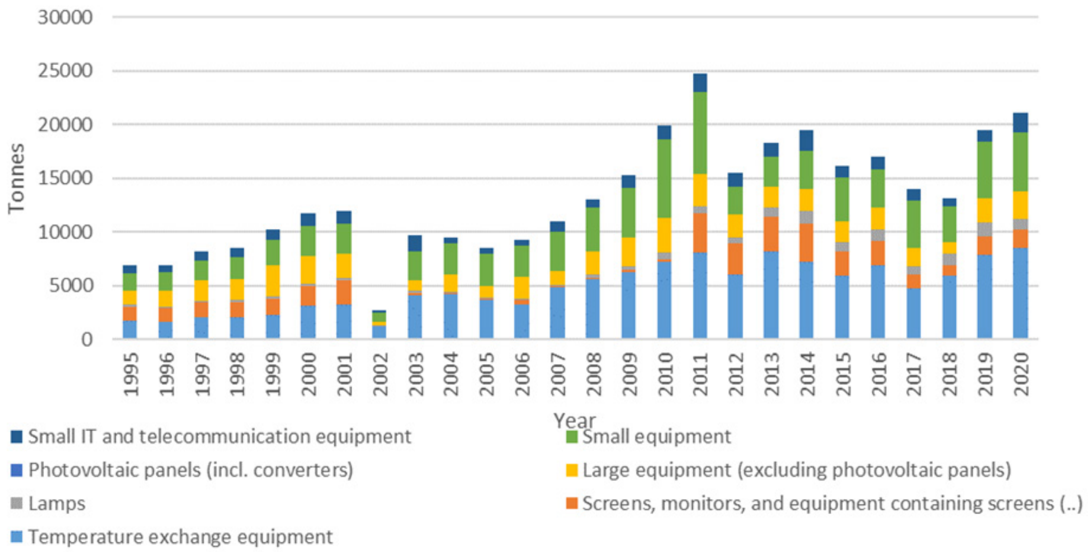


Figure 4: Proportion of EEE POM in Botswana, by weight (%) per EU6 category share for 2020

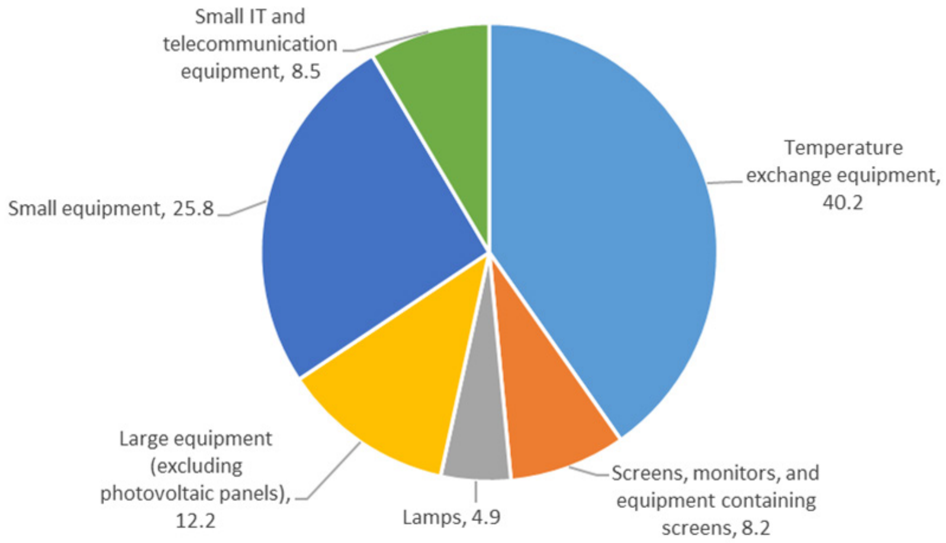


Figure 5 illustrates the amount of EEE POM in Botswana (tonnes) from 2002 to 2020, showing the peak in 2011.

Figure 5: EEE POM in Botswana in tonnes, 2002 – 2020

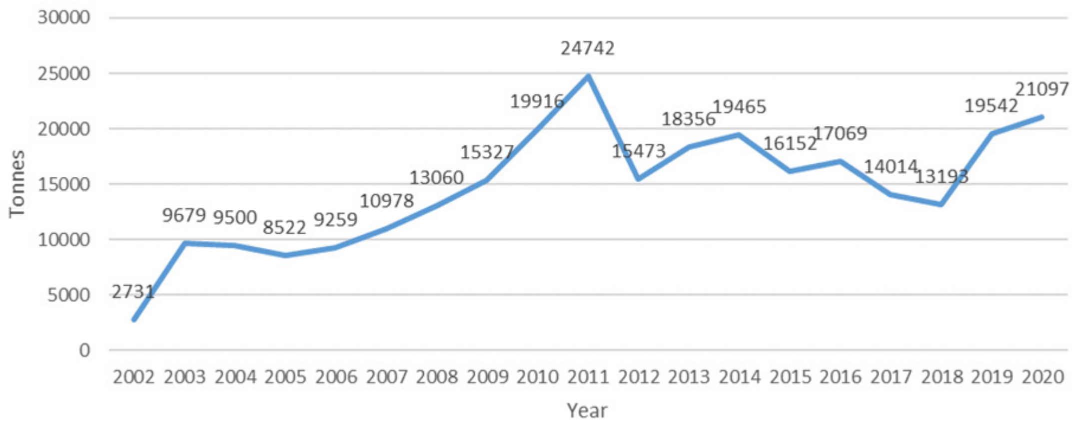
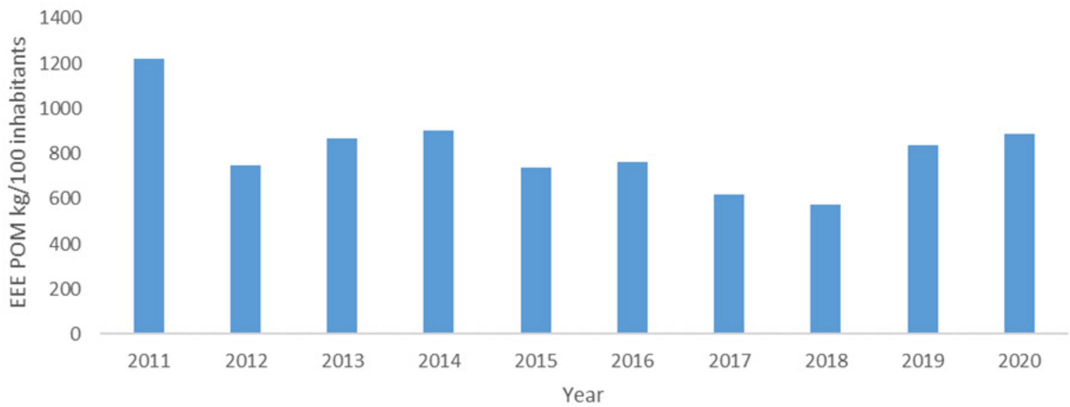


Figure 6 demonstrates the EEE POM in Botswana (kg) per 100 inhabitants from 2011 to 2020, which was also the highest in 2011.

Figure 6: EEE POM in Botswana in kg per 100 inhabitants, 2011 – 2020



4.2 E-waste generated

E-waste generated in Botswana was calculated from 1995 to 2020 and showed an increasing trend over time (Figure 7). Therefore, 2020 (latest year of available data) has the highest amount of e-waste generated at 13 494 tonnes. The entire dataset can be consulted in Annex D of this report. The Global E-waste Monitor estimated that in 2019, Botswana generated a total of 19 000 tonnes of e-waste, on average equivalent to 7.9 kg per inhabitant. Compared to that estimation, the national analysis shows that the country generated 12 462 tonnes of e-waste. This difference could be explained by the fact that this assessment was performed using data from the national official databases (i.e. trade data from Trade Statistics Unit). Another reason behind this difference could be that the national analysis considered only EEE imports and exports, with domestic production excluded. Their inclusion would increase both EEE POM and e-waste generated.

The EEE categories that appear to be most relevant for e-waste generated in Botswana are the temperature exchange equipment category, followed by the small equipment category. As similarly noted for EEE POM for 2020, the temperature exchange equipment category had the largest share of e-waste generated at 34 per cent, followed by small equipment at about 30 per cent (Figure 8).

However, it should be noted that historically, in the dataset, small equipment had the largest share of e-waste generated. This pattern shifted in 2016 when the temperature exchange equipment category increased its share and has since become the category with the largest proportion of e-waste. This is possibly because Botswana's climate is characterized by increasingly high temperatures, which makes temperature exchange equipment a necessity for many households and businesses. It is however observed that the small equipment category maintained its share (these are deemed everyday use items), other categories notably the screens, monitors and equipment category, and the large equipment categories have recorded a reduction in shares over the years as shown in Figure 8. The decline in the share of the large equipment could be an indication of a shift from the traditional way of doing business, as technology is moving, such as replacing duplication of documents through duplicating machines to scanning and sending material using cell phones.

Figure 7: E-waste generated (tonnes) in Botswana, 1995 – 2020

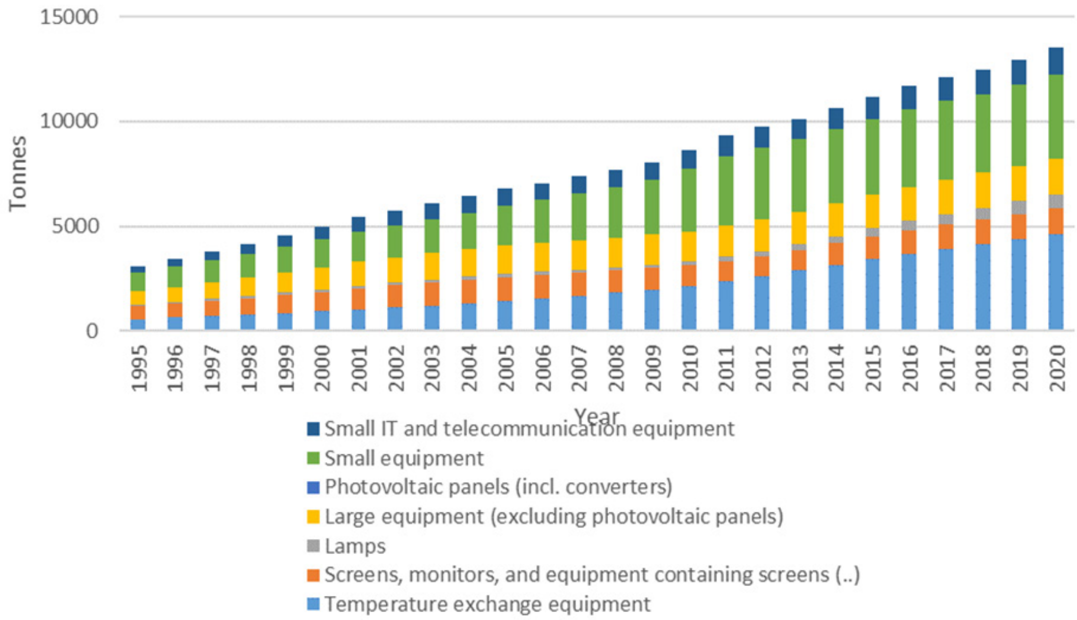
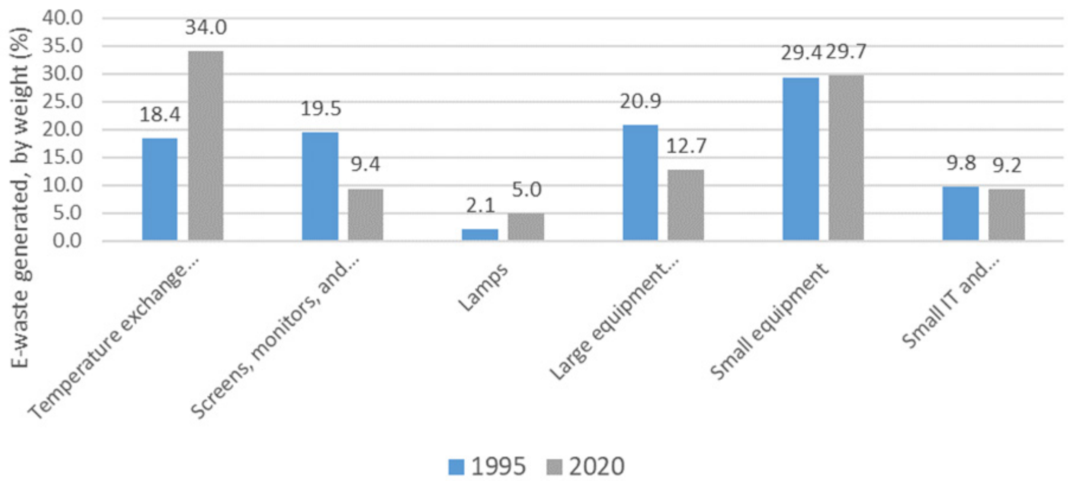


Figure 8: Proportion of e-waste generated in Botswana by weight (%) for each EU6 category, 1995 and 2020



4.3 E-waste flows

Analysis for this study was confined to EEE POM and e-waste generated; no other flows were examined due to the present lack of data. Other e-waste flows such as those listed below could be considered in future data collection and analysis efforts:

- *E-waste collected and recycled in an environmentally responsible manner:* for instance, consulting with e-waste collection and recycling actors in the country. If this information could be obtained, the e-waste collection rate can then be calculated.
- *E-waste informally collected and/or undergoing other recycling techniques (e.g. with metal or plastic waste):* this is difficult to get quantitatively, but also qualitative and anecdotal information can be collected from recyclers.

- *E-waste imported and exported:* this can be collected through Basel Convention annual reports, or customs consultations.
- *E-waste in waste bin mixed with general waste:* through surveys for instance, or waste bin sampling activities.

5 Recommendations

The final goal of the National Monitor is to put forward a series of recommendations on how to improve e-waste data availability and quality in Botswana. This will help track and monitor e-waste overtime and support the implementation of the national e-waste strategy. The table below summarizes some key actions to be undertaken in the future to regularly keep internationally comparable e-waste statistics up to date in Botswana.

Table 3: Recommendations to improve e-waste data availability and quality in Botswana

Action
Continue to expand and annually update the time series of trade statistics data to improve the estimation of EEE POM and e-waste generated flows.
Perform quality check and validation of the data obtained through the Tools (e.g. missing years or UNU-KEYs, outliers, etc.).
Analyze the reporting under the Basel Convention and see if there are available data on e-waste transboundary movements (import and export).
Include data on domestic production of EEE.
Implement the e-waste statistics methodology as regular routine in the country.
Start including e-waste in the country-wide census and surveys to add a data source to cross-check the analysis.
Build a national database to record yearly e-waste generated and e-waste collected.
Integrate other data sources into the analysis (for instance the e-waste collected and recycled, or e-waste illegally imported and exported, e-waste in waste bin, etc.).
Develop a strategy/routine for the collection of information from all the stakeholders involved.
Defining an e-waste classification which can be recognized nationally, improving harmonization and uniformity at the national/international level (e.g. adoption of the UNU-KEYs or six e-waste categories).
Consider publish findings on the website of Statistics Botswana as the national statistics dissemination office.
Develop a specialized team to monitor and control e-waste data.
Develop training programs to build skills and technical knowledge of other staff within Statistics Botswana, and continue to build on from the training provided by the UNITAR – SCYCLE Programme, ITU and UBOS.
Engage with academia and conduct research on e-waste nation-wide.

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Annexes

Annex A

UNU-KEYs classification and link to the six categories.

UNU-KEY	Full Name	Six Categories
0001	Central Heating (household-installed)	IV
0002	Photovoltaic Panels	IV
0101	Professional Heating & Ventilation (excl. cooling equipment)	IV
0102	Dishwashers	IV
0103	Kitchen (e.g. large furnaces, ovens, cooking equipment)	IV
0104	Washing Machines (incl. combined dryers)	IV
0105	Dryers (wash dryers, centrifuges)	IV
0106	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	IV
0108	Fridges (incl. combi-fridges)	I
0109	Freezers	I
0111	Air Conditioners (household-installed and portable)	I
0112	Other Cooling (e.g. dehumidifiers, heat pump dryers)	I
0113	Professional Cooling (e.g. large air conditioners, cooling displays)	I
0114	Microwaves (incl. combined, excl. grills)	V
0201	Other Small Household (e.g. small ventilators, irons, clocks, adapt-ers)	V
0202	Food (e.g. toaster, grills, food processing, frying pans)	V
0203	Hot Water (e.g. coffee, tea, water cookers)	V
0204	Vacuum Cleaners (excl. professional)	V
0205	Personal Care (e.g. tooth brushes, hair dryers, razors)	V
0301	Small IT (e.g. routers, mice, keyboards, external drives & accesso-ries)	VI
0302	Desktop personal computers (excl. monitors, accessories)	VI
0303	Laptops (incl. tablets)	II
0304	Printers (e.g. scanners, multi-functionals, faxes)	VI
0305	Telecom (e.g. [cordless] phones, answering machines)	VI
0306	Mobile Phones (incl. smartphones, pagers)	VI

(continued)

UNU-KEY	Full Name	Six Categories
0307	Professional IT (e.g. servers, routers, data storage, copiers)	IV
0308	Cathode Ray Tube Monitors	II
0309	Flat Display Panel Monitors (LCD, LED)	II
0401	Small Consumer Electronics (e.g. headphones, remote controls)	V
0402	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	V
0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)	V
0404	Video (e.g. video recorders, DVD, Blu-ray, set-top boxes)	V
0405	Speakers	V
0406	Cameras (e.g. camcorders, photo, and digital still cameras)	V
0407	Cathode Ray Tube TVs	II
0408	Flat Display Panel TVs (LCD, LED, Plasma)	II
0501	Lamps (e.g. pocket, Christmas, excl. LED and incandescent)	V
0502	Compact Fluorescent Lamps (incl. retrofit and non-retrofit)	III
0503	Straight Tube Fluorescent Lamps	III
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	III
0505	LED Lamps (incl. retrofit LED lamps and household LED luminaires)	III
0506	Household Luminaires (incl. household incandescent fittings)	V
0507	Professional Luminaires (offices, public space, industry)	V
0601	Household Tools (e.g. drills, saws, high-pressure cleaners, lawnmowers)	V
0602	Professional Tools (e.g. for welding, soldering, milling)	IV
0701	Toys (e.g. car racing sets, electric trains, music toys, biking computers)	V
0702	Game Consoles	VI
0703	Leisure (e.g. large exercise, sports equipment)	IV
0801	Household Medical (e.g. thermometers, blood pressure meters)	V
0802	Professional Medical (e.g. hospital, dentist, diagnostics)	IV
0901	Household Monitoring & Control (alarm, heat, smoke, excl. screens)	V

(continued)

UNU-KEY	Full Name	Six Categories
0902	Professional Monitoring & Control (e.g. laboratory, control panels and invertors)	IV
1001	Non-Cooled Dispensers (e.g. for vending, hot drinks, tickets, money)	IV
1002	Cooled Dispensers (e.g. for vending, cold drinks)	I

Annex B

Six categories classification.

6 Categories in EU WEEE Directive[17]	Description
I	Temperature exchange equipment (TEE)
II	Screens and monitors
III	Lamps
IVa	Large equipment (excl. PV panels)
IVb	Photovoltaic panels
V	Small equipment
VI	Small IT and telecommunication equipment

[17] European Commission (2018). Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012L0019 (accessed January 2020).

Annex C

EEE POM in Botswana (tonnes) – per category.

EU-6		1995	1996	1997	1998	1999	2000	2001	2002	2003
I	Temperature exchange equipment (TEE)	570.3	640.8	714.0	789.3	867.6	949.3	1 038.0	1 124.9	1 220.3
II	Screens and monitors	604.7	666.7	728.3	789.8	852.0	915.7	984.1	1 045.7	1 094.4
III	Lamps	64.0	71.8	80.5	90.6	102.4	113.8	124.7	127.8	132.6
IVa	Large equipment (excl. PV panels)	647.8	716.4	788.0	863.4	950.1	1 047.2	1 146.5	1226.9	1285.0
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equipment	913.2	986.7	1 063.5	1 150.6	1 244.2	1 350.9	1 459.0	1 493.1	1 577.8
VI	Small IT and telecommunication equipment	303.6	351.4	406.3	465.0	525.1	603.1	683.1	704.6	788.7
	Total	**3 103.5**	**3 433.7**	**3 780.7**	**4 148.7**	**4 541.4**	**4 979.9**	**5 435.4**	**5 723.0**	**6 098.8**

EU-6		2004	2005	2006	2007	2008	2009	2010	2011	2012
I	Temperature exchange equipment (TEE)	1 322.1	1 433.2	1 546.5	1 674.7	1 820.0	1 977.1	2 162.8	2 392.3	2 626.0
II	Screens and monitors	1 127.4	1 141.3	1 139.9	1 121.7	1 082.8	1 025.2	953.6	945.0	951.5
III	Lamps	135.9	137.2	137.8	138.5	142.9	154.6	181.2	214.4	241.6
IVa	Large equipment (excl. PV panels)	1 330.9	1 363.0	1 385.5	1 403.9	1 417.0	1 433.4	1 454.5	1 481.8	1 509.5
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equipment	1 721.9	1 882.2	2 030.5	2 209.9	2 399.1	2 612.9	2 977.7	3 313.6	3 430.4
VI	Small IT and telecommunication equipment	821.2	827.4	824.8	833.7	835.3	863.8	913.3	963.1	967.2
	Total	**6 459.4**	**6 784.3**	**7 065.1**	**7 382.4**	**7 697.1**	**8 067.0**	**8 643.1**	**9 310.1**	**9 726.3**

EU-6		2013	2014	2015	2016	2017	2018	2019	2020
I	Temperature exchange equipment (TEE)	2 891.9	3 167.0	3 430.5	3 689.6	3 922.8	4 140.8	4 365.1	4 592.3
II	Screens and monitors	975.4	1 021.0	1 065.8	1 116.2	1 153.0	1 183.5	1 217.6	1 265.1
III	Lamps	279.4	338.6	394.8	456.0	507.9	558.1	617.3	671.4
IVa	Large equip-ment (excl. PV panels)	1 534.7	1 560.6	1 588.2	1 619.9	1 647.8	1 666.8	1 686.7	1 713.9
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equip-ment	3 482.9	3 538.6	3 621.1	3 682.1	3 735.2	3 745.5	3 849.3	4 007.2
VI	Small IT and telecom-munication equipment	967.2	1 013.2	1 063.1	1 117.5	1 157.8	1 167.3	1 183.8	1 244.3
	Total	**10 131.6**	**10 638.9**	**11 163.6**	**11 681.3**	**12 124.5**	**12 461.9**	**12 919.8**	**13 494.2**

EEE POM in Botswana per year (expressed in tonnes, kg/inh, kg/100 inh).

Year	EEE POM		
	Total POM (tonnes)	POM per inhabitants (kg)	POM (Kg) per 100 inhabitants
2011	24 742	12.2	1 221.9
2012	15 473	7.5	747.1
2013	18 356	8.7	867.9
2014	19 465	9.0	902.7
2015	16 152	7.4	735.8
2016	17 069	7.7	765.1
2017	14 014	6.2	618.2
2018	13 193	5.7	572.9
2019	19 542	8.4	835.6
2020	21 097	8.9	8 884

Annex D

E-waste generated in Botswana (tonnes) – per category.

EU-6	E-waste generated	1995	1996	1997	1998	1999	2000	2001	2002	2003
I	Temperature exchange equipment (TEE)	570.3	640.8	714.0	789.3	867.6	949.3	1 038.0	1 124.9	1 220.3
II	Screens and monitors	604.7	666.7	728.3	789.8	852.0	915.7	984.1	1 045.7	1 094.4
III	Lamps	64.0	71.8	80.5	90.6	102.4	113.8	124.7	127.8	132.6
IVa	Large equipment (excl. PV panels)	647.8	716.4	788.0	863.4	950.1	1 047.2	1 146.5	1 226.9	1 285.0
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equipment	913.2	986.7	1 063.5	1 150.6	1 244.2	1 350.9	1 459.0	1 493.1	1 577.8
VI	Small IT and telecommunication equipment	303.6	351.4	406.3	465.0	525.1	603.1	683.1	704.6	788.7
	Total	**3 103.5**	**3 433.7**	**3 780.7**	**4 148.7**	**4 541.4**	**4 979.9**	**5 435.4**	**5 723.0**	**6 098.8**

EU-6	E-waste generated	2004	2005	2006	2007	2008	2009	2010	2011	2012
I	Temperature exchange equipment (TEE)	1 322.1	1 433.2	1 546.5	1 674.7	1 820.0	1 977.1	2 162.8	2 392.3	2 626.0
II	Screens and monitors	1 127.4	1 141.3	1 139.9	1 121.7	1 082.8	1 025.2	953.6	945.0	951.5
III	Lamps	135.9	137.2	137.8	138.5	142.9	154.6	181.2	214.4	241.6
IVa	Large equipment (excl. PV panels)	1 330.9	1 363.0	1 385.5	1 403.9	1 417.0	1 433.4	1 454.5	1 481.8	1 509.5
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equipment	1 721.9	1 882.2	2 030.5	2 209.9	2 399.1	2 612.9	2 977.7	3 313.6	3 430.4
VI	Small IT and telecommunication equipment	821.2	827.4	824.8	833.7	835.3	863.8	913.3	963.1	967.2
	Total	**6 459.4**	**6 784.3**	**7 065.1**	**7 382.4**	**7 697.1**	**8 067.0**	**8 643.1**	**9 310.1**	**9 726.3**

EU-6	E-waste generated	2013	2014	2015	2016	2017	2018	2019	2020
I	Temperature exchange equipment (TEE)	2 891.9	3 167.0	3 430.5	3 689.6	3 922.8	4 140.8	4 365.1	4 592.3
II	Screens and monitors	975.4	1 021.0	1 065.8	1 116.2	1 153.0	1 183.5	1 217.6	1 265.1
III	Lamps	279.4	338.6	394.8	456.0	507.9	558.1	617.3	671.4
IVa	Large equipment (excl. PV panels)	1 534.7	1 560.6	1 588.2	1 619.9	1 647.8	1 666.8	1 686.7	1 713.9
IVb	Photovoltaic panels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	Small equipment	3 482.9	3 538.6	3 621.1	3 682.1	3 735.2	3 745.5	3 849.3	4 007.2
VI	Small IT and telecommunication equipment	967.2	1 013.2	1 063.1	1 117.5	1 157.8	1 167.3	1 183.8	1 244.3
	Total	**10 131.6**	**10 638.9**	**11 163.6**	**11 681.3**	**12 124.5**	**12 461.9**	**12 919.8**	**13 494.2**

E-waste generated in Botswana per year (expressed in tonnes, kg/inh, kg/100 inh).

Year	E-waste generated		
	Total e-waste generated (tonnes)	E-waste generated (kg) per inhabitants	E-waste generated (kg) per 100 inhabitants
2011	9 310	4.0	1 221.9
2012	9 726	4.1	414.6
2013	10 132	4.3	431.8
2014	10 639	4.5	453.5
2015	11 164	4.8	475.8
2016	11 161	5.0	497.9
2017	12 124	5.2	516.8
2018	12 462	5.3	531.2
2019	12 920	5.5	550.7
2020	13 494	5.8	575.2

Annex E

The mathematical description of e-waste generated is a function of the lifespan of EEE and the amount of EEE POM in the previous years. In particular:

- *E-waste generated (n)* is the quantity of e-waste generated in evolution year *n*.
- *POM (t)* is the product sales (POM) in any historical year (*t*) before year *n*.
- t_0 is the initial year that a product was sold.
- $L^{(p)}(t, n)$ is the discard-based, lifetime profile for the batch of products sold in historical year *t*.

Equation 3

$$E\ waste\ generated\ (n) = \sum_{t=t_0}^{n} POM\ (t) * L^{(p)}(t,n)$$

The lifespan $L^{(p)}(t, n)$ is the lifespan profile of an EEE product sold in year *t,* which reflects its probable obsolescence rate in evaluation year *n*. The discard-based lifespan profile for a product can be modelled using several probability functions. The Weibull distribution function is considered the most suitable for describing discard behaviour for EEE and has been applied in the European Union and in scientific literature.

Owing to social and technical developments, a product's lifespan can be time-dependent. For instance, the cathode ray tube monitor rapidly became outdated as a result of technological developments in flat-screen monitors. In such cases, lifespan distributions should ideally be modelled for each historical sales year. The Weibull function is defined by a time-varying shape parameter $\alpha(t)$ and a scale parameter $\beta(t)$, as described in the equation below:

Equation 4

$$L^{(p)}(t,n) = \frac{\alpha(t)}{\beta(t)^{\alpha(t)}}(n-t)^{\alpha(t)-1}e^{-[(n-t)/\beta(t)]^{\alpha(t)}}$$

For other, more stable products, time-independent lifespans are sufficient to describe actual behaviour. In such cases, the variations in the shape and scale parameter over time are minor and, as such, can be disregarded. The distribution of product lifespans in such cases can thus be simplified as follows:

Equation 5

$$L^{(p)}(t,n) = \frac{\alpha}{\beta^{\alpha}}(n-t)^{\alpha-1}e^{-[(n-t)/\beta]^{\alpha}}$$

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