AFRICA'S WASTED POTENTIAL

Unlocking Industrial Waste in Circularity

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INTRODUCTION

The current global linear model extracts, consumes, and discards resources, leading to challenges of resource depletion and unscientific waste disposal. Amidst these growing concerns, the circular economy model has gained traction.

Africa, the fastest-growing continent, faces rapid urbanization and rising waste dumping, with a projected increase of waste generation to 66 per cent by 2050. With 90 per cent of waste getting dumped, the continent already has 19 of the world’s 50 biggest dumpsites. Various initiatives supporting circularity currently focus on municipal solid waste and plastic waste.

Africa’s manufacturing sector contributes to 30–40 per cent of the continent's total GHG emissions.With the projection of these emissions doubling by 2050, there is an urgent need of coupling industrial waste into a circularity model.

Integrating circularity in industrial waste will not only reduce landfill pressure but also help industries to achieve net-zero targets through resource efficiency, reduced GHG emissions, lower costs, energy efficiency and employment creation.

1.1 Background

The concept of circular economy has become pivotal in the recent decade. The environmental challenges due to the looming crisis of depleting natural resources and unscientific disposal of waste are the main reasons for this growing attention.

The global economy currently follows a linear model, where resources are extracted, consumed, and then discarded into the environment. Apart from this being a capital-intensive and linear process, this model negatively impacts the environment and exploits natural resources. According to the United Nations Environment Programme's (UNEP's) 2024 global outlook,[1] extraction and processing of natural resources (fossil fuels, minerals, non-metallic minerals and biomass) account for over 55 per cent of greenhouse gas emissions (GHGs) and 40 per cent of particulate matter (PM) globally. In the absence of concerted actions in the usage pattern of resources, global material resource extraction could increase by almost 60 per cent by 2060 from 2020 levels, increasing from 100 to 160 billion tonnes in 2020–60.[2]

This high usage pattern of natural resources and consequent overburdening of land by waste dumping is increasingly visible in developing regions like Africa. Being the fastest growing continent and experiencing rapid population growth and accelerating urbanization, Africa is also facing the brunt of this growth in the form of unprecedented increase of waste dumping. Considering the current pace of growth, the waste volume in Africa is projected to triple, from 174 million tonnes in 2016 to approximately 516 million tonnes by 2050. In the absence of adequate waste collection systems, more than 90 per cent of Africa's waste is currently either disposed of in unregulated dumpsites and landfills or is subject to open burning. Notably, 19 of the world's 50 biggest dumpsites are in Africa, underscoring the urgent need for improved waste management, including circular economy interventions.[3] The continent also struggles with various challenges—including weak strategic, institutional and organizational structures; shortage of essential waste management skills; inadequate budgets; low public awareness and weak enforcement mechanisms—that hinder the achievement of adequate waste management.

Given Africa's growing waste management crisis, a shift towards a system that minimizes disposal and maximizes resource recovery is essential—this is where the circular economy emerges as a solution. It operates on the principle 'waste is a resource' and is gaining traction as a strategy for sustainable growth. It emphasizes on a production and consumption model based on sharing, leasing, reusing, repairing, refurbishing and recycling of material use, thereby extending its lifecycle and minimizing waste disposal. The circular economy also offers a promising alternative to the traditional manufacturing-led growth strategy by fostering industrial development and job creation through sustainable resource management.

Recognizing the potential of a circular economy, Africa is gradually progressing towards adopting more sustainable waste disposal and management technologies. This shift is evident from the fact that for the period 2025–30, out of total 160 disclosed urban infrastructure projects across African cities, waste management projects are ranked the highest, accounting for a total of 50 projects valued at US $935 million.[4] The key initiatives of these projects include phasing out open dumpsites, constructing sanitary landfills, and redirecting trash from landfills to waste recovery and treatment facilities, thus promoting more sustainable waste management practices. The Africa Waste Management Market is also experiencing significant growth, driven by the emergence of companies focused on increasing recycling capacity. Many African nations are integrating circular economy strategies to align with their Sustainable Development Goals (SDGs), using waste circularity as a key tool to meet national targets.

The efforts to advance circularity are also supported by various international, continental and national initiatives addressing waste management and recycling. The initiatives generally aim to span circularity across multiple sectors. Currently, however, the two waste streams that are prioritized in the African continent are municipal solid waste (MSW) and plastic waste.

MSW, which includes household and commercial waste, is a growing concern in Africa due to the combined effect of rapid urbanization and inadequate waste management systems. As of 2016, Africa generated approximately 174 million tonnes of MSW annually, and projections estimated that this figure would increase to 244 million tonnes by 2025.[5] More concerning, however, is the long-term trajectory—by 2050, waste generation is expected to triple, reaching an estimated 516 million tonnes per year across the African continent.[6] Only about 4 per cent of MSW is currently being recycled, leaving the vast majority of waste either dumped in uncontrolled landfills or openly burned.

As for plastic waste, its generation in Africa has been increasing at an alarming rate, with projections indicating a near-tripling by 2060. Among the African regions, Sub-Saharan Africa is projected to witness a significant increase in plastic waste production—this region could produce 116 million tonnes of plastic waste annually by 2060, a drastic rise from 18 million tonnes in 2019.[7] With the continuation of current trends, it is projected that half of all plastic waste will still be landfilled,

INITIATIVES ON CIRCULARITY IN AFRICA

The Africa Circular Economy Facility (ACEF), launched by the African Development Bank (AfDB) in 2022, is a multi-donor trust fund supporting circular economy initiatives beyond waste management. It integrates sustainability into Africa's green growth strategies and provides technical assistance to the African Circular Economy Alliance (ACEA), a government-led coalition promoting the transition to a circular economy.

The African Circular Economy Network (ACEN) connects businesses, policymakers and researchers across South Africa, Kenya, Ghana, Nigeria and Uganda to drive knowledge sharing, policy advocacy and resource efficiency.

The African Circular Economy Hub (ICLEI Africa) provides guidance and tools to help cities implement waste-to-energy and regenerative urban planning strategies.

The UNEP-led Switch Africa Green programme supports Small and Medium Enterprises (SMEs) in adopting sustainable business models in agriculture, manufacturing, tourism and waste management across seven African nations.

In Ghana, the Waste Recovery Platform (UNDP) facilitates waste-to-product innovation, turning waste into recycled plastics, biofuels and compost fertilizers.

The Ellen MacArthur Foundation's Circular Economy in Africa programme collaborates with governments and businesses in South Africa, Kenya, Nigeria and Rwanda to develop circular economy roadmaps, investment strategies and policy reforms.

and less than a 20 per cent recycled[8] by 2060. Despite the African Union's Agenda 2063 setting an ambitious target for African cities to recycle at least 50 per cent of their waste by 2023,[9] the reality of waste management scenarios in the continent shows a different picture.

The vast potential of waste reuse remains to be utilized in most African countries. When implemented effectively, albeit in isolated successes, circular practices have, however, proven that waste can be repurposed into valuable products, such as the use of waste plastic in making construction materials. Thus, while continued efforts to manage MSW and plastic waste remain critical, there is a need to extend these efforts to circularity of industrial waste.

1.2 Need for industrial waste circularity in Africa

The inclusion of industrial waste in circularity is significant because industrial development, while being a key driver of economic growth, is also one of the largest consumers of natural resources and contributors to waste generation. Generated waste includes vast volumes of reusable waste, and in absence of a circularity model these reusable materials continue to be dumped, contributing to increased landfill pressure.

Although Africa's manufacturing sector is relatively small—contributing just 3 per cent to global manufacturing GHG emissions—at the continent level it is responsible for 30–40 per cent of total African emissions, emitting 440 megatonnes of carbon dioxide equivalent (MtCO_2e) in 2018.[10] It is important to note that half of the continent's potential 2050 GHG-emitting industries have not yet been built. Considering the growth trajectory of industrialization in the continent, without any decarbonization efforts the emissions are likely to double by 2050, reaching 830 MtCO_2e.

Thus, there is an urgent need and also a huge opportunity for the continent to prioritize and accelerate low-carbon manufacturing mechanisms in the industries by transitioning to a circular model prioritizing waste minimization, resource reuse and closed-loop production.

INDUSTRIAL WASTE DUMPING AND ASSOCIATED ISSUES ARE A CONCERN ALL OVER AFRICA

Report maps manufacturing pollution in sub-Saharan Africa and South Asia

24 septiembre 2020

The study explores the environmental and resulting health impacts of pollutants generated by the manufacturing sector, often touted as a driver of economic growth.

The Burning Truth Behind an E-Waste Dump in Africa

Ending the toxic smoke rising from an iconic dump in Ghana will take more than curbing Western waste

Africa's growing lead battery industry is causing extensive contamination

By The Conversation — February 18, 2020 Reading Time: 4 mins read

Toxic waste dumping in the Gulf of Guinea amounts to environmental racism

Nigeria ranks third in Africa with 500m kg of eWastes yearly

South Africa authorizes dumping at sea of cargo that turned volatile

August 26, 2024 Profiles, Sector

Beyond the bin: Decent work deficits in the waste management and recycling industry

The waste management and recycling industry faces numerous challenges, including high rates of informality, low wages, and long working hours.

Senegal's Hann Bay, a tourist paradise turned industrial sewer

Once considered one of the most beautiful coves in all Africa, Hann Bay has become a dumping ground.

Annemarie Roodbol

23 February 2024

The alarm about the "critical state" of solid waste accumulation in Africa was sounded at Africa's Green Economy Summit on Thursday in Cape Town.

Solid waste is choking African cities, potential to grow and develop

21 APR 2022

Toxic trash dumps Africa in the danger zone

Mafia groups are increasingly involved in global waste disposal, putting North African citizens at risk.

STORY | CENTRE FOR INVESTIGATIVE JOURNALISM | JANUARY 25, 2023

Factories Dump Chemicals Into Key Rivers

Country:

LESOTHO

FAST FASHION, SLOW POISON: NEW REPORT EXPOSES TOXIC IMPACT OF GLOBAL TEXTILE WASTE IN GHANA

Ferdinand Omondi

11 September 2024 • 3 min read

Circularity in industrial waste can be achieved through various models. Several real-world models already exist and demonstrate how waste can be reintegrated into production cycles. These include:

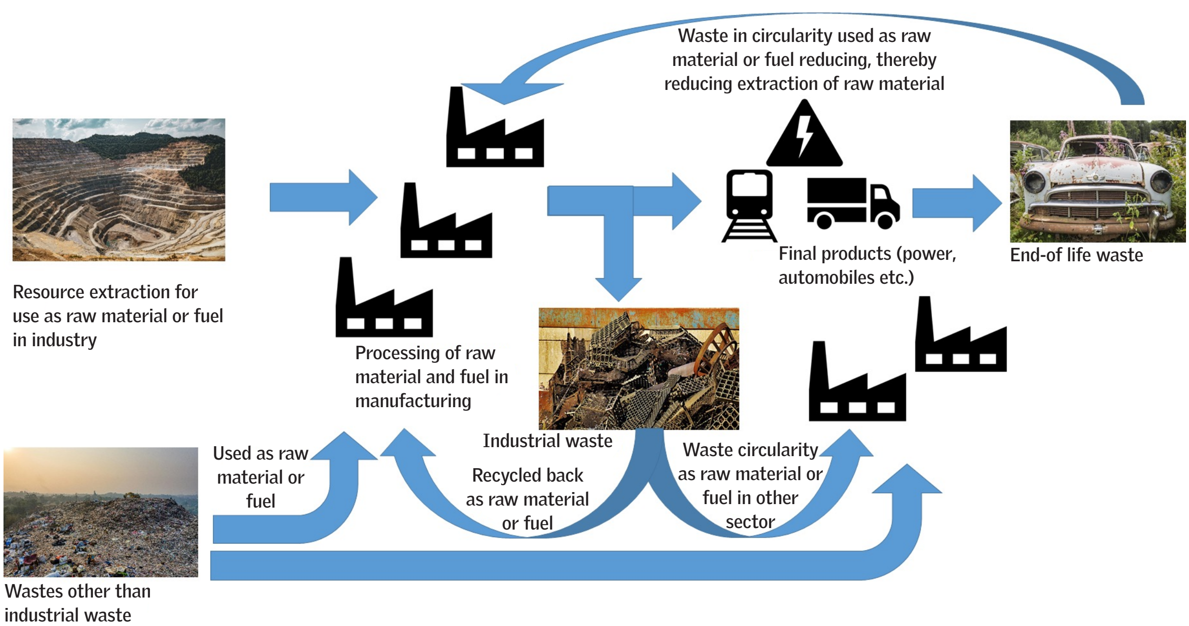
1. Industrial symbiosis: Waste from one industry serves as raw material or fuel for another. For example, fly ash from power plants can be utilized by the cement industry.

2. Non-manufacturing applications: Industrial waste is repurposed for other sectors. For instance, slag from the iron and steel industry is used in road construction.

3. Alternative fuel sources: Non-industrial waste is processed and used as fuel in industries. For example, processed municipal solid waste can replace fossil fuels in the cement industry (see *Figure 1: Material flow in a circular economy*).

Industries that integrate these models of circularity in industrial waste will find that it is not only an effective solution for reducing waste dumping, but is also instrumental in achieving net-zero targets for industries by offering the following multifaceted benefits:

Figure 1: Material flow in a circular economy



Source: Centre for Science and Environment

1. Resource efficiency

Waste circularity has a huge potential in saving limited natural resources by enabling the reuse/recycle of materials as raw material or fuel, thereby reducing the need for raw material extraction. For instance, Africa's natural gas demand reached 181 billion cubic metres by 2024.[11] If cement industries substitute just 10 per cent of this demand with industrial waste as fuel, the continent could save approximately 18 billion cubic metres of natural gas.

2. Reduced GHG emissions

Fossil fuels have long been the dominant energy source in industrial processes, but their extraction and combustion contribute significantly to greenhouse gas (GHG) emissions. The mining, refining and transportation of coal, oil and gas release carbon dioxide and methane, accelerating climate change. Substituting fossil fuels with industrial waste-derived alternatives, such as refinery sludge, can help lower overall fuel consumption. This shift will aid in reducing GHG emissions.

3. Reduced cost economics

Manufacturing costs increase when it involves extraction of raw material/fuels from natural resources. With the implementation of circularity, the costing of manufacturing is expected to reduce significantly as it enables reuse of waste materials. The economic viability of circular models however varies, depending on various factors such as technology, industry type and raw material requirement.

4. Increased energy efficiency

Using waste materials in manufacturing has the potential of reducing energy consumption since processing secondary raw materials often requires less energy than extracting, transporting and refining virgin resources. This reduction in energy demand translates to lower operational costs and decreased industrial carbon emissions, improving overall energy efficiency.

5. Employment opportunities

The transition to a circular economy will drive job creation, requiring both manual labour for material recovery, as well as digital and technical expertise to develop and manage advanced circular supply chains. As industries adopt circular practices, demand will grow for technicians, engineers and data analysts to maximize resource use and map recycling systems. This expansion has the potential to support long-term economic growth while providing employment opportunities at various skill levels.

Recognizing both the numerous benefits of integrating industrial waste into circularity as well as Africa's potential to implement this model, this report examines current circular economy practices in key African nations. It also identifies challenges in implementation, proposes a roadmap for scaling circular solutions, and highlights best practices from industries across Africa that can be used as models for wider adoption across the continent.

2

STATUS OF INDUSTRIAL WASTE CIRCULARITY

Half of the surveyed countries lack data on industrial waste—how much is generated, how much is recycled and/or reused or disposed of—leaving a major gap in waste-management insights. Even where there is data, the accuracy is questionable, highlighting the need for a robust data-management system.

Despite data gaps, circular economy practices are emerging across a few industries—recycling waste tyres, aluminium scraps, used lead batteries, glass, paper, sugar, cashew and electronic waste. The practices underscore the potential of industrial waste in minimizing landfilling and reducing GHG emissions.

Assuming 100 per cent upscaling of just four types of industrial waste at the continent level, a reduction of 8.7 million tonnes greenhouse gas (GHG) emissions could be attained.

Several African nations are introducing waste policies and circularity roadmaps, but most are focused on municipal waste. Despite the rapid pace of industrialization in these nations, industrial waste is largely overlooked, with limited integration into national frameworks.

2.1 Industrial waste profile of key African countries

A large number of African countries are driven by the agricultural sector and focus primarily on processing of agricultural goods involving wood processing, livestock production, horticulture, fisheries, forestry etc. The agriculture sector is not only a key driver in Africa's economy but is also the means of livelihood for the people. However, with the rapid surge in industrialization, other kinds of industrial sectors are also expanding. These include sectors like sugar, textile, mining, cement, brewery, food and beverage, paper, steel mills and metal foundries among others.

These industrial sectors are known to generate a diverse range of hazardous and non-hazardous wastes. Many of the generated waste types such as plastic, paper, electronics, fly ash etc., which have proven utilization and/or recycling streams, are being dumped at dumping sites in many African countries. The reasoning for this negligence is the unavailability of information both with the industries and regulators.

The Centre for Science and Environment (CSE) contacted regulators of different African countries for providing data on type and quantity of industrial waste being recycled and/or reused in their country. While a few countries have some data, other countries faced challenges in providing the requested information. The countries even struggled to share information on the quantity and type of waste generated in their province.

The received response from 10 countries reveals astonishingly that 50 per cent of the contacted countries do not have industrial waste listed in terms of quantity generated, recycled and/or reuse and disposed of. These countries—Kenya, Tanzania, Uganda, Ethiopia and Rwanda—surprisingly are ones experiencing rapid industrialization and the absence of such essential information questions the handling and management of industrial waste. In contrast, Ghana, Nigeria, South Africa, Eswatini and Malawi have developed an inventory of industrial waste in their country. The data provided by these countries, however, highlights a large difference in reported data. For instance, the reported annual waste generation by Ghana seems inadequate considering the pace of industrial development in the country (see *Table 1: Country-wise data on waste generated and recycled*), indicating either weak inventory or incorrect reported data. Similar findings are observed for Malawi and Eswatini as the provided data seems inadequate and this has been validated in the report.

Table 1: Country-wise data on waste generated and recycled

Country	Total waste generation (tonnes/year)	Total waste recycled/reused (tonnes/year)	Total waste landfilled (tonnes/year)
South Africa	39 million	2.1 million (5 per cent)	36.9 million (95 per cent)
Nigeria	41 million	12.8 million (31 per cent)	28.2 million (69 per cent)
Ghana	32,502	25,903 (80 per cent)	6,599 (20 per cent)
Eswatini	3.3 million	2.9 million (88 per cent)	0.3 million (12 per cent)
Malawi	90	90	0
Kenya	Information not available	Information not available	Information not available
Tanzania	Information not available	Information not available	Information not available
Uganda	Information not available	Information not available	Information not available
Ethiopia	Information not available	Information not available	Information not available
Rwanda	Information not available	Information not available	Information not available

Source: Data shared by country regulators and compiled by CSE

Interestingly, the bulk waste generated in South Africa consists of fly ash, bottom ash, slag and sludge, which has the potential of being recycled. Malawi has only sugar industries and the waste generated is completely reused in distilleries. Ghana and Nigeria have a wide range of industrial sectors and thus the type of generated waste is also diverse. Thus, these two countries have potential for developing multiple industrial symbiosis and providing an array of possibilities for utilization of various types of wastes. Details of industrial sectors and the corresponding waste management is discussed in the next section.

South Africa

The country has power plants, pulp and paper and ferro alloys as the major industrial sectors. The major portion of the waste generated from these sectors includes fly ash, bottom ash, metal slag and sludge. Currently, the fly ash is utilized in brick making and agricultural activities, a small portion of metal slag is used for construction purposes and sludge from refineries is also getting recycled. However, this utilization/recycling contributes to only 5 per cent of generated waste, the remaining waste is being dumped at the landfill (see *Table 2: Industry-specific waste generation and reuse—South Africa*).

Table 2: Industry-specific waste generation and reuse—South Africa

Industrial sector	No. of industries	Total production from sector	Type of waste generated	Quantity of waste generated (tonnes/annum)	Waste recycled and/or reused	
					Quantity (tonnes/annum)	Percentage
Power generation (coal)	15	17,369 MW	Bottom ash	28 million	0	0
			Fly ash	1 million	1 million	100
Pulp and paper	13	2.11 million tonnes/annum	Bottom ash	5.8 million	0	0
Ferro alloy	46	2.9 million tonnes/annum	Ferrous metal slag	2.1 million	0.2 million	10
Petroleum oil refineries	6	Information not available	Sludge	1.2 million	0.9 million	75
Mining	Information not available	Information not available	Mineral waste	0.85 million	0	0
Total	80			39 million	2.1 million	5

Source: Data shared by DFFE and compiled by CSE

Nigeria

Nigeria has approximately 4,000 major industries governed by a few industrial sectors. These include food and beverage; chemicals and pharmaceuticals; plastic and rubber; metal, paper and paper products; electrical and electronics; textile and leather and others. The total waste generated by these sectors amounts to approximately 41 million tonnes annually. This includes 0.8 million tonnes of hazardous waste, 10 million tonnes of organic waste, 9.5 million tonnes of plastic and packaging and 20.7 million tonnes of other solid waste from different sectors. With the current practices, the country is able to recycle and/or reuse a total of 12.8 million tonnes of waste, which accounts to 33 per cent of generated waste (see Table 3: *Industry-specific waste generation and reuse—Nigeria*). The waste recycled/reused consists of plastic and packaging (3.5 million tonnes), organic waste (5 million tonnes), metal waste and other solid waste (4.3 million tonnes). The remaining 67 per cent of generated waste is assumed to be dumped.

Table 3: Industry-specific waste generation and reuse—Nigeria

Industrial Sector	No. of industries	Total production from sector (tonnes/annum)	Quantity of waste generated (tonnes/annum)	Waste recycled and/or reused	
				Quantity (tonnes/annum)	Percentage
Food, beverages and tobacco sector	1,000	50 million	15 million	5.6 million	37
Chemicals and pharmaceuticals	600	30 million	2.6 million	0.1 million	3.8
Basic metal and fabricated products	500	11 million	3 million	1.8 million	0.6
Plastic and rubber	300	4 million	6 million	1.5 million	25
Pulp, paper and printing	200	1.5 million	3 million	1.6 million	53
Electrical and electronics	300	2.3 million	2.7 million	0.6 million	22
Textile and leather	400	2.8 million	3 million	0.4 million	13
Others	600	14.5 million	5.7 million	1.2 million	21
Total	3,900		41 million	12.8 million	31

Source: data shared by NESREA and compiled by CSE

Ghana

Ghana has reported various industrial sectors, with plastic and rubber manufacturing as the dominating sector. The total annual waste generated from all the reported sectors is only 32,502 tonnes. As highlighted earlier, the figures for quantity of waste generated and consequently recycling seem too low considering the production capacities of all sectors. Subsequently, there is skepticism about the achievement of the claimed 80 per cent of waste recycling by the country. This clearly showcases the scenario of incorrect data reported by industries and need for developing a method for verifying the reported data.

Table 4: Industry-specific waste generation and reuse—Ghana

Industrial sector	No. of industries	Total production from sector (tonnes/annum)	Quantity of waste generated (tonnes/annum)	Waste recycled and/or reused	
				Quantity (tonnes/ annum)	Percentage
Plastics and rubber manufacturing	60	2.6 million	10656	8256	77
Cement	17	30.6 million	6,881	5,717	83
Food and beverage	17	1.6 million	1,530	1,377	90
Metal smelting and fabrication	11	0.1 million	85	55	65
Oil and fat processing	11	0.8 million	1,177	13	1
Wood processing	8	0.7 million	10,696	10,152	95
Cocoa processing	7	0.4 million	1478	333	23
Total	131		32,502	25,903	80

Source: Data shared by Ghana Environmental Protection Agency and compiled by CSE

Eswatini

Eswatini does not have a large number of industries. A total of 10 major industries operate, including the sugar, brewery, distillery, cardboard recycling and timber sectors. Since the waste from these industries is mostly organic—12 per cent of the disposed waste comprises plastic waste and boiler ash—the country is able to recycle and/or reuse 88 per cent of the generated waste ash (see *Table 5: Industry-specific waste generation and reuse—Eswatini*).

Table 5: Industry-specific waste generation and reuse—Eswatini

Industrial sector	No. of industries	Total production from sector (tonnes/annum)	Quantity of waste generated (tonnes/annum)	Waste recycled and/or reused		
				Quantity (tonnes/ annum)	Percentage	Application
Sugar	3	5 million	Cane tops—1.3 million	1.3 million	100	Used as cattle feed
			Bagasse—1.5 million	1.5 million	100	Used as boiler fuel
			Filter mud —0.35 million	0	-	-
			Molasses—0.02 million	0.02 million	100	Used in distillery
Timber	3	0.3 million	Unused timber, dust, shavings—0.12 million	0.12 million	100	Used as biofuel
Brewery	1	0.02 million	Spent grain—4,640 Spent yeast—255 CO_2—974	5,614	95	Sold as animal feed, reused in process
Cardboard recycling	1	0.03 million	Plastic—1.68	0	-	-
Distillery	2	0.03 million	No information available	-	-	-
Total	10		3.3 million	2.9 million	88	

Source: Data shared by EEA and compiled by CSE

As discussed, a significant amount of waste currently gets dumped in the landfill in different countries. Moreover, the kind of waste being dumped (see *Table 6: Type of waste dumped in different African countries*) is waste that has proven recycling and/or reuse options and the countries are already implementing those recycling streams. With both the adoption and upscaling of the recycling practices, a huge amount of waste will be saved from getting dumped.

Table 6: Type of waste dumped in different African countries

Type of waste getting landfilled	Country
Slag	Ghana, Nigeria, South Africa, Mozambique
Fly ash/boiler ash	South Africa
Paper	Ghana, Nigeria
Plastic/PET bottles	Eswatini, Ghana, Nigeria

Source: CSE

While unavailability of technologies or processes for recycling/reusing different kinds of waste is an obvious reason, absence of waste inventory in the country is also one of the key reasons for the waste being dumped. In the absence of waste data with the authority, its disposal also remains unidentified. The environmental regulators should have a detailed inventory on the type and quantum of waste generated from different industrial sectors in the country. This inventory will enable the regulators to keep a track on waste management by an industry and to also understand the demand and supply requirements for waste in the country.

The inventory can be developed either by obtaining the relevant data from the Environmental Impact Assessment (EIA) or Environmental Audit report, or by asking for the required data from the industries. However, as highlighted in CSE's earlier reports, currently the EIA and audit reports of many African countries lack the technical data. Obtaining data from industries is a tedious process and where it is received, the accuracy of the data is questionable. Thus, the regulatory bodies should develop a rule of thumb, a theoretical method of estimating waste quantity. This rule of thumb is developed by collecting data on production capacity and generated waste for a few industries of a particular sector and a solid waste generation factor (SWGF) is calculated as follows:

SWGF = Waste generation (annual quantity)/ Production capacity (annual)

This factor is to be developed for different kinds of waste from a particular industry. These SWGFs can then be used to estimate the waste generation from an industry based on its production capacity. Such SWGFs should be developed for all the industrial sectors prevalent in the country.

For instance, according to SWGFs calculated for Indian sugar industries, one tonne of sugar production is estimated to generate approximately 1.85 tonnes of bagasse, 0.3 tonnes of press mud and 0.4 tonnes of molasses. When this information is applied for Malawi, which reports three sugar industries in the country and no data availability, a quantity of 0.5 million tonnes of bagasse, 0.09 million tonnes of press mud and 1.2 million tonnes of molasses can be estimated to be generated in the country (see *Table 7: Estimation of waste generation by using rule of thumb*).

Table 7: Estimation of waste generation by using rule of thumb

Country	Number of industries	Production capacity (tonnes/year)	Quantity of waste (tonnes/year)			
				Bagasse	Molasses	Press mud
Malawi	3	300,000	Data not available	-	-	-
			Calculated by SWGF	0.5 million	1.2 million	0.09 million
Eswatini	3	5,000,000	Provided by regulatory body	1.5 million	0.02 million	0.35 million
			Calculated by SWGF	9.2 million	2 million	1.5 million

Source: Data shared by countries and analysed by CSE

While data availability is essential, its accuracy determines the effectiveness of waste management strategies. Without reliable data, policies and interventions may fail to address the actual scale of industrial waste challenges. Developing these SWGFs will provide regulators the added advantage of cross-checking the data reported by industries.

For instance, Eswatini reported waste generation data for the sugar industries in the country. As discussed, with the SWGFs for the sugar industries applied, the values calculated were completely different from the reported values. According to our calculations, bagasse generation was estimated to be 9.2 million tonnes (six times higher than the reported value); press mud was 1.5 million tonnes (five times higher) and molasses 2 million tonnes (10 times higher) (see *Table 7*). This huge gap is representative of the inaccuracy in industry-reported data, and thus the need for such a model at the regulator's end is crucial.

While the countries face challenges in gathering data, there are good practices already in progress in some parts of Africa. These good practices could be a model for other countries and regions looking to incorporate waste circularity into their economy. Replicating and scaling of such good practices could aid in reducing emissions from the manufacturing sector, which contributes approximately 30–40 per cent of total continent's carbon emissions. Many such practices are also supported by international groups aligning to Africa's transition towards a circular economy. Some of these good practices are discussed in detail in the following sections.

INTERNATIONAL SUPPORT FOR CIRCULARITY IN AFRICA

Marine Plastic Reduction (IUCN-MARPLASTICCS): Active in Kenya, Mozambique and South Africa, promoting waste collection, recycling and circular solutions to tackle marine plastic pollution.

Rwanda Hazardous Waste Management Project (UNDP-GEF): A US $7 million initiative from 2022 to 2027 enhancing hazardous waste management to protect environmental and human health.

Ethiopia's National E-Waste Strategy (UNIDO and partners): Establishes Ethiopia as a regional e-waste hub, providing training and secure handling of non-recyclable materials.

Ghana Waste Fair (UNDP and Coca-Cola Foundation): A national platform connecting stakeholders, entrepreneurs and policymakers to advance circular business models.

Ethiopia's Circular Economy in Textiles (GEF-UNIDO): A five-year project promoting circularity in Ethiopia's textile and garment sector by focusing on sustainable chemical and waste management.

Egypt and North Africa's SwitchMed Programme (UNIDO and UNEP): Supports sustainable consumption and production policies in Egypt, Tunisia, Morocco and Algeria to reduce industrial waste.

2.2 Good practices on industrial waste circularity

1. Waste utilization as fuel in cement manufacturing

As of 2021, Africa's continent-wide cement industry had a production capacity of 386.1 million tonnes per annum, or 5 per cent of global production. The capacity is largely concentrated within 10 countries accounting for 73 per cent of the continent's cement output. Historically a leader in Africa's cement industry, Nigeria possesses the largest cement industries within West Africa amounting to a merged cement capacity of 58.9 million tonnes per year (MT/year).[12] The country has three significant cement producers: Dangote Cement Plc, which holds 60 per cent of the domestic market and is also the largest cement producer in sub-Saharan Africa, BUA Cement, which stands second with a 20.4 per cent of domestic market share, closely followed by Lafarge with 19.5 per cent of the domestic market and a few smaller players.[13]

According to the National GHG Inventory report, 2021, Nigeria's cement sector emitted approximately 5,240 gigagrams (5.24 million tonnes) of CO_2 in 2017, an increase of 86 per cent from 2007 emissions.[14] These figures highlight the significant rise in the GHG emissions by the sector. Nigeria's cement industry traditionally uses natural gas, imported and domestic coal, and some domestic petroleum as a fuel for processing limestone into clinker.

The cement industry can contribute to the circular economy largely by virtue of co-processing. Co-processing is a process of utilizing waste from various industries as an alternative fuel in the kiln—also called alternative fuel resource (AFR)—by the cement industry. Due to high temperature of the kilns in the cement industry, the incineration of this waste leaves no residues and thus the cement industry in a way acts as a sink for different kinds of waste generated by various industrial sectors, including municipal solid waste.

Lafarge Africa has taken the lead among Nigeria's cement companies on the use of non-fossil fuels in its plants. The drive has been led by Lafarge Africa's alternative fuels subsidiary, Geocycle, which co-processes industrial waste, agricultural waste, tyre chips, biomass and even synthetic hairs to power its kiln as an alternative fuel.

Lafarge's cement plant at Ewerko has a production capacity of 3.5 million tonnes per annum. The plant utilizes 0.33 million tonnes of fuel annually in the process, which includes 0.11 million tonnes of natural gas/heavy fuel oil and 0.21 million tonnes of alternative fuel. The industry utilizes a wide variety of waste as AFR such as palm kernel shell, carbon black, shredded tyres/tyre crumbs, shredded plastics and laminates, and agricultural residues in the form of rice husk and saw dust.

Types of waste used as alternative fuel resources (AFRs) by Lafarge

Process

The plant has a laboratory set up for evaluating the properties of the waste received by the plant. The received waste is stored in the pre-processing area, with different sections allocated for storage of different kinds of waste streams. Depending on the requirement of the fuel, a 'homogenous mix' is prepared by mixing different waste streams to make it suitable for co-processing in cement kilns. This homogenous mixture is then fed to the kiln through a conveyor belt along with the natural gas/ heavy fuel oil.

Different types of waste are shredded and stored as separate piles

The utilization of AFR has resulted in multifold benefits for Lafarge.

Re-routing of waste from dumpsite: The waste utilized by the industry was earlier being dumped at the dumpsite. Currently, the industry uses 0.21 million tonnes/annum of solid waste as fuel in their process, thus diverting this quantum of waste from dumpsites.

Africa generated approximately 174 million tonnes of municipal solid waste (MSW) in 2016, and is projected to reach 244 million tonnes by 2025.[15] With the adoption of increase in the use of solid waste as AFR by cement industries, a large amount can be diverted from the landfill sites.

Saving on fossil fuel: With the utilization of these AFR, the industry is able to replace 32,912 tonnes of natural gas and 15,485 tonnes of heavy fuel oil annually which in return results in saving of **0.16 million tonnes of CO_2 emissions** (assuming emissions factor of 56,100 kg of CO_2 emissions per terajoule (TJ) for natural gas and 77,400 kg of CO_2 emissions per TJ for heavy fuel oil).

2. Waste tyres to tiles

End-of-life tyre (ELT) or scrap tyre refers to a tyre that has exhausted all its reuse options. These tyres are usually discarded in landfills, stockpiled or burned in open fields. These discarded tyres pose significant environmental threats due to their large volume and non-biodegradable characteristics. Various studies have quantified disposal of approximately 1–1.8 billion used tyres worldwide each year.[16] Nigeria, being a fast developing nation, is also observing a rapid increase in the importation and purchase of all forms of motor vehicles. This consumption pattern has caused an increase in the amount of scrap tyres, with an annual generation reaching approximately 259 million.[17]

As the struggle to manage these ELTs continues, FREEE Recycle Limited has launched an innovative idea aiming to solve the problem of waste tyres by converting them into reusable rubber-moulded products. FREEE Recycle Ltd is a waste recycling and rubber manufacturing facility situated in Oyo state of Nigeria. The facility has established an integrated recycling and manufacturing (IRM) facility that diverts waste tyres from landfills and open dumping grounds and transforms them into valuable crumb rubber that becomes feedstock for their manufacturing operations. Having commenced operations in November 2020, the company has so far successfully recycled over 250,000 waste tyres into finished rubber products and aims to increase recycling to 5 million scrap tyres annually.

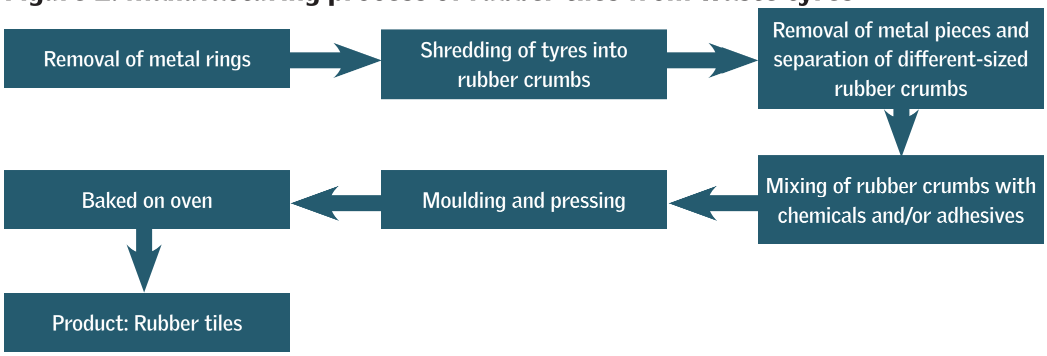
Crushed rubber crumbs are moulded and baked to prepare rubber tiles

Process followed

The facility receives waste tyres either from registered aggregators who get it sourced from vulcanizers or through the Extended Consumer Responsibility (ECR) initiative where corporate organizations are encouraged to send their waste tyres for an eco-friendly recycling. Tyres generally consist of rubber, steel and fibre; thus for the processing, first the metal rings are removed and the rubber part is fed into the shredder to make rubber crumbs. The shredded crumbs are passed through a vibrator where the rubber crumbs are separated from rubber powder and fibre with further removal of small metal pieces by magnetic separator. The separated rubber crumbs are then mixed with chemicals to enable moulding in the preferred shape and sent for mechanical pressing. The moulded rubber is then placed in an oven to dry. The output from the oven is the final product, i.e. rubber tiles (see *Figure 2: Manufacturing process of rubber tiles from waste tyres*).

The industry currently recycles approximately 90,000 tyres annually and through its operation is able to save more than 8,100 tonnes of CO_2 emissions as shared by the industry.

Figure 2: Manufacturing process of rubber tiles from waste tyres



Source: Centre for Science and Environment

Apart from being a recycling industry, the unit claims to be a zero-waste generator. The whole process of changing tyres into rubber tiles generates metal chips, fibre and metal rings. The processing generates approximately 120 tonnes of fibre and 170 tonnes of metal chips annually. The generated fibre is sent to the Lafarge cement plant for co-processing as fuel. The metal rings removed from the tyre and the metal chips are sent to the metal recyclers. The industry however has plans to set up a smelting unit for production of ingots from the metal rings.

Considering Nigeria's current waste tyre generation of 259 million, upscaling of such good practice has the potential of reducing approximately **23 million tonnes of GHG emissions of the country.**

3. Aluminium scrap to alloys

Aluminium offers numerous benefits over ferrous materials, including ductility, malleability, corrosion resistance, superior conductivity, low density and, most notably, recyclability. The recyclability of aluminium is a critical factor that contributes to its extensive utilization in the manufacturing industry, particularly in the automotive sector. Moreover, the energy requirement in the production of aluminium, which involves extracting bauxite (a primary resource), is nearly 10 times higher than that of steel production, resulting in virgin aluminium being five times more expensive than steel.[18]

In contrast, aluminium recycling is both cost-effective and energy efficient when compared to primary resource utilization. Production of a given mass of aluminium from recycled scrap is estimated to require only 5 per cent of the energy needed to produce the same mass from bauxite. Moreover, aluminium can be smelted and shaped an infinite number of times without losing its quality. This makes aluminium a renewable raw material with an unbeatable environmental footprint.

Africa represents a fifth of the global population and is considered a mining force, but the continent produces only about 1 per cent of the world's secondary aluminium. The entire continent has a total of only 50 metal recycling facilities.[19] Nigeria, being the most industrialized country in Africa, is estimated to recycle only 13 per cent of recyclable goods, with almost no formal waste diversion process in place.

Terra Alloy is one such facility involved in the recycling of aluminium waste to alloys. The facility, based in Ogun state of Nigeria, sources raw materials from local community/vendors. The raw material includes beverage cans, aluminum scraps, car radiators, silicon metals, cover flux, and other metal scraps. Terra's state-of-the-art machines, including the Skelner furnace and silicon carbide crucible, allow it to efficiently process these materials and transform them into high-quality aluminum alloy ingots and used beverage cans ingots. Currently the facility has an installed capacity of 8,600 tonnes/month and receives approximately 3,000 tonnes of aluminium waste monthly. It uses natural gas as a fuel for operating the plant, with a monthly consumption of 73,658 standard cubic metre (SCM).

Shredded scrap waste to feed in furnace

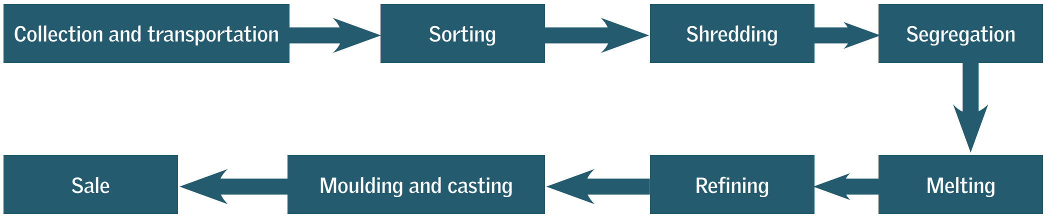
Ready aluminium alloys from scrap waste

Process

On receipt of the aluminium scrap in the facility, the waste is first sorted either manually or via the auto-sorting plant to remove other metals. The sorted aluminium is then shredded into smaller pieces and is further segregated through magnetic separators to remove iron and other metal pieces. The segregated aluminium scrap is loaded in the furnace for melting. Any iron material charged in the furnace, which could not be removed during sorting, is removed from the furnace in the form of white iron. The purified aluminium is poured in iron moulds and cast into aluminium ingots which are then bundled and prepared for sale (see *Figure 3: Manufacturing process of aluminium alloys from scrap*).

The aluminium melting process generates dross as a waste which contains some traces of aluminium. The facility has an additional dross-processing unit where dross is further reprocessed to extract more aluminium. The aluminium ingot from this reprocessing is called the dross blocks or dross ingots. These dross blocks are used as correction material at Skelner furnaces. The waste from dross melting produces dross sand which still has remnants of aluminium.

Figure 3: Manufacturing process of aluminium alloys from scrap



Source: Centre for Science and Environment

The facility in this recycling process generates approximately 600 tonnes of aluminium dross, 3,000 tonnes of white iron and 180 tonnes of dross sand as waste annually. While 70 per cent of the dross is used in producing dross blocks, 30 per cent is sold; 100 per cent of the white iron and dross sand are sold to the other vendors.[20]

The facility has plans for expansion both in terms of diversification in the metals recycled and the production capacity. It has recently obtained funding of EUR 9 million, after which it will become the country's largest and first industrial-scale aluminium recycler. With such large-scale production, the facility estimates to **cut carbon emissions equivalent to removing 100,000 passenger vehicles from the road**.[21]

Nigeria generates approximately 160,000 tonnes of aluminium scrap annually, as shared by Terra Alloy, and the country exported 6,817 tonnes of aluminium scrap to other countries in 2023, according to a 2023 World Bank report.[22] Nigeria needs more such facilities in-house to manage the waste within the country and reap both the economic and climate change benefits.

4. Used battery to metal alloys

Lead-acid batteries are globally the dominant battery type, used in motor vehicles, backup power systems and industrial applications. The escalating global demand for electronic devices and electric vehicles has led to a significant increase in battery usage, amplifying the need for efficient battery recycling solutions.

Africa generates over 1.17 million tonnes[23] of waste lead-acid batteries (WLABs) annually, comprising 1 million tonnes from vehicles and 0.17 million tonnes from uninterrupted power supplies (UPSs). A significant portion of this waste is currently processed through informal recycling methods. Studies estimate that there are approximately 7,000[24] informal lead-acid battery processing sites across the continent. Informal lead-acid battery recycling which includes dismantling batteries and melting down the material in open vessels or crude furnaces releases lead dust and fumes and due to lack of any pollution control measurement it poses detrimental health and environment risks. The informal practices also result in 50 per cent of the lead being lost to the environment. Thus, improving the recycling practices will not only provide significant energy savings but will also result in less greenhouse gas emissions.

Nigeria, the largest economy and most populous country in Africa, is central to battery recycling. The country generates the highest volume of used batteries in the continent accounting for approximately 0.1–0.2 million tonnes annually.[25] Thus, the country is also home to the largest lead-acid battery recycling industries in Sub-Saharan Africa having at least ten industrial scale battery recycle facilities, recovering raw materials such as lead, tin and antimony.[26]

One such facility is Hanushi Manufacturing Limited, a leading lead smelter facility in Nigeria. The industry extracts lead from the waste batteries or other lead scraps and produces lead alloys which is again sent to battery manufacturers or secondary lead smelters. The industry itself also makes fresh lead batteries from the produced lead alloy. With the monthly processing capacity of 400 tonnes of waste lead-acid batteries (LAB), the industry produces 600 tonnes of lead alloy in a month and 10,000 units of new lead batteries.

Manual dismantling of waste batteries at Hanushi Manufacturing

Process

The received LABs are dismantled to separate lead components, plastic casings, and electrolytes. The liquid, if any, is collected and diverted to ETP. The extracted lead plates are fed into smelters, where they are melted and refined to remove impurities. This molten lead is then casted and molded into alloys, which is sold and also serves as raw material for new battery production.

The process generates plastic waste, dross/slag and ETP sludge. Plastic waste (100 tonnes/month) is crushed into pellets and sold to recyclers whereas slag (30 tonnes/month) and ETP sludge (5 tonnes/month) is sent to Ogun Environmental Protection Agency (OGEPA) for safe management.

Moulded lead blocks made from scrap at Hanushi Manufacturing

According to a recent study, extraction of lead from secondary source (batteries) results in reduction in CO_2 emissions by 73 per cent as compared to its extraction from primary source (virgin ore). While the primary source extraction generates 2,445 kg CO_2 per tonne of metal, the secondary source extraction generates 650 kg of CO_2 per tonne of metal. Thus, a total of 1,795 kg of CO_2 is saved on every tonne of lead extracted from secondary sources.[27] With this context, Hanushi is able to save approximately **13,000 tonnes of CO_2 emissions annually through its process.** Thus, the industry not only reduces environmental and public health issues associated with informal smelting but also contributes in reducing GHG emissions of the country serving as a model for other similar facilities.

Extrapolating this saving to the continent level will be able to **reduce 3.24 million tonnes of CO_2 emissions annually**, considering 100 per cent recycling of 1.17 million tonnes of LAB generated in Africa.

5. Glass waste recycling

Glass is one of the most recyclable materials in the world, capable of being endlessly repurposed without losing its quality. Yet, despite its sustainability potential, global glass recycling remains low—of the 130 million tonnes of glass produced annually, only 27 million tonnes is recycled, a mere 21 per cent recovery rate.[28] At the same time, rapid urbanization and industrial growth is driving increased consumption of bottled beverages, pharmaceuticals and packaged food products, further escalating generation of glass waste. This inefficiency contributes to excessive energy consumption, as manufacturing new glass requires significantly more energy than recycling. Although glass waste comprises 4 per cent of generated municipal waste in Africa, this small percentage adds up to large volumes of non-degradable waste in landfills since the glass persists in landfills indefinitely.

Kenya presents an example of this challenge, with a generation of approximately 204,000[29] tonnes of glass waste annually and only about 30 per cent of this waste currently recovered for recycling and reuse. Emerging recycling efforts are required to not only mitigate environmental harm and reduce pressure on landfills but also to conserve raw materials, lower carbon emissions and unlock the economic benefits of recycling.

One such innovative glass recycling effort is operationalized by Ardagh Glass Packaging–Africa (AGP–A), a glass production facility in Nairobi, Kenya. Established in 2022, the facility serves the food, beverage and pharmaceutical industries by providing a wide variety of glass packaging bottles and jars. The facility receives around 15,000 tonnes of waste glass (cullet) annually and accepts only transparent, amber and green bottle glass waste. The annual production of AGP-A is currently 34,000 tonnes; the difference between the quantity of waste glass received and the fresh glass produced is attributed due to addition of other raw materials.[30]

Process

On receipt of waste glass sorted into clear, green and amber glass. Based on the colour of bottle to be manufactured, specific glass waste is added with other raw materials like limestone, soda ash and sand. For green-coloured products, chrome is added while for amber-coloured products amber is added. The mixture gets crushed in the crusher and then fired in the furnace at 1500°C. The molten glass is then moulded in the required shapes and cooled down. The final products are packed and dispatched.

For preparation of transparent bottles, the facility is able to use 70 per cent of the cullet while for coloured glass bottles, up to 75 per cent of the cullet is utilized. In the transition phase, when the colour of the product needs to be changed, the percentage of cullet feed is increased gradually per week (30 per cent, 35 per cent etc.) to reach 75 per cent. The quantity of other raw material is increased till the desired colour is obtained. The product coming out of the furnace during the transition phase is the waste. Currently, the facility generates 300 tonnes of this waste annually which is sent to landfill. However, the company has a target to achieve zero waste to landfill by 2025.

By using waste glass, the facility is able to lower the required melting temperature for glass production, leading to energy savings. For each 10 per cent increase in cullet in the feed mixture, energy needs drop by nearly 3 per cent.[31] The recycling process also leads to a reduction in natural resource consumption and GHG emissions. Every tonne of glass recycled conserves approximately 1 tonne of natural resources in the form of sand, soda ash and limestone. Similarly, 1 tonne of CO_2 emissions is reduced for every 6 tonnes of glass recycled.[32]

Considering the above criteria, the efforts by AGP-A enables **an annual reduction of 2,500 tonnes of CO_2 emissions and 15,000 tonnes of natural resources.** Enhancing such initiatives can help in further lowering the GHG emissions.

Considering the 100 per cent recycling of generated glass waste in Kenya, the country has the potential to reduce **33,000 tonnes of GHG emissions annually.**

6. Sugar waste recycling

Sugar cane processing generates three main types of waste: bagasse, molasses and filter mud. Bagasse comes from crushing sugarcane to extract juice, molasses is left after sugar crystallization, and filter mud is a residue from juice filtration. If not managed properly, these wastes contribute to air, water and soil pollution—bagasse burning releases greenhouse gases, molasses runoff contaminates water sources, and filter mud disposal can lead to soil degradation. The sugar industry produces around 279 million tonnes of sugar cane waste globally each year.[33] Africa contributes approximately 5 per cent[34] of global sugar cane production, with 83 per cent of this output coming from Sub-Saharan Africa. Uganda, as a key sugar cane producer in the Sub-Saharan region, plays a significant role in meeting regional sugar cane demands. This is highlighted by the fact that the country's production has seen a significant increase, rising from 1.5 million tonnes in 2000 to 5.8 million tonnes in 2020.[35]

This increased production has also resulted in an increased amount of waste generation from the process. A sugar industry in Uganda has incorporated innovative ways to manage this waste in a sustainable manner. The Sugar Corporation of Uganda Limited (SCOUL), operational since 1926, is one of Uganda's leading sugar manufacturers under the Lugazi Sugar brand. With an annual production capacity of 100,000 tonnes, the company plays a significant role in Uganda's economy and is one of the largest employers in the country.

Process

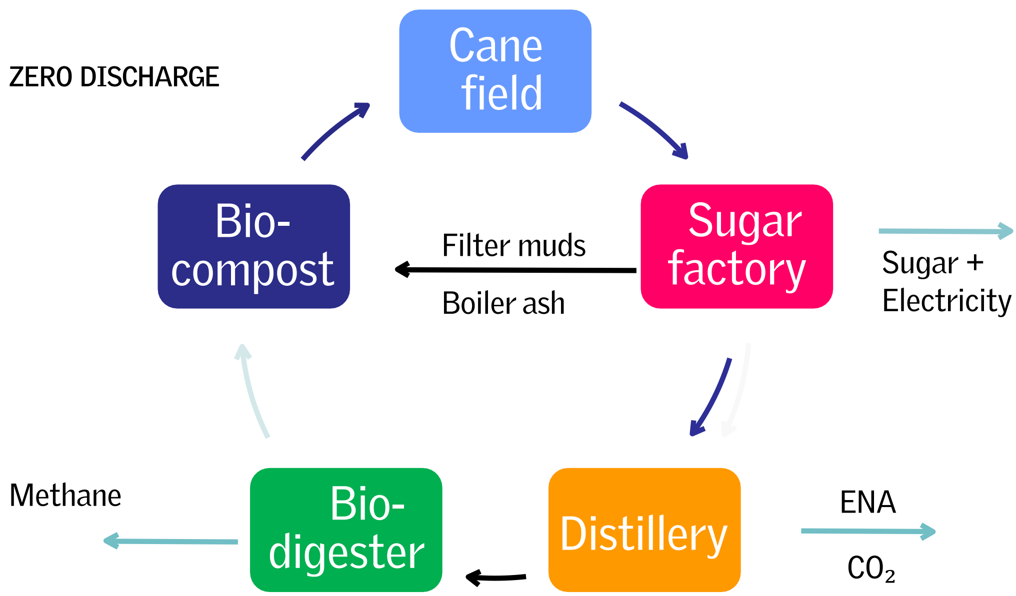
The sugar manufacturing involves the crushing of sugar cane to extract juice, which undergoes processing to produce sugar. This process generates three major byproducts: bagasse, molasses and filter mud. SCOUL has a 30 MW in-house power plant and the generated 3.7 million tonnes/annum of bagasse is fed in the boilers to generate electricity. Generated steam is used for sugar processing, while 24 MW of electricity is supplied to the national grid. This creates an additional revenue stream for the company.

The generated molasses is diluted and fermented in the in-house distillery with a capacity of 45,000 litres to produce 30,000 litres of extra neutral alcohol. The facility previously used demineralized water for this dilution process, but now with the new intervention it reuses spent wash as the diluter instead of water. The facility generated 18,921 cubic metre of spent wash annually, which was sent to the effluent treatment plant (ETP) for treatment. With this intervention, the facility is able to save 18,921 cubic metre of demineralized (DM) water, the cost of pumping the DM water (US $6,650) and the cost of treating the spent wash in the ETP.

The concentrated spent wash generated after dilution is processed through anaerobic digestion, which generates methane gas. The methane is burned in boilers to generate additional steam which is used to run the distillation plant. With the use of this steam, the distillery becomes self-sufficient, thereby reducing fossil fuel dependency. This is SCOUL's Clean Development Mechanism (CDM) project; SCOUL earns carbon credits from this. The fermentation process in the distillery generates CO_2, which is captured, purified and converted into food-grade CO_2. The purified CO_2 is compressed into dry ice and supplied to the beverage and transport industries. The facility generates 10 tonnes of CO_2 per day with this intervention, which adds to the revenue and also cuts down on approximately **3,300 tonnes of CO_2 emissions into the environment.**

After all the above recycling, the final waste generated from the facility includes boiler ash, spent wash and filter mud. This waste is converted into bio-compost

Figure 4: Circularity model adopted for sugar manufacturing



Source: Sugar Corporation of Uganda Limited

which is then used in sugar cane fields, enhancing both soil health and sustainability (see *Figure 4: Circularity model adopted for sugar manufacturing*). According to SCOUL, this has resulted in reduction of fertilizer use in sugar cane fields by 40 per cent and an increase of cane yield by 30 per cent.

SCOUL's integrated waste management approach demonstrates how industrial byproducts can be repurposed to enhance energy efficiency, reduce environmental impact, and create economic value. By optimizing waste utilization across multiple industries—from renewable energy generation to carbon capture and fertilizer production—SCOUL serves as a model for sustainable sugar manufacturing in Uganda and beyond.

7. Cashew waste to oil

Global cashew nut production has experienced significant growth, more than doubling during 2000–18.[36] This surge was primarily driven by increasing consumer demand, particularly in health-conscious markets.

As demand surged, Africa has emerged as a key supplier, producing more than half of the global raw cashew nut output. It has seen a drastic growth from having the third of the global cashew harvest area in early 2000 to having the cashew harvest area almost twice of all other parts of the world summed together. In 2019, the continent produced about 2.33 million tonnes of raw cashew nut (RCN),[37] with two-thirds of the production contributed by just four countries—Côte d'Ivoire (34 per cent), Burundi (12 per cent), Tanzania (10 per cent) and Benin (9 per cent).

In 2022, Tanzania produced approximately 216,907 tonnes of cashew nut, representing about 20 per cent of Africa's total cashew production. By 2024–25, production almost doubled, reaching approximately 408,600 tonnes[38] underscoring Tanzania's significant role in the industry. This growth in production has also resulted in an increase in waste, particularly cashew nut shell (CNS), which constitutes a significant portion of the nut's total weight.

Cashew is exported in two forms: with shell and shelled. The first form is unshelled RCN with no further processing after harvesting except drying and packaging. Whereas the shelled cashew nut is semi-processed, i.e. the shell is removed and the edible part, called kernel, is exported. Cashew nut shelling requires technology and skill to avoid harming humans due to the consumption of improperly processed cashew nuts. The shell contains an acidic oil that can burn human skin and produce toxic fumes when burnt.[39]

Thus, in the absence of proper management strategies, the increasing volume of CNS waste presents a challenge for both sustainability and public health.

Tan-Ko Mirae Green Company Limited in Pwani, Tanzania, has developed a system to convert this CNS waste into biofuel and industrial products, promoting industrial circularity and mitigating harm. The facility was operationalized in 2023, with an annual processing capacity of 3,000–4,000 tonnes of raw cashew nut. With over 35 years' experience in the chemical supply business and an international market network, the company has now established a cashew nut shell liquid manufacturing plant and a charcoal briquette production plant. The company also plans to produce biochar, a combination of biomass and charcoal, which will serve as an eco-friendly soil enhancer.

Process

The facility sources shell waste from cashew processing factories in Tanzania. The shells are crushed to produce oil terms as cashew nut shell liquid (CNSL). CNSL is environmentally friendly bio heavy oil and consists of 70 per cent anacardic acid, 5 per cent cardanol, and 18 per cent cardol, making it suitable for power plant, braking systems, paint manufacturing and to treat dermatological disorders. The facility produces 2,500–3,000 tonnes of CNSL annually.

The cashew nut shell (CNS) residue after extraction of oil is crushed in a roller crusher. In order to make high-quality charcoal briquettes, the shell has to be crushed into pieces smaller than 5 mm. The crushed pieces are then dried to reduce the moisture content required for briquette formation. These pieces are then moulded and pressed in a ball press and finally fed into the dryer for three to four hours at 135°C to get the final product. The briquettes obtained are immediately packed or stored in silos. Currently, 2,700 tonnes of briquettes/charcoal flakes are produced annually by the facility. The facility produces 2,700 tonnes of charcoal flakes/briquettes every year, reducing reliance on wood-based charcoal.

Burning of cashew nut shell releases approximately 0.1 tonnes of CO per tonne of shell. By this initiative, the company is **saving 400 tonnes of CO_2 emissions**. Tan-Ko Mirae Green Company's initiative demonstrates how industrial waste can be repurposed into fuel and commercial products, reducing pollution and promoting renewable energy.

Considering Africa's 2019 data where it generated 2.33 million tonnes of cashew nut, the upscaling of such practice at the continent level has the potential to **save 0.23 million tonnes of GHG emissions.**

8. E-waste recycling

E-waste is generated from discarded electronic devices, including computers, mobile phones, televisions and household appliances, and it has become one of the fastest-growing waste streams globally. In 2022, the world generated approximately 62 million tonnes of e-waste, a figure projected to reach 82 million tonnes by 2030.[40] This surge is primarily driven by rapid technological advancements, increased consumer demand for electronic devices, and shortened product life cycles. This increase is reflected in the continent of Africa as well, where in 2022 approximately 3.6 million tonnes of e-waste was generated, an increase from 2.9 million tonnes in 2019.[41]

Dumping e-waste in landfills causes soil contamination as heavy metals like lead and cadmium seep into the ground, affecting plant and food systems. Water pollution occurs when these toxins leach into groundwater, contaminating drinking sources and aquatic life. Air pollution results from the release of volatile organic compounds (VOCs) and persistent organic pollutants (POPs), degrading air quality. Exposure to e-waste toxins from landfill sites can cause neurological damage, respiratory diseases, cancer risk and developmental issues in children,[42] who are usually the informal waste-pickers. Recycling e-waste therefore not only extends the lifespan of electronic components, it also prevents harming entire ecosystems and aids in public health management.

Kenya, as a developing country in Africa, is also experiencing a notable increase in e-waste. The country generates approximately 51,300 tonnes of e-waste annually, yet less than 5 per cent is formally recycled[43]and the remaining 95 per cent often ends up in informal dumpsites.

Taking into consideration the growing issue of e-waste mismanagement, a recycling centre was established in Nairobi in 2012. The Waste Electrical and Electronic Equipment (WEEE) Centre, one of Africa's largest ISO-certified e-waste management facilities, processes all types of e-waste to recover materials, minimize waste and ensure safe disposal. The centre has recycled nearly 10,000 tonnes since its inception in 2012. Through its operations, it has also spurred job creation in the recycling sector, providing employment opportunities and fostering economic growth within local communities.

Dismantling of cathode rube tube monitors at Waste Electrical and Electronic Equipment (WEEE)

Process

The WEEE Centre collaborates with various partners, including corporations, schools, and individuals, to collect electronic waste, and receives approximately 35–50 tonnes[44] of e-waste in a month from these collaborators. The received e-waste undergoes inventory registration, after which the waste is evaluated, and reusables and recyclable items are sorted. Functional e-waste is refurbished, tested for quality and redistributed, often to educational institutions and community centres, thereby extending the lifespan of electronic devices. Non-functional items are dismantled, disassembled and sorted to segregate components such as metals, plastics and circuit boards, facilitating efficient recycling and material recovery. The sorted components get upcycled, reused and recycled in various streams.

Plastic and glass material is shredded and mixed with adhesives to produce construction blocks and poles. Non-processable waste like printed circuit boards (PCBs) are sent to global certified recycling facilities for safe disposal. The centre has plans to expand the recycling to urban mining where high-value components like gold and palladium will be extracted from end-of-life electronics and circuit boards via specialized treatments. Another expansion which the centre is planning is to re-manufacture lithium ion batteries, which can be used in e-mobility and lighting.

Cathode-ray tube (CRT) monitors are one of the biggest components of e-waste due to their replacement by newer technologies. They are bulky and their disposal is complex, with each part processed separately and some of these parts containing hazardous materials including lead, cadmium, phosphorus, mercury and beryllium. According to the WEEE Centre, an estimated 40,000 units are disposed of annually, which require processing.[45] Cathode-ray tubes require separate processing of the front panel and funnel glass. The lead-free panel glass, which is 80 per cent of the CRT glass, is removed in the specialized CRT machine. The removed glass is sent to glass recyclers, where art pieces and household glassware are created from recycled glass. The centre currently processes 250 tonnes of CRT annually, and aims to expand its capacity to 500 tonnes.

Through this structured approach, the centre not only mitigates the environmental impact of electronic waste but also contributes to the circular economy by recovering valuable materials and promoting the reuse of electronic devices. Every tonne of e-waste managed results in the reduction of 1.44 tonnes of CO_2 emissions; thus these practices have enabled the centre to prevent **14,400 tonnes[46] of CO_2 emissions** along with reduction in landfill waste by managing 10,000 tonnes of e-waste.

At the continent level, e-waste recycling, if done 100 per cent, has the potential to save **5.2 million tonnes of annual GHG emissions**.

9. Paper recycling

In rapidly growing economies, the surge in consumption of packaging, office supplies and print media has led to a corresponding increase in paper production. This escalation has, in turn, increased the generation of paper waste. Such waste originates from discarded materials like packaging, office documents, newspapers and industrial byproducts, encompassing items such as cardboard, office paper and mixed paper.

Globally, approximately 420 million tonnes of paper[47] and cardboard are produced annually, with over half of the raw materials sourced from recovered paper. As for Africa, in 2019, the continent produced about 3 million tonnes of paper,[48] while its total consumption stood at 8 million tonnes, leaving a 5-million-tonne deficit largely covered by imports.

Some of the largest producers, such as South Africa and Egypt, have sustained domestic production, but many others, including Kenya, have seen a steep decline. In Kenya, the paper industry has experienced a decline over the years, primarily due to the industry's dependence on fibrous wood and insufficient raw material supplies due to deforestation, along with the use of outdated technology. In 2019, the country's total production of pulp, paper and paperboard was reported as negligible, with no significant output recorded.[49] However, the demand for paper products in the country remains intact. To bridge the gap between local supply and demand, Kenya has increasingly relied on imports. This is evident as the country observed an increase of 17.6 per cent[50] in paper imports between 2021 and 2022, which is the second largest growth for imports that year in Kenya. Such a high increase of imports signals a struggle in Kenya's domestic paper production to keep up with demand. This rising dependence on imports makes the country vulnerable to global price shocks and supply disruptions.

Since the growing demand of paper results in equally high quantities of waste paper generation, it presents an opportunity for revival for the country. By leveraging the increasing volumes of wastepaper generated, Kenya could develop a circular economy in the paper sector. This would reduce dependence on virgin raw materials, ease pressure on natural resources, and create a more sustainable and resilient local industry.

Kenya's MegaPaper and Boards Ltd has such a facility where waste paper is recycled to make cartons, envelopes, paper bags and egg trays. The company, operating since 2015 in the Nakuru region of Kenya, processes 24,000 tonnes of waste paper annually.[51]

Process

On receipt of waste paper at the facility, it is first sorted, with the non-paper materials removed. The sorted paper is shredded and fed into the pulper to produce pulp. Pulping is the process of breaking down the paper fibres by means of chemicals and water into a liquid form termed as pulp. Once the pulp is produced, it is passed through a series of screens to remove larger pieces of contaminants. The clean pulp material is then mixed with new pulp to enable solidifying of the slurry and form a firmer end product. As the pulp dries, it is passed through an automated machine that presses out excess water. The solid pulp is then passed through steam-heated cylinders that facilitate the formation of flattened long rolls of continuous sheets of paper. These sheets are further used for preparation of cartons, boxes and other products. 90–95 per cent of the waste sludge generated from the process is reused within the facility to make egg trays. The remaining industrial waste is disposed of in Nakuru's municipal dump site.

The facility, with its process of using waste paper, prevents the need for approximately **350,000 cubic metre of wood-derived pulp** thereby reducing both deforestation and waste dumping. The reusing of produced waste within the facility additionally aids in minimizing landfill waste. The Mega Paper recycling plant demonstrates effective use of circularity that aids in reducing the impact on virgin resources.

Another similar practice is adopted by Chandaria industries in Kenya which recycles waste paper to produce tissue paper. Generally, 100 tonnes of paper waste produces 60 tons of recycled tissue. With an annual processing capacity of 48,000 tonnes, the facility claims to have saved **22 million trees through** its 31 years of operation.[52]

The discussed good practices highlight how innovative waste management can transform industrial byproducts or waste into valuable resources thereby reducing environmental impacts while also generating economic benefits by creating new revenue streams. By adopting circular economy principles, these initiatives not only minimize waste, but also aid in reducing greenhouse gas emissions.

As previously mentioned, Africa's manufacturing sector emitted about 440 megatonnes of carbon dioxide equivalent ($MtCO_2e$) in 2018. In the business-as-usual scenario these emissions are expected to double, reaching 830 $MtCO_2e$ by 2050. Scaling up the circularity models in industrial waste has a huge potential in reducing significant amounts of GHG emissions at the continent level. For instance, assuming 100 per cent recycling of only four types of industrial waste, Africa has the potential to reduce 8.7 million tonnes of CO_2 emissions, which is equivalent to 2 per cent of total GHG reduction (see *Table 8: Potential reduction in GHG emissions through various sectors*).

In order to adopt and elevate the circularity model, African countries need strong policies that support and encourage circular models, both financially and technologically, and provide a roadmap for improved implementation.

Table 8: Potential reduction in GHG emissions through various sectors

Industrial practice	Potential annual reduction in GHG emissions—Africa level (million tonnes)
Lead-acid battery recycling	3.24
Glass waste recycling	0.03
Cashew waste recycling	0.23
E-waste recycling	5.2
Total	8.7

Source: Data estimated by CSE

2.3 Notable policies and roadmaps in Africa

African nations are heading towards addressing the waste management issues by developing waste-management strategies, roadmaps for circular economies and even dedicated acts for waste management. This is a constructive effort.

Some of these policies, however, seem to provide broad approaches and fail to discuss any targeted actions for management of industrial waste. To a great extent, the focus is largely on Extended Producer Responsibility (EPR), which ensures that manufacturers take responsibility for their products at the end of their life cycle. However, EPR currently covers consumer end wastes such as plastics, e-waste and packaging materials and does not include industrial waste generated from the manufacturing process. Due to lack of concrete measures for recycling and reuse of industrial wastes, these wastes usually find their way to landfills instead of being repurposed. The next section gives a detailed analysis of a few existing policies for different African countries.

Malawi's National Waste Management Strategy (2019–23) focuses on improving waste management through an implementation matrix. It calls for developing and aligning policies with economic instruments to encourage better waste handling. It also recommends benchmarking waste management technologies and applying the most appropriate ones in the country. Moreover, it calls for providing equipment and transport for segregated waste, piloting waste segregation programmes, and introducing and upscaling best practices for waste recycling. Additionally, it highlights the need to set up recycling and waste treatment facilities as well as develop sanitary landfills to manage waste less hazardously. Finally, it proposes the creation of public awareness on waste-management options.

Beyond these broad initiatives, however, the strategy falls short in addressing specific industrial waste concerns. For instance, while the strategy defines different kinds of wastes, it lacks a directive for the development of waste inventorization for industry-specific waste streams. The absence of such a requirement gets demonstrated in the incomplete industrial waste data shared by Malawi with CSE. The data, which highlights three sugar industries in the country, lacks specific quantities for different waste types generated from these industries. Although the strategy document asks for upscaling of recycling practices, it is impossible to identify recycling opportunities or establish industrial symbiosis without information on the type and quantity of waste generated.

Moreover, the strategy doesn't clarify whether the concerned recycling practices are within the same industry itself, or if it includes the concept of industrial symbiosis, i.e. reuse between different industries. Inclusion of industrial symbiosis is critical as it will allow identification of waste synergies between various industries, where generated waste from one industry might not be usable within the same facility but could be used as raw material or fuel by another facility. A lack of clear focus on industrial symbiosis will lead to valuable waste being lost to landfills, as well as missed opportunities for virgin raw material conservation.

Further, the strategy lists the formulation of economic instruments as one of the priorities, but it does not detail what these instruments are, who they are applied to, and how they will be implemented. Economic instruments can be of various types—tax incentives, subsidies as well as penalties—and each one functions differently and influences industry actions in various ways. For instance, in the absence of any financial incentive schemes, industries will have little motivation to reuse their waste instead of dumping it, and even if they want to they won't have clarity on how or which specific way they would benefit financially from participating in industrial waste circularity.

Lastly, the strategy's focus on developing new sanitary landfills raises a key concern. While sanitary landfills are more acceptable than haphazard dumping, the primary goal should be to reduce reliance on landfills, whether existing or new. Although sanitary landfills prevent contamination issues from waste, they don't reduce waste, and the fundamental issue of loss of resources in the form of waste remains the same. More critically, if landfills remain the easiest option, there's no real push for industries to focus on reuse. This would perpetuate the system of waste disposal, instead of circularity.

Kenya's Environmental Management and Coordination (Waste Management) Regulations, (2024) is a Kenyan legal framework under the Environmental Management and Coordination Act. These regulations aim to establish a system for waste disposal, transportation and treatment, covering various types of waste. One of the salient features of this framework is the mandatory requirement of the development and maintenance of a national waste information system for recording data on the quantity and type of waste generated, transported, and reduced, reused, recycled or disposed of. This is a vital step towards addressing the significant gap in the progress of industrial waste circularity in the nation.

Oddly, however, the regulations place a disproportionate emphasis on waste disposal over reuse and recovery. The policy, for instance, mandates waste segregation, in terms of hazardous and non-hazardous waste and further into organic and non-organic fractions. Once segregated, the regulations, however, jump directly towards waste disposal, providing detailed procedures for handling, storage, transportation of waste, including structured formats for these processes as well as penalties for improper disposal. No similar provisions supporting manufacturing waste reuse exist in the regulations, which gives the impression of the country's prioritizing waste disposal over waste circularity. This regressive approach reinforces a linear model of waste management and misses a critical opportunity to guide industries towards reuse and recycling solutions.

In terms of industrial waste circularity, the regulations broadly touch upon the requirement of waste minimization through cleaner production methods, such as conserving raw materials and energy, reducing waste as well toxic emissions, and enabling the reuse and recovering of waste where possible. While these principles have the potential to significantly advance industrial waste circularity goals, the absence of directions in the policy hinders the achievement of these goals. Additionally, the policy fails to provide any financial incentives, infrastructure or technological support needed to adopt these cleaner production methods. With regards to industrial waste, the document reads like a passive set of suggestions, when it had the potential to be a transformative set of regulations that could have driven real change by guiding industries towards circular waste practices.

Contrary to the Environmental Management and Coordination (Waste Management) Regulations (2024), **Kenya's Sustainable Waste Management Act (2022)** focuses more strategically on waste circularity. The Act has called for the development of regulations prescribing the closure of open dumpsites and other procedures for sustainable waste management. It has also mandated the creation of regulations aimed at expanding the market for recycled products through incentives, government procurement preferences, and policies. The Act further mandates the creation of regulations for the formation of waste collection, materials recovery and recycling-oriented organizations. It requires waste to undergo sorting, segregation, composting and recycling at a material-recovery facility before transporting residual waste to disposal sites.

The Act showcases a valued aspect by addressing leveraging financial incentives to support the adoption of circular practices in the industry. It emphasizes the introduction of incentives for both locally produced and imported sustainable waste management equipment along with private investments in materials recovery and waste recycling activities. Further, the Act mandates prescribing incentives and developing regulations for the preferential use of recovered or recycled materials over newly manufactured materials with no recycled content. This focus ensures that financial incentives are directly integrated into regulatory frameworks, motivating industry participation in circular practices.

The Act also strengthens waste data accountability by mandating private sector entities to prepare a three-year waste management plan and submit annual monitoring reports detailing the quantity and the type of waste generation as well as waste management methods. The act also has introduced penalty provisions in case of non-compliance. This is an appreciable step as requiring private sector entities to report waste generation data regularly entails availability of consistent and reliable data with the regulators on waste management, which aids in developing waste inventory at the national level.

Finally, the act mandates the development of regulations for inter-county waste management partnerships. This is crucial since it will enable the potential of upscaling and replicating good management practices rather than working in silos. Additionally, through such partnerships, waste can be transported to regions with better processing capabilities, thus reducing landfill dependency overall.

South Africa's National Waste Management Strategy (2020) develops a comprehensive plan with specific targets: 40 per cent of waste diverted from landfills within five years, 55 per cent within 10 years, at least 70 per cent within 15 years, and zero waste to landfill beyond 2035. The document highlights that organic waste is the highest contributor (more than 50 per cent) to the total general waste disposed of in the country and thus this waste stream is prioritized for waste prevention and diversion from landfill. The country has relatively high rates of recycling for paper, plastics, glass, metals and tyres with room for improvement. In terms of hazardous waste by tonnage, fly ash at almost 66 per cent of the total, together with bottom ash (9 per cent), contribute 75 per cent of the total volume of hazardous waste. The country has low recycling rates for WEEE—less than 10 per cent—while lead-acid batteries have achieved lower rates of disposal to landfill. The strategy is thus premised on three outcomes, namely Waste Minimization, Effective and Sustainable Waste Services and Compliance, and Enforcement and Awareness. Thus, the strategy outlines a few key measures to achieve these outcomes.

The strategy first acknowledges that **collection of waste data** enables proper recording and tracking of waste in the value chain but also states that significant gaps exist in enforcement mechanisms and the design of the reporting framework leading to under-reporting of the waste data. Thus, the strategy calls for regulations that mandates waste data reporting from private sectors while emphasizing on enhancing reporting templates and providing training to improve reporting capacity. It is a positive step that the strategy not only recognizes the importance of better waste data, but also outlines a few concrete measures to do so.

The strategy also recognizes the **need for infrastructure** to support waste minimization and has emphasized financial requirements for developing facilities like Material Recovery Facilities (MRFs) and recycling processing plants. It also calls for private sector investment in waste minimization measures, including separation at source and recycling. Acknowledging this need is important because without adequate infrastructure, industries cannot divert the waste from landfills.

Further, this strategy emphasizes **industrial symbiosis** as a method to minimize waste. It sets performance indicators for the same, such as tracking the number of industrial symbiosis programmes in a region. The document, however, does not provide specific technical guidance discussing various possibilities in which industrial waste can be used. Without similar technical know-how for industrial waste, industries don't know what waste can be reused, how to process it, or who to exchange it with. Though the strategy requires developing and implementing best practice guidelines and standards for the reuse of Construction & Demolition (C&D) waste, it lacks similar proposals for other waste generated from industries. Many waste materials need treatment before reuse, but without guidance on technology or infrastructure, industries may remain stuck, and the concept of industrial symbiosis remains difficult to implement.

The strategy mentions that **financial mechanisms** already exist for municipal waste and that there is a need for expanding them. However, it is not detailed if this expansion of financial mechanisms will extend explicitly to industrial waste as well. As previously discussed, industries often face high costs in setting up reuse and recycling methods for their process waste. Extending financial mechanisms to focus towards industrial waste would encourage more industries to shift towards circular practices.

With the foundation laid by earlier policies—such as waste management acts—some countries have now moved a step further by developing Circular Economy (CE) Roadmaps to provide structured, sector-specific strategies for integrating circularity. **Rwanda, Nigeria and Ghana** have notably already taken steps in this direction, embedding circular economy principles into their national frameworks. This shift marks a transition from broad legislative efforts to more targeted roadmaps. While these documents signal progress, their impact in terms of industrial waste circularity depends on how effectively they address industrial waste and provide actionable strategies for the same, since the approach and focus of these roadmaps differ across countries.

Rwanda's Circular Economy Action Plan and Roadmap (2022) aims to provide a structured approach for the country's transition to a more circular economy over the next 14 years, until 2035. According to the roadmap, Rwanda's economy remains strongly dependent on agriculture (26 per cent) followed by the industrial sector (19 per cent) that includes construction and textile sector as key players. The roadmap outlines strategies for key sectors, but the priority sectors are limited to agriculture, waste, water and construction.

The roadmap addresses the need for a comprehensive and detailed overview of the total waste generated and its different waste streams as a prerequisite for successful and effective waste management, stating that only 2 per cent of the total waste generated in the country is currently recycled, which leaves a large economic potential unexploited. It also acknowledges that developing a data collection system for waste will facilitate the monitoring and assessment of the waste sector. For effective implementation of the data reporting, it provides the option of cancelling the contract of the waste collector or fines on individual stakeholders in case of every non-compliance. Despite the aforementioned requirements, the roadmap surprisingly largely focuses, with regard to waste management interventions, on municipal solid waste (MSW). Additionally, for construction and demolition waste (CDW), it emphasized on the need to characterize different types of CDW and to establish guidelines for recycling this waste.

Without a full accounting of the different waste streams, not including industrial waste—which currently contributes a considerable share and is likely to increase—in the circular economy measures leaves a significant gap, which makes the roadmap incomplete.

Turning to Ghana, its Circular Economy Roadmap and Action Plan, though not yet published, is in its final pre-publication form as of March 17, 2023. The roadmap claims to pave the way towards a circular economy for Ghana in the next 10 years, until 2033.

The roadmap acknowledges that Ghana's economy has seen a structural shift, with the primary sector (agriculture, mining, forestry and fisheries) shrinking from 39 per cent to 20 per cent of GDP during 2000–19, while the share of the service sector grew from 32 per cent to 46 per cent. During this decade, the country's secondary/industrial sector (including manufacturing, wood and agro-processing, and textile production) also witnessed a steady growth, expanding from 28 per cent to 34 per cent. The roadmap also highlights that, over the past two decades, Ghana's resource extraction has doubled, increasing from 100 million tonnes to 200 million tonnes in 2000–17.

Surprisingly, the roadmap focuses on six priority sectors, including waste, water, plastics, agriculture and food, built environment and textiles. While the waste sector discusses only municipal solid waste, the textile sector largely focuses on secondary textile imported into the country. None of the goals and action plans of the document integrate the industrial waste generated from the manufacturing process. This **absolute neglect of industrial waste in the CE roadmap** is completely contradictory to the highlighted growth of industrial development and increased resource usage in the country. Sidelining the industrial waste, which could drastically reduce natural resource extraction and waste dumping from landfills, in the CE model seems to be a half-hearted attempt rather than a comprehensive and forward-looking strategy. Given that the roadmap is yet to be published, it is imperative to reconsider the explicit inclusion of industrial wastes.

While Rwanda and Ghana's circular roadmap missed the industrial waste in their roadmaps, Nigeria has developed a robust CE Roadmap with a defined approach to industrial waste circularity. The roadmap (2024–33) aims to transition from a linear to a circular economy by 2050.

Nigeria's 2024 Circular Economy Roadmap is a comprehensive document that outlines seven priority sectors, each with its own set of goals. While earlier country roadmaps included the waste sector as a priority area, Nigeria explicitly **identified** and incorporated the **industrial and manufacturing** sector as one of the priority sectors, a key step towards achieving industrial waste circularity. The roadmap calls for the development of sector-specific policies across all waste streams and emphasizes the need to review and update industrial policies to integrate circular economy principles.

As this report highlights, availability of accurate and robust data forms the foundation of industrial circularity. Nigeria's roadmap underscores the same, recognizing that improving data availability, quality and frequency of collection is a prerequisite for transitioning to circularity. To this end, to enhance coordination in data collection and reporting, the roadmap calls for establishing standards and formats. Importantly, it assigns a short-term (two-year) timeline for these actions, clearly showcasing the mandatory requirement of this information before implementation of other plans.

The strategy stresses on the need to integrate circular infrastructure into industrial hubs and the development of dedicated financing options to support these circular infrastructure projects such as introduction of green bonds, carbon market and environmental offsets, Extended Producer Responsibility (EPR) etc.

Beyond infrastructure, the roadmap also focuses on the need for financial mechanisms, such as **developing incentives** to promote circular business, including modifications in tax laws to support cleaner production. The benefits to be included for green production are however not clearly defined.

An innovative tool proposed in the roadmap to promote circular industrial production is the introduction of **eco-labelling of circular products**. In line with this, the strategy calls for strengthening the markets for sustainable, recycled,

POLICIES ON WASTE CIRCULARITY IN DIFFERENT AFRICAN COUNTRIES

1. Rwanda has taken a proactive approach with its Circular Economy Action Plan and Roadmap (2022), a 14-year strategy integrating circularity into waste, water, agriculture and construction. The plan enhances waste segregation, collection and treatment, prioritizes local and renewable materials in construction, and promotes organic fertilizers and sustainable farming.

2. South Africa introduced the National Waste Management Strategy (2020), which aims to divert 40 per cent of waste from landfills within five years through reuse, recycling and recovery initiatives. The strategy enforces Extended Producer Responsibility (EPR), mandating manufacturers, importers and retailers to manage the lifecycle of their products, particularly in sectors like packaging, electronics and lighting.

3. Nigeria's Circular Economy Roadmap (2024) outlines strategic interventions for integrating circularity into key sectors such as agriculture, industry, construction and waste management. The Extended Producer Responsibility (EPR) programme (2014) mandates electronics and plastics manufacturers to manage product recycling and disposal.

4. Kenya's Sustainable Waste Management Act (2022) establishes Kenya's national framework for circular economy, extended producer responsibility (EPR), and phased landfill reduction, promoting waste recovery, recycling and sustainable management. The Environmental Management and Coordination (Waste Management) Regulations (2024) provide operational guidelines for waste handling, transportation, treatment and disposal in Kenya, focusing on licensing, compliance and enforcement mechanisms.

5. Namibia's National WEEE Policy (2021–26) enforces Extended Producer Responsibility (EPR) for electronics, mandating manufacturers/importers to manage e-waste collection, recycling and disposal.

6. Malawi's National Waste Management Strategy (2019–23) promotes waste segregation at source and supports projects that convert waste into energy, such as biogas production from organic waste, to provide alternative energy sources and reduce reliance on traditional fuels.

7. Ghana's Circular Economy Roadmap and Action Plan (2023) aims to guide the country's transition to a circular economy over the next decade, focusing on key sectors such as waste, water, construction and agriculture. It outlines policy interventions to promote resource efficiency, waste reduction and sustainable production practices.

and repurposed materials including integration of green procurement into procurement regulations, ensuring that circular products are prioritized within the government procurement processes.

The roadmap also aims to strengthen sectoral integration and collaboration through adoption of circular business models and resource sharing within the manufacturing sector. While this is a notable step towards reduction of resource consumption, scope of this waste sharing across various industrial sectors **seems to be unclear** in the roadmap. Since the waste from one industrial sector could be a resource for another sector, extension of the collaboration to **cross-sectoral participation** is crucial for resource conservation and waste minimization.

Finally, in terms of **enforcement**, the strategy calls for enhancing technical capacities as well as other provisions for the regulatory bodies for effective enforcement. However, it assigns a long-term timeline of six years for this process to materialize. If enforcement is expected to take six years, there is no clarity on how compliance will be tracked and enforced in the meantime. This will lead to lack of accountability amongst stakeholders.

Having such circular economy roadmaps in place is a big step forward in terms of industrial waste circularity. They set the stage for future improvements and give industries and policymakers a starting point to build on. Other African countries such as **Uganda and Chad** are also in the process of developing their own frameworks to incorporate industrial waste circularity, showing a growing recognition of the need for such targeted policies.

3

ROADMAP FOR ENHANCING INDUSTRIAL WASTE CIRCULARITY

Industrial waste circularity in Africa faces multiple challenges, including lack of waste data inventory, weak policies, limited technological and financial support, and poor industrial symbiosis practices. The existing policies lack provisions of financial incentives leading to non-interest of industries to invest in circular practices.

To address these issues, CSE recommends establishing a national-level industrial waste inventory, developing financial incentives to encourage waste reuse, strengthening policy frameworks with explicit mandates for industrial waste management and expanding industrial symbiosis programmes to enable waste exchange between industries.

3.1 Major roadblocks

Africa, with an expected GDP growth of 4.2 per cent in 2025—its GDP growth in 2024 was 3.8 per cent, higher than projected global average of 3.2 per cent—is set to remain the second-fastest-growing region after Asia.[53] The continent is also expected to experience the fastest increase in the population, with a projected net increase of 740 million people by 2050.[54] This rapid growth of the continent's economy will result in increasing demand for resource requirements and waste generation. With the current limited waste management arrangements in the continent, waste will be dumped haphazardly or be burnt.

This is the time for the continent to pave the way for inclusive growth by transitioning to a circular economy and gear towards sharing the growth benefits across the system by addressing crises of resource scarcity, biodiversity loss and climate change, building greater resilience for future disruptions and investing in human capital, economic diversification and job-friendly economies. The continent, however, currently faces a few major shortcomings which hampers drawing benefits from industrial waste circularity with its full potential.

1. Unavailability of industrial waste data with regulators

Most African countries do not have consolidated records on the types or volumes of industrial waste generated in their country. In cases where data exists, it is often incomplete or inconsistent.

CSE's analysis found significant discrepancies between industry-reported waste data and estimated figures calculated. Data availability is the first step for developing any action plans for waste management as it furnishes an understanding of the characterization of waste that needs to be managed. The absence of this information makes it difficult to develop effective waste management policies since waste unreported is considered as waste unmanaged.

2. Lack of industrial waste targeted policies

Most existing policies in African nations that mention waste circularity currently focus only on consumer-end waste management. Extended Producer Responsibility (EPR), which governs post-consumer waste, does not extend to industrial waste generated from manufacturing processes. These policies lack explicit mechanisms for industrial waste categorization, mapping and incentivized frameworks for industrial waste circularity. Without policies specifically targeting industrial waste reuse, industries are unable to systematically incorporate industrial waste circularity and cannot reap the benefits of the advantages and incentives provided in the policies for encouraging waste circularity.

3. No financial incentives

The cost strain connected to waste recycling and reuse discourages industries from adopting circular practices in Africa. Unlike other waste streams that receive subsidies, industrial waste processing lacks financial incentives such as tax reductions or transportation benefits in collecting waste for reuse. Since the linear waste management process is cost-effective, industries have very little reason to invest in circular waste management without strong economic incentives.

4. Non identification of industrial symbiosis

Industrial symbiosis, a process in which waste from one industry serves as raw material for another, remains largely unrecognized in national waste strategies. The unavailability of any form of structured information on potential reuse of different industrial wastes, makes it difficult for industries to capitalize on cross-sector waste utilization and resultantly the waste gets dumped in the landfills. Isolated case studies in African nations do demonstrate the feasibility of industrial symbiosis, but its widespread adoption requires dedicated policy support and funding.

3.2 The way forward

The African countries have high potential for waste circularity and, as the report highlights, many facilities across Africa are already implementing circular waste practices and achieving tangible benefits such as reduced landfill burden and **lower GHG emissions**. It is now required that these benefits should be scaled up from the facility level to the national and continental levels. The scaling will help African countries significantly cut their GHG emissions linked to industrial waste, thus aiding in achieving their Sustainable Development Goals (SDGs).

Considering these opportunities, CSE recommends a structured roadmap to integrate industrial waste into Africa's circular economy. This requires targeted interventions, including waste inventory, cross-industry waste exchange, policy reforms, financial incentives, infrastructure investment, and technical guidance to make circularity both viable and profitable for industries.

1. Establishing a waste inventory

The circular economy cannot function without data. Without having robust data on type of industrial wastes generated, their quantities and utilization and/or disposal, it is not feasible to integrate the waste back into production cycles and form a circular production system. As discussed in Chapter 2, many African countries do not have consolidated data on how much industrial waste they generate, let alone how much is recycled. This lack of a structured system prevents the current policies from being comprehensive and data driven. The absence of this data also results in waste being lost rather than repurposed—metals that could go back into manufacturing, biomass that could be used for energy, and industrial byproducts that could replace virgin raw materials are instead landfilled.

To address these challenges, the first and most crucial step for African countries is to develop a comprehensive national inventory detailing the types of waste generated across different industrial sectors. This process should involve categorizing waste based on industry type, production processes and disposal methods. A well-structured inventory will provide a foundational understanding of different waste streams, allowing for better policy development. **Kenya**'s Sustainable Waste Management Act (2022) mandates private sector entities to report industrial waste data, ensuring regulators have data on waste generation, management methods and recycling, which further supports a structured national inventory.

Waste quantification: Once the waste inventory is developed, it needs to be supported by quantification of actual volumes of waste being produced across different industries. Ideally, this information should be derived from Environmental Impact Assessment and environmental audit reports submitted by industries. However, given the current gaps of data reporting in audit reporting across many African nations, a baseline needs to be developed.

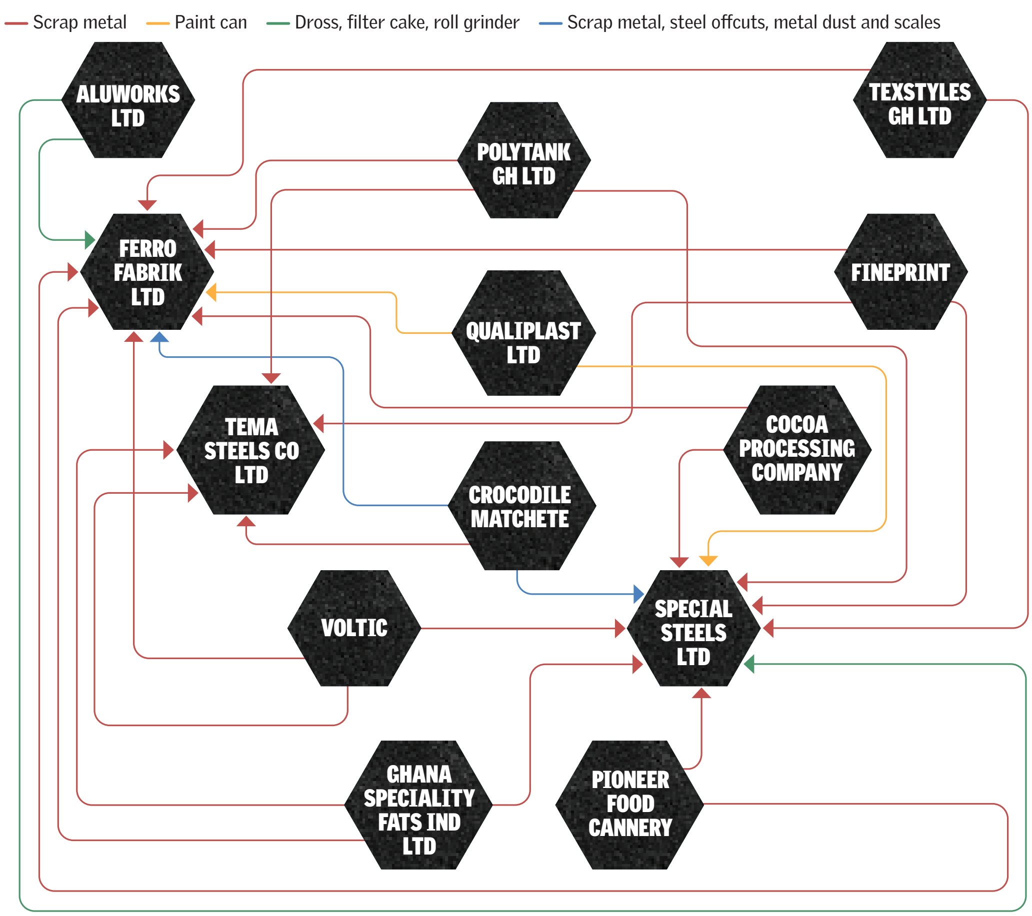
This can be undertaken by developing a rule of thumb for different waste types from a particular industrial sector as already discussed in Chapter 2. A solid waste generation factor (SWGF) is to be calculated for each waste type by collecting production capacity and waste generation for a few industries of a particular industrial sector. This factor can be extrapolated to calculate waste from an industry. Since the SWGF varies depending on the industrial sector, the countries should develop and implement this model tailored to its industrial composition, production process and raw material requirements. Since this model will also enable the regulators to cross-verify industry reported waste data, it will serve a dual purpose.

2. Mapping industrial symbiosis

Once a national inventory is developed, the next step involves mapping of symbiosis between industries, i.e. identifying potential utilization of different types of generated waste for industrial or non-industrial use. This way, waste can be utilized to initiate a new production line within the same facility or a different industry, resulting in the creation of new products from waste. Although the mapping will be country-specific, several waste utilization methodologies practised in different parts of the world can be used as a precursor for initiating the protocol.

Ghana has already undertaken a similar mapping process in 2018 in partnership with the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The project, with an aim to enhance resource productivity and environmental performance through industrial symbiosis, identified 135 potential synergies across 46 waste streams from 26 industrial sectors, encompassing materials such as plastics, biomass/wood waste, paper/cardboard, and scrap metal (see *Figure 5: Mapping of industrial symbiosis in Ghana*). Of these, 56 synergies were successfully implemented, facilitating the transfer of four waste streams to micro, small, and medium-sized enterprises (MSMEs). With this project, Ghana successfully diverted approximately **98 million tonnes of waste from landfills**, leading to a reduction of **804 tonnes in greenhouse gas emissions**. Moreover, the project generated 1,623 jobs and achieved cost savings of around US $31,500.

Figure 5: Mapping of industrial symbiosis in Ghana



Source: Environmental Protection Agency, Ghana

South Africa's Western Cape Industrial Symbiosis Programme (WISP) serves as another example of industrial symbiosis in action. Established in 2013 and facilitated by GreenCape, a non-profit organization, WISP connects companies with underutilized resources—such as materials, energy and water—to businesses that can use them productively, reducing landfill disposal and enhancing circularity. Through this targeted matchmaking the programme has enabled over 220 resource exchanges, diverting approximately 135,000 tonnes of waste[55] from landfills and preventing 435,000 tonnes of greenhouse gas emissions. The initiative has also driven economic growth, generating over R150 million in financial benefits for participating businesses.

Ghana and South Africa's experience underscores the many advantages of industrial symbiosis. By transforming waste into valuable inputs, industrial symbiosis enhances small and medium-sized enterprises engagement, creating new business opportunities while lowering production costs and increasing profitability. Beyond economic benefits, industrial symbiosis contributes to reduced dependency on virgin raw materials, water and energy savings, and carbon emissions reduction, aligning with SDG goals. It also stimulates job creation and strengthens local economies, leading to higher tax revenues for governments.

Considering these multifaceted benefits, African nations should establish national waste exchange platforms that connect the waste-generating industries with those that can repurpose it, ensuring that valuable materials do not end up in landfills.

3. Introducing financial incentives

As highlighted earlier, linear waste disposal remains the cheaper and more convenient option for industries due to the absence of financial incentives and clear policy direction. Despite the growing recognition and awareness of circular economy principles, major industries continue to rely on virgin raw materials partly because waste-derived alternatives lack significant market incentives.

It is thus necessary for the governments to gear policies that are more economically rewarding and technically driven. The foremost requirement for the governments is to **introduce financial mechanisms** in their policies—such as **tax breaks, levies and subsidies**—that encourage industries to adopt circular practices. A few existing waste management strategies and circular economy roadmaps already value this approach, recognizing the need for financial incentives to encourage circular economic practices. For example, **Rwanda's** Circular Economy Action Plan and Roadmap (2022) proposes grants of up to US $410,000 for startups that use waste as their raw material and offers tax reductions on locally sourced circular construction materials. South Africa provides an example of how targeted levies can turn polices into action. In 2017, **South Africa** introduced a Tyre Levy, set at US $54 per tonne of tyre waste regardless of tyre type, imposed on usage of new tyres in the country both locally made and imported. The approach aims to reduce landfill disposal of tyre waste while promoting reuse, treatment and recycling. Such targeted fiscal measures should be expanded to other industrial waste, ensuring that waste-intensive sectors are financially incentivized to shift away from dumping the waste in landfills.

4. Policy interventions

The above discussed recommendations will be effective when backed up by strong policy interventions that support and promote waste circularity. One of the additional barriers to circularity is the absence of technical guidance and infrastructural support. Many industries, particularly smaller enterprises, lack the necessary technological support and infrastructure to integrate circularity seamlessly. Technical guidance in the form of guidelines and best practices manuals would ensure that successful models do not remain isolated cases but become scalable, adaptable solutions. Additionally, capacity-building programmes, exposure visits and awareness programmes for the relevant stakeholders will enable the understanding of required technicalities for adopting the best practices and the related challenges. Finally, incorporating discussions of cost benefits analysis into circularity could further drive industrial participation. This will help industries see waste reuse not just as an environmental obligation, but as a financially profitable strategy.

South Africa's National Waste Management Strategy (2020) is an example of a policy that demonstrates the importance of sector-specific guidelines, by calling for best practice guidelines and standards for the reuse of construction and demolition waste. Similar sector-specific guidelines **are needed across all industrial waste streams to comprehensive waste recovery**. **Nigeria's** Circular Economy Roadmap (2024) also underscores the need for technical guidance by proposing the creation of manuals with step-by-step instructions for the implementation of circular economy strategies in the waste management sector.

Additionally, governments should invest in circularity promoting infrastructure—such as improved waste collection centres, material recovery facilities (MRFs) and industrial symbiosis hubs. These facilities will provide the opportunity for the enterprises to send, collect and process their waste efficiently instead of dumping which may result in facilitating smoother upscaling. The need for these measures are recognized and are already being proposed in a few national policies across

Africa. **Nigeria's** Circular Economy Roadmap (2024) proposes institutional arrangements to support circularity, which includes establishment of engagement platforms between relevant institutions, training programmes and programmes for public awareness. Similarly, **Kenya's** Sustainable Waste Management Act (2022) calls for the creation of material recovery facilities (MRFs) to support recycling and circularity. To enable funds for establishing such infrastructures, **Ghana,** under its Hazardous and Electronic Waste Control and Management Act (2016), introduced a thoughtful provision by introducing an eco-levy on the imported electronics. The collected fund from the provision was allocated for developing formal e-waste recycling infrastructure. Similar provisions can be adopted by other countries to develop and run these infrastructures sustainably.

To further promote waste circularity, the governments can consider introducing a dedicated labeling system for products made from circular waste, maybe naming such products as 'green'. This formal recognition of waste-derived products will not only push the implementation of circularity but will also ease the classification of products eligible for incentives. **Nigeria's** Circular Economy Roadmap has already recognized the need for this proposing an eco-labelling legislature for circular products.

It is encouraging to witness several countries taking steps toward structured circular economy policies by developing their circular economy roadmaps. Nigeria, Rwanda and Ghana have already developed their roadmaps while Uganda, Chad and other African countries are in the process of drafting theirs. However, these documents need to be publicly available and widely accessible as it will foster cross-country knowledge sharing, allowing countries to learn from each other's success and failures. The sharing of insights and best practices from each country's experiences will be valuable in strengthening circular economy polices and upscaling their implementation across the continent.

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Africa's industries generate millions of tonnes of waste annually. Most of it ends up in landfills or is burnt openly due to inefficient management systems. Unlike municipal or plastic waste, industrial waste lacks tailored policies, recovery mechanisms and explicit financial incentives for reuse. The result is growing environmental burden and missed economic opportunities.

Can waste become a resource? This report examines the current state of industrial waste circularity across key African countries, revealing how a lack of targeted policies and technological support as well as waste inventory gaps are holding back progress. Through successful case studies, it highlights isolated yet promising models of waste reuse, from co-processing in cement kilns to industrial symbiosis in manufacturing.

This report further offers a roadmap charting opportunities for scaling circular practices and steps to achieve industrial symbiosis. With the right strategies, industrial waste can be transformed into a driver of sustainable growth, reducing landfill dependence, cutting GHG emissions, and creating jobs while easing reliance on virgin resources. Africa's industries have the choice between treating waste as a liability or harnessing it as an opportunity. This report traces the path forward.

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