METHODOLOGY FOR INVENTORIZATION OF NON-HAZARDOUS INDUSTRIAL WASTE

TOOLKIT FOR TANZANIA

Authors: Ishita Garg and Ahana Ghosh

Editor: Rituparna Sengupta

Cover and design: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

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Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: cseindia@cseindia.org
Website: www.cseindia.org

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Introduction

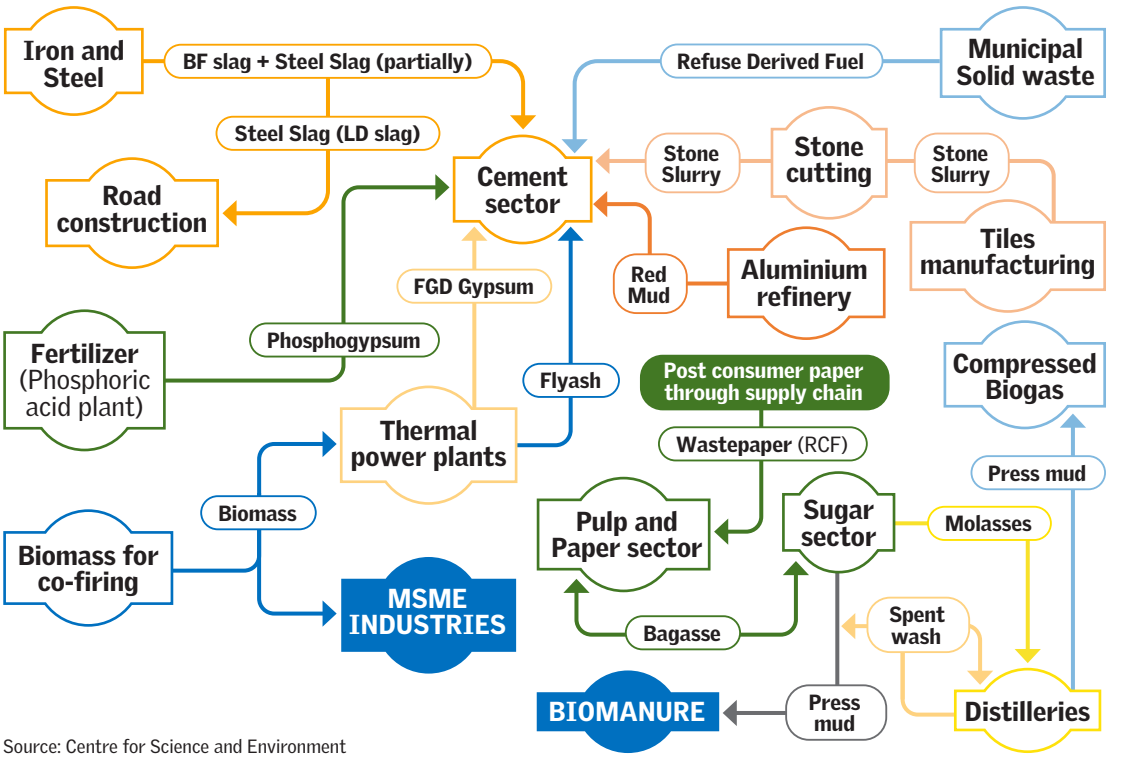
Africa's rapid population growth is complemented by changes in consumption patterns, along with a sharp increase in waste generation. Unfortunately, the waste management systems have not kept pace with this consumption spike. Over 90 per cent of the continent's waste is currently either dumped in unregulated dumpsites/landfills or is burnt in the open. The extent of waste generation in Africa is evident from the fact that 19 of the world's 50 largest dumpsites are located in this continent, and that the total waste volumes is projected to triple—from 174 million tonnes in 2016 to 516 million tonnes by 2050.[1]

The waste challenge in Africa extends beyond general or municipal waste; it also constitutes a large amount of industrial waste. Industrial development, while being a key driver of economic growth, is also one of the biggest contributors to waste generation. Much of this generated industrial waste is produced in large volumes, and is non-hazardous. Non-hazardous waste refers to the waste generated from industrial or non-industrial processes that may not pose a direct threat to human health or the environment like hazardous waste does, but still requires appropriate management due to the high volume and non-biodegradable characteristics. Common examples of such waste include plastics, glass, metals and e-waste. Non-hazardous waste has significant potential for reuse or recycling; however, unlike hazardous waste, which is managed through specific rules and regulations in most countries, non-hazardous waste often falls outside formal oversight. To overcome this lack of oversight and prevent this waste from becoming a burden, the principles and advantages of circular waste management can be applied to this category of waste. This can be done by assessing the utilization potential of various types of such waste and gaining an understanding of how they can be reused as raw material or fuel within the industrial systems.

This approach has a two-pronged benefit. Firstly, this would reduce the pressure on already overburdened landfills, as the current general practice is to dump such waste there. Secondly, reusing this waste as raw materials or fuel would reduce the industrial dependence on virgin raw materials, thereby enabling industries to cut down on their greenhouse gas (GHG) emissions that arise from energy-intensive extraction and processing of virgin raw materials.

This second aspect is crucial in the African context, where manufacturing growth is accelerating and by extension, industrial emissions are steadily rising. For

Figure 1: Circularity and waste management- Interlinking non-hazardous wastes in industrial ecosystems



Source: Centre for Science and Environment

instance, in 2018, the manufacturing sector accounted for 30–40 per cent of the continent's total emissions, emitting around 440 megatonnes of carbon dioxide equivalent ($MtCO_2e$). By 2050, these emissions are likely to nearly double, reaching 830 $MtCO_2e$[2]. Reducing the reliance on virgin raw materials is one of the ways to mitigate these accelerating emissions—an area where proper reuse of non-hazardous waste can play a significant role. CSE's 2025 study, *Africa's wasted potential: Unlocking industrial waste in circularity,* also highlighted various case studies showcasing how different high-volume, non-hazardous industrial wastes get managed through circular interventions across various African countries[3]. The study further notes that the reduction in greenhouse gas (GHG) emissions achieved from such intervention; for instance, recycling waste from only four waste streams—lead-acid batteries, glass, cashew, and e-waste—could achieve up to a two per cent reduction in Africa's total GHG emissions.

The recycling and reuse of non-hazardous waste, therefore, offers a practical opportunity to scale up circularity while minimizing environmental impact. A model on this potential symbiosis of different non-hazardous waste is shown in

the figure *(see Figure 1: Circularity and waste management- Interlinking non-hazardous wastes in industrial ecosystems)*. To make such symbiosis possible, it is first essential to develop an inventory of the types of waste that are being generated and their quantities, for different industrial sectors.

With this objective in mind, and in the absence of reliable data, this toolkit outlines a simple method for estimating waste quantities and compiles various reuse and recycling opportunities for non-hazardous industrial waste. This toolkit also aims to guide stakeholders in the inventorization and quantification of non-hazardous industrial waste in their regions, and in fostering the broader goal of developing a circular economy in the industrial sector.

Methodology for estimating non-hazardous industrial waste

Most African countries currently have little to no data on how much non-hazardous waste is generated by their industries. Even environmental clearance and audit reports rarely quantify the expected amounts of such waste from industrial operations. As already discussed, without this quantification, mapping the waste streams into circular pathways is not possible. Thus, filling this data gap is critical. To do so, it is essential to establish a baseline—a very clear understanding of the types and quantities of non-hazardous waste produced by different industrial sectors. This baseline can then serve as the foundation for effective waste management planning and strategic interventions.

One way to achieve this baseline is by establishing specific solid waste generation factors (SWGF) for each type of waste generated from an industrial process. SWGF represents the ratio of solid waste generated per unit of production within a specific period of time (day, month, or year). To maintain consistency and compatibility, monthly (kg/month) or yearly (tonne/year) data should be preferred where possible.

SWGF = Quantity of waste generated (in kg, tonnes, or units) per month or year / Quantity of production (in kg, tonnes, or units) per month or year.

The development of SWGF typically involves two key steps—first, a reconnaissance survey to collect industrial production and waste generation data, and second, forecasting to estimate waste generation trends across sectors and regions. Note that for the purpose of this toolkit, the term 'industrial type' or 'industrial sector' refers to a group of industries that are engaged in similar activities (for instance, the textile sector, food processing sector, or metal fabrication sector). Whereas, the term 'industrial facility,' 'industry' or simply, 'facility' refers to an individual industrial establishment or factory where production activities take place.

1. Reconnaissance survey

The reconnaissance survey comprises multiple steps, beginning with a preliminary information collection, before moving to an onsite survey, followed by data collation and finally using that compiled data to develop the SWGF.

Step 1: Preliminary information collection

Before initiating the process of the onsite survey, some preliminary information must be gathered to ensure that the survey is systematic and representative. This includes:

- Identification of major industrial areas or clusters.
- Mapping the locations of identified industrial areas/clusters.
- Identification of the type and number of industries located in each selected industrial area.

Selection of a few representative units of each industrial type within the selected area. This sample size should be proportionate to the total number of industries. For instance, if there are ten industries in a selected region, three units can be selected for the survey. If there are 50, around ten units can be selected. The exact number of the industries selected is at the discretion of the surveyors.

Step 2: Onsite survey

Once the preliminary information is in place, an on-site survey should be conducted to collect ground-level data from the selected facilities. This data includes details on various aspects, such as production capacity, the major types of non-hazardous waste being generated, the actual quantities of each waste type, and the current waste management practices in that industry. To support this assessment, developing an industry-specific process flow/block diagram pinpointing the waste-generating unit operations can help in identifying and categorising the various waste streams. The data collected through this step forms the foundation for calculating SWGF across facilities and industry types.

A sample questionnaire for the data collection during the survey is provided in Annexure: Sample questionnaire for reconnaissance survey.

Step 3: Data collation

Once data is collected, the SWGF for each waste type generated at every surveyed facility should be calculated using the previously provided formula.

To illustrate this concept, consider a hypothetical sugar sector in an industrial region that has three facilities (Facility A, Facility B, Facility C). It is important

to note that three facilities are taken as a representative sample for this industrial area. For example, if the area has around ten sugar industries, three are selected to represent the overall scenario.

The sugar industry generates three main types of non-hazardous waste: bagasse, press mud, and molasses. For illustration, consider *Facility A* with an annual production capacity of 1,00,000 tonnes. Based on survey data, the facility generates approximately 1,88,000 tonnes of bagasse, 31,000 tonnes of press mud, and 41,000 tonnes of molasses each year. From here, the specific SWGF for all three wastes from Facility A can be calculated as follows:

- SWGF for bagasse from Facility A (SWGF B1) = Quantity of bagasse (tonnes/annum)/Total production of facility (tonnes/annum) = 1,88,000/100,000 = 1.88
- SWGF for press mud from Facility A (SWGF P1) = Quantity of press mud (tonnes/annum)/Total production of Facility (tonnes/annum) = 31,000/100,000 = 0.31
- SWGF for molasses from Facility A (SWGF M1) = Quantity of molasses (tonnes/annum)/Total production of facility (tonnes/annum) =41,000/100,000 = 0.41

The above calculation applies to Facility A. Similarly, SWGFs for the three waste types should be computed for Facilities B and C. For illustration, assume that Facility B has SWGFs of 1.75 for bagasse (B2), 0.25 for press mud (P2), and 0.33 for molasses (M2); and Facility C has SWGFs of 1.92 for bagasse (B3), 0.34 for press mud (P3), and 0.46 for molasses (M3).

Step 4: Sectoral SWGF

After the SWGFs for each facility is known, to develop SWGFs for a particular industrial sector, an average of the facility-specific SWGFs for a particular waste is taken. Revisiting the sugar sector example, the SWGFs for the sugar sector can be established as follows:

- SWGF for bagasse (B) from the sugar sector = SWGF B1 + SWGF B2 +SWGF B3/ Total number of facilities = (1.88+1.75+1.92)/3 = 1.85
- SWGF for press mud (P) from the sugar sector = SWGF P1 + SWGF P2 +SWGF P3/ Total number of facilities = (0.31+0.25+0.34)/3 = 0.30
- SWGF for molasses (M) from the sugar sector = SWGF M1 + SWGF M2 +SWGF M3/ Total number of facilities = (0.41+0.33+0.46)/3 = 0.40

These calculated averages represent the sector-level SWGFs which indicate the typical quantity of each waste generated per unit of product for that sector.

It is vital to understand that the SWGF for each waste type is a sector-specific value and varies depending on the industrial sector it is generated from. Therefore, the SWGF for a particular waste must be calculated separately for each sector—one cannot apply a single SWGF value for a waste without considering its sector of generation. This is because waste generation is very process-dependent, and it would be misleading to compare or aggregate waste intensity across industries that operate differently, even if the waste looks similar. For instance, iron scraps are the waste products of both the foundry sector as well as the automobile manufacturing sector, but the processes involved to produce the same waste are different. Hence, the SWGF of iron scrap derived for the foundry sector cannot be applied to the iron scrap generated from the automobile manufacturing sector; it must be calculated separately using the process described above.

2. Forecasting

With the sector-specific SWGFs now established, the next step is to apply these factors to estimate the total generation of a particular waste from an industrial sector in an industrial area or the whole country. This is done by simply summing the production capacities of all industries of a particular industry type and multiplying the total by the calculated SWGF for that waste. This approach allows the findings from the onsite surveys to be scaled up to the present context using a relevant scaling factor.

The principle is illustrated continuing with the example of the sugar sector as discussed previously. If there are a total of nine sugar industries (A, B, C, D, E, F, G, H, I) in a country, the total quantity of wastes generated from the entire sector can be calculated as follows:

- Assuming all facilities have 1,00,000 tonnes per annum of production capacity each, then the total production capacity (Z) will be the sum of their individual capacities.
- Total production capacity of the sector (Z) = A+B+C+D+E+F+G+H+I = 900,000 tonnes per annum
- The production capacity of a facility can be obtained from the environmental impact assessments, environmental audit reports or even from their licenses. Once the total production capacity of the sector is known, the total quantity of non-hazardous waste produced by that sector can be calculated as follows:
  - Total quantity of bagasse from sector: SWGF for bagasse (B) x Z = 1.85*900,000 = 1,655,000 tonnes per annum
  - Total quantity of press mud from the sector: SWGF for press mud(P) x Z = 0.30*900,000 = 270,000 tonnes per annum

- Total quantity of molasses from the sector: SWGF for molasses (M) x Z = 0.40*900,000 = 360,000 tonnes per annum.

These calculations illustrate how established SWGFs can be applied to estimate sector-level waste generation, offering a clearer understanding of each industrial sector's contribution and forming a basis for targeted waste management and resource recovery strategies.

With this objective in mind, CSE has developed specific solid waste generation factors (SWGFs) for various industrial sectors as part of this toolkit (*Refer Table 1*). The provided SWGFs are based on surveys conducted in industries, consultations with sector experts, and information from secondary sources. Sectors with a highly diverse range of waste types, such as the FMCG sector, have not been included in this toolkit.

Table 1: Template for specific solid waste generation factor (range) for various non-hazardous industrial waste and estimation of waste generation

S no.	Industrial sector	Type of waste	Specific solid waste generation factor	Total production (tonnes/annum) or specify units	Estimated quantity of waste generated (tonnes/annum)	Present practices for waste (recycle / disposal)	Potential applications
	1	2	3	4	5=3*4	6	7
1.	Engineering fabrication						
	a. Bearing industry (forged)	Metal scrap	12–14 per cent of total production			Sent to scrap dealers, Melted in furnaces	
		Iron dust	1–2 per cent of total production			Landfilled	Briquetting- re-used in sinter plants or Blast Furnace in steel industries
		Waste cloth	1–2 per cent per tonne of production			Burned or dumped in nearby area	
	b. Metal fabrication	Metal scrap	15-20 per cent of total production			Sent to scrap dealers, Melted in furnaces	
2.	Plastic Manufacturing Industries (PET bottles, plastic granules, HDFE and PVC pipes, polypropylene. Bags, HDPE products)	Plastic scrap	4-6 per cent of total production			Recycled and dumped	Shredded and recycled into packaging/fibers.

S no.	Industrial sector	Type of waste	Specific solid waste generation factor	Total production (tonnes/annum) or specify units	Estimated quantity of waste generated (tonnes/annum)	Present practices for waste (recycle / disposal)	Potential applications
	1	2	3	4	5=3*4	6	7
3.	Sponge iron	Iron oxide fines	0.03–0.05 tonnes per tonne of production			Landfilled if unrecoverable.	Can be used in pigments or cement.
		Char	0.2–0.4 tonnes per tonne of production				As fuel, adsorbing agent
4.	Foundry						
	a. Induction furnace	Silica sand	5–6 per cent of total production			Very few industries send slag to cement plants, most industries dump this waste	Reuse in foundries/construction.
	b. Cupola furnace	Slag	5-6 per cent of total production			Landfilled	Mix in concrete for construction purposes
5.	Wire and cable						
	a. Copper and aluminum wire units	Metal scrap	2–3 per cent of total production			Sent to scrap dealers, Melted in furnaces	
	b. MS wire/GI wire/ Barbed wire	Metal scrap	2–3 per cent of total production			Sent to scrap dealers, Melted in furnaces	
	c. PVC & XPLE (cross linked polyethylene) cable and conductor units	Metal scrap	0.2–0.5 tonne/ kilometre			Sent to scrap dealers, melted in furnaces	
6.	Rolling mill	Mill scale	2–4 per cent of total production			Either used in cement plant as additive or dumped	As raw material in sinter plants in steel industry or iron palletization
		Metal scrap	4–5 per cent of total production			Sent to scrap dealers, melted in furnaces	
7.	Footwear	Polyurethane	1–2 per cent of total production			Dumped	Crushed and use as carpet underlay or as soundproofing material.
		Rubber	10–12 per cent of total production			Recycled and dumped	Co-process in cement plants
		PVC	8–10 per cent of total production			Secured landfill (hazardous if burned).	Reprocess into pipes/flooring.

S no.	Industrial sector	Type of waste	Specific solid waste generation factor	Total production (tonnes/annum) or specify units	Estimated quantity of waste generated (tonnes/annum)	Present practices for waste (recycle / disposal)	Potential applications
	1	2	3	4	5=3*4	6	7
8.	Rice mills	Rice husk	220 kg per tonne of paddy processed			Used as fuel in biomass-based boilers	Silica extraction, and biochar production
9.	Sugar and distillery (molasses based)	Bagasse	1.85 tonnes per tonne of production			Used as fuel for boiler	Raw material in paper industry for making moulded products like plates/ trays
		Molasses	0.4 tonnes per tonne of production			Used in distillery	
		Press mud	0.3 tonnes per tonne of production			Used as soil nutrient	Raw material for compressed biogas production
		Spent wash	8-12 litres/ litre of alcohol produced			Treated in ETP	Fuel in boilers in distillery
10.	Iron and steel industry	Blast furnace slag	0.3-0.5 tonne per tonne of production			As an additive in cement making and in road construction	Cement substitute, and road construction
		Steel slag	0.15-0.2 tonnes per tonne of production			Majorly landfilled	As an additive in cement making and in road construction
		Electric arc furnace slag/ Induction furnace slag	0.2 tonnes per tonne of steel			Internal road making within the industries or landfilled	
		Desulphurization slag	14-16 kilogram per tonne of hot metal			Internal road making within the industries or landfilled	
11.	Aluminium	Red mud	1-1.5 tonnes per tonne of production			Stored in ponds	As a raw material for cement
12.	Rubber	Cured rubber waste	2-5 per cent of total production			Landfilled	As a filler in new rubber
13.	Copper	Ferro sand	1.6-1.9 tonnes per tonne of production			Landfilled	Sand replacement in concrete.

S no.	Industrial sector	Type of waste	Specific solid waste generation factor	Total production (tonnes/annum) or specify units	Estimated quantity of waste generated (tonnes/annum)	Present practices for waste (recycle / disposal)	Potential applications
	1	2	3	4	5=3*4	6	7
14.	Zinc smelting (pyro-metallurgical)	Zinc slag	0.8-1 tonne per tonne of production			Secured landfill	Zinc recovery and road construction.
15.	Textile sector	Yarn and fabric trimmings	2-5 per cent of total production			Landfilled or sent to informal units	Upcycle to make rugs, cushions, bags etc.
16.	Leather manufacturing (finished leather)	Unusable wet blue splits, wet blue shavings and trimmings	171-180 tonnes per tonne of finished leather (for heavy bovine leather) 180-513 tonnes per million m^2 finished leather (for sheep and goat leather and light bovine leather)			----	Shred and use as filler for composite boards
		Dry leather wastes (trimmings, dust)	28-30 tonnes per tonne of finished leather (for heavy bovine leather) 83-151 tonnes per million m^2 finished leather (for sheep and goat leather and light bovine leather)			---	Recycle into bonded leather
17.	Automobile and auto parts	Metal scrap (steel, aluminium)	3-6 per cent of total production			Sent to scrap dealers, Melted in furnaces	
		Plastic and rubber parts	1-2 per cent of plastic and rubber components			Landfilled or sold to informal recyclers	As alternative fuel in cement plants
18.	Ferro alloys	Silica fines	0.1-0.2 tonnes per tonne of total production			Reused within the process or dumped	
		Fe-Cr slag	0.8-1.2 tonnes per tonne of total production			Dumped in Slag yards	Metal recovery (Cr/Fe), cement/ road construction.
		Charcoaland coke fines	0.1-0.2 tonnes per tonne of total production			Reused as fuel	

S no.	Industrial sector	Type of waste	Specific solid waste generation factor	Total production (tonnes/annum) or specify units	Estimated quantity of waste generated (tonnes/annum)	Present practices for waste (recycle / disposal)	Potential applications
	1	2	3	4	5=3*4	6	7
19.	Chlor-alkali						
	Caustic soda	Brine sludge	20-30 kilogram per tonne of caustic soda			Landfilled or TSDF	Utilize for brick making
	Soda ash	Fines of raw limestone from screening	30 –300 kilogram per tonne of soda ash			Either dumped or used in construction	
		Grits from slaker containing inert material	10 –120 kilogram per tonne of soda ash			Landfilled	As construction material

Note: The range of solid waste generation factors derived in the table is based on survey of industries, inputs of sectoral experts and secondary resources. These are indicative in nature and tend to change with production capacity as well as efficiency of the manufacturing process.

APPLYING THE METHODOLOGY FOR INDUSTRIAL SECTORS IN TANZANIA

Tanzania stands today as one of East Africa's most steadily growing economies, recording a GDP growth of around 5.3 per cent in 2023, up from the 4.7 per cent of 2022.[4] For a long time, the country's economics have been anchored in agriculture (crops, forestry and fishing), which accounts for, on average, around 26 per cent of the country's GDP as well as the service sector (trade, transport, tourism etc.,) which accounts for around 37 per cent of the overall GDP.[5]

In 2024, the industry sector, including manufacturing, mining, and construction, accounted for approximately 28.7 per cent of Tanzania's GDP, with manufacturing contributing around eight per cent. Though modest, this share reflects steady growth and resilience, supported by rising investments in infrastructure, energy, and logistics. With industrialization emerging as a national priority, the government increasingly views manufacturing as a key driver of employment generation and economic diversification in the coming decade.

As the manufacturing sector expands, this is the right moment to integrate circular economy practices into non-hazardous waste management while the overall waste burden is still relatively low. Early adoption will ensure that as production capacity and waste generation increase, these systems can be scaled up rather than built from scratch when the challenge becomes more complex. As discussed earlier, effective industrial symbiosis depends on a clear inventory of the types and quantities of waste generated across sectors. Building on this foundation, the following sections apply the methodology to the cement and sugar industries to illustrate how a waste inventory can help map each sector's non-hazardous waste footprint, supporting regulators in planning waste utilization and circularity interventions at the national level.

Cement sector

Cement consumption in Tanzania has grown steadily averaging about nine per cent over the past ten years and accelerating to nearly 11 per cent per annum during the past five years. This rising demand is largely driven by the government's

focus on housing and industrial development through continuous infrastructure of residential and commercial buildings. To meet this demand, Tanzania's cement industry currently comprises 12 plants—six integrated units and six grinding units—with a combined production capacity of about 13 million tonnes per annum (MTPA). Notably, the cement industry is set to expand even further, raising the total installed capacity to nearly 15 MTPA by 2028.[6] The country's leading cement producers include Dangote, Tanzania Portland Cement, Huaxin Cement, Tanga Cement, and Lafarge Tanzania. Tanzania has ample reserves for both limestone and coal—major raw materials for cement production—to support its current and planned clinker capacities.

The six integrated units form the backbone of Tanzania's cement production system. Unlike grinding units, which mainly handle blending and packaging, integrated plants carry out the full manufacturing process, including clinkerization and power generation via in-house power plants that use coal. As a result, they are responsible not only for a larger share of cement production but also for the generation of associated non-hazardous industrial waste fly ash from the power plants that use coal.

Instead of being treated as a waste burden, the generated fly ash can be transformed into a valuable resource that contributes to global efforts toward a greener and more sustainable future. This contribution could be achieved by recovering and then using fly ash to replace a portion of the clinker, which is the most energy and carbon-intensive component of cement. Typically, 15 per cent to 30 per cent of the Portland cement can be replaced with fly ash,[7] with the amount increasing depending on the grade of fly ash. Since the clinker production stage of cement manufacturing accounts for between 60–70 per cent of the total CO_2 emissions of the industry as a whole, this substitution will reduce GHG emissions, lower production costs and conserve the virgin natural resource limestone. Further, fly ash could also be used in the construction industry in the form of fly ash bricks, replacing natural clay as the primary raw material. Thus, the uses of this waste range from within an industrial sector to inter-industries as well.

Thus, to make effective use of fly ash, it is vital to understand the total fly ash waste generated at a national level. This can be done systematically by applying the SWGF methodology previously discussed.

***Step 1*:** The first step is to take a representative sample from the six integrated units. Note, grinding units are not considered as they do not produce any fly ash. Since there are only six integrated units, one facility will suffice as a representative

sample. Assume that is Dangote Cement, which has a production capacity of three million tonnes per annum and produces approximately 3,75,000 tonnes per annum of fly ash (assuming 1.5 million tonnes of coal usage with 25 per cent fly ash content). This quantity of fly ash produced by a facility—3,75,000 tonnes per annum—needs to be obtained by the reconnaissance survey, if not already available. From this, the facility-specific SWGF for fly ash can be calculated as follows:

The facility-level SWGF for fly ash= Quantity of fly ash generated (tonnes/annum)/ Total production of facility (tonnes/annum) = 3,75,000/30,00,000 = 0.125

***Step 2*:** Since only one facility is the representative sample here, this facility-specific SWGF will be considered as the sector-level SWGF as well. With the sector-specific SWGF for fly ash available, the next step is to apply this factor to estimate the total generation of fly ash from the integrated units of the cement sector in Tanzania. Considering 60 per cent of the total production capacity of the cement industry (13 million tonnes per annum) under the six integrated units, the six integrated units will have a production capacity of 7.8 million tonnes per annum**.** Thus, the total quantity of fly ash produced in the country will be:

Total quantity of fly ash currently produced = Sector-level SWGF * Production capacity of the integrated units = 0.125*7.8 million tonnes per annum = 975,000 tonnes per annum.

***Step 3*:** The methodology can also be used to forecast future waste amounts. With the total cement production capacity increasing to 15 MTPA by 2028 as forecasted, with 60 per cent again being accorded to the integrated units (9 MTPA), the projected fly ash generation = 9 × 0.125 = 1.13 million tonnes per year.

Such large quantities of fly ash generated each year require robust handling and management to minimize environmental pollution. Access to this information supports data-driven decision making for sustainable industrial development.

Sugar sector

The development of the sugar industry is among the Tanzanian government's key agricultural priorities, aimed at achieving self-sufficiency by meeting the rising demand from the domestic market. A 2021 article highlighted that Tanzania's annual demand for sugar stood at around 470,000 tonnes in 2019, while the country's domestic production capacity was approximately 378,000 tonnes.[8] In 2023, though the annual production expanded to 460,000 tonnes,[9] it wasn't

enough to meet the local demand as the country still imported around 63,562 tonnes of raw sugar in that year.[10] Considering the increasing demand, the country aims to expand its annual sugar production to one million tonnes by 2030, aligning with the government's goal of achieving self-sufficiency in sugar and reducing import dependence.[11] The government has also approved six new varieties of sugarcane for the production of sugar as a measure to strengthen the production capacities of the existing plants.

Currently, the country has five established sugar industries, which collectively account for nearly all national production. The leading producers are Kilombero Sugar Company Limited (37 per cent), Tanganyika Planting Company Limited (29 per cent), Kagera Sugar Limited (24 per cent), Mtibwa Sugar Estates Limited (9 per cent) and Manyara Sugar (1 per cent).[12] The production of sugar generates three major wastes—bagasse, molasses and press mud. Bagasse is the fibrous residue left after crushing sugarcane to extract the juice; molasses is the thick syrup remaining after sugar crystallization; and press mud is the solid residue formed during juice clarification. With the aspired increase in production of sugar in Tanzania, the wastes generated by this process will also increase.

These wastes are not simply by-products to be discarded, but are valuable resources with multiple reuse pathways. Bagasse can be used as a fuel in boilers for steam and power generation, often making sugar mills energy self-sufficient and reducing their dependence on fossil fuels. Molasses can be used as a raw material for alcohol production, while press mud is rich in nutrients and can be applied to fields as a soil conditioner, improving soil health and properties, as well as reducing the need for synthetic conditioners. These materials are being utilized to some extent; however, their full recovery and valorization potential remains underutilized. Quantifying their generation at the national level would allow their utilization to be planned and optimized in a more structured manner.

***Step 1*:** The first step is to take a representative sample from the existing industries. Since there are only five major industries, one facility will suffice as a representative sample. Assume the facility to be KSCL sugar estate, which has an annual production capacity of 126,000 tonnes, receives a sugar cane supply of 600,000 tonnes per annum and generates approximately 180,000 tonnes per annum of bagasse, 30,000 tonnes per annum of molasses and 30,000 tonnes per annum of press mud. This quantity of bagasse, molasses and press mud produced by a facility needs to be obtained during the reconnaissance survey, if not already available. From this information, the facility-specific SWGF for the three wastes can be calculated as follows:

The facility-level SWGF for bagasse = Quantity of bagasse generated (tonnes/annum)/Total production of facility (tonnes/annum) = 180,000/126,000 = 1.43

The facility-level SWGF for molasses = Quantity of molasses generated (tonnes/annum)/Total production of facility (tonnes/annum) = 30,000/126,000 = 0.24

The facility-level SWGF for press mud = Quantity of press mud generated (tonnes/annum)/Total production of facility (tonnes/annum) = 30,000/126,000 = 0.24

***Step 2*:** Since only one facility is the representative sample here, this facility-specific SWGF will be considered as the sector-level SWGF as well. With the sector-specific SWGFs for bagasse, molasses and press mud available, the next step is to apply these factors to estimate the total generation of these wastes from the sugar sector in Tanzania. The five units have a production capacity of 460,000 tonnes per annum**.** Thus, the total quantity of these wastes produced in the country will be:

Total quantity of bagasse currently produced = Sector-level SWGF * Production capacity of the sugar sector= 1.43*460,000 tonnes/annum = 657,800 tonnes/annum.

Total quantity of molasses currently produced = Sector-level SWGF * Production capacity of the sugar sector= 0.24*460,000 tonnes/annum = 110,400 tonnes/annum.

Total quantity of press mud currently produced = Sector-level SWGF * Production capacity of the sugar sector= 0.24*460,000 tonnes/annum = 110,400 tonnes/annum.

***Step 3*:** The methodology can also be used to forecast future waste amounts. With the total sugar production capacity increasing to 1 MTPA by 2030 as forecasted;

The projected bagasse generation = 1 * 1.43 = 1.43 million tonnes/annum

The projected molasses generation = 1* 0.24 = 0.24 million tonnes/annum

The projected press mud generation = 1* 0.24 = 0.24 million tonnes/annum

The sugar industry as a whole, produces varied amounts and types of waste, all of which have different applications. Such large quantities of waste generated each year require a structured management plan to minimize the environmental burden as well as increase the utilization of these wastes. To develop such a plan, access to a quantified inventory is paramount, which can be created even with scant data using the methodology depicted.

Annexure : Sample questionnaire for reconnaissance survey

1. Name of industry

2. Type of industry

3. Address

4. Type of products and quantity

S. No	Name of product	Production (tonnes/year)

5. Type of non-hazardous solid waste and quantity of generation

S. No	Type of non-hazardous waste	Waste generation (tonnes/year)

6. Quantity of waste recycled

S. No	Name of waste	Waste generation (tonnes per year)	Quantity of waste recycled (tonnes per year)	Applications where recycled

7. Quantity of waste reused within the industry

S. No	Name of waste	Waste generation (tonnes per year)	Quantity of waste recycled (tonnes per year)	Frequency of reuse

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Industrialization in Tanzania is accelerating, bringing with it a sharp rise in waste generation. Although a major part of this waste is non-hazardous, it still requires proper management due to its high volume and non-biodegradable nature. Such waste holds significant utilization potential and can play a vital role in advancing circularity principles; however, in the absence of any reliable data on its quantity, its reuse potential remains substantially underutilized.

The toolkit offers a practical step-by-step methodology to quantify and map non-hazardous industrial waste even in data-scarce contexts. It also illustrates how early inventorization can help countries integrate circular economy principles by turning industrial wastes into valuable resources rather than environmental burdens.—By enabling data-based waste management, this toolkit aims to support regulators and policymakers in building a foundation for sustainable industrial growth in Tanzania.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
E-mail: cseindia@cseindia.org Website: www.cseindia.org