EngineeringX

Open burning of waste in Africa: Challenges and opportunities

Royal Academy of Engineering

RACE TO ZERO

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United Nations High Level Champions (UNHLC) and Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation

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This report was prepared by Professor Desta Mebratu and Dr Andriannah Mbandi, who are the Lead and Deputy Lead of the UNHLC Initiative on Open Burning of Waste (OBW) in Africa that is supported by Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation. The report was produced under the supervision of Hazel Ingham and Charlie Fenn, Senior Manager and Programme Manager, Engineering X, and Fiona Napier, UNHLC Engagement Lead in Africa. The authors wish to acknowledge the review inputs provided by: Dr Alice Kaudia, Climate and Clean Air Coalition (CCAC); Dr Mansoor Ali, Founder of Learning in Development Limited and Independent Consultant; Dr Terry Tudor, Independent consultant', Sonia Dias, Women in Informal Employment, Globalizing and Organizing (WIEGO); Jokudu Guya, ICLEI-Africa; Heavy Industry Sector Lead for Harald Friedl, UNHLC Lead on Mining; Patrick Mwesigye and Alexander Mwagiro, United Nations Environment Programme (UNEP).

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Front cover images
Top left: Gambia -WasteAid dumpsite on fire © WasteAid (2017)
Top right: Nairobi, Kenya, East Africa
Bottom left: Kibera, Nairobi - Open burning of uncollected waste on the pavement (2017)
Bottom right: Douala, Cameroon © WasteAid (2019)

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Foreword by Nigel Topping (right) and Dr Mahmoud Mohieldin (left), UN Climate Change High-Level Champions for COP26 and COP27

The unchecked open burning of waste in Africa is fuelling illness, premature death and climate change, and needs to be reined in if we are to cut emissions and advance sustainable development within the 2020s.This report makes it clear that the challenges are big, but so are the opportunities for the region.

Sub-Saharan Africa generated around 9% of global waste as of 2016, or 180 million tonnes. About two-thirds of that is dropped in landfills and open dump sites, left to pollute the nearby environment and global climate.

Children living near those dump sites are ingesting and inhaling toxic substances. The particulate matter emitted in the air causes lung and heart disease, cancer, infertility, low birthweight, premature birth, cognitive development problems, and premature death. On top of that, the dump sites are emitting around 20% of the world's methane and 11% of black carbon – two potent short-lived greenhouse gases that must be slashed in order to limit the impacts of climate change.

Around 70-80% of the municipal solid waste generated in African cities is recyclable – such as biodegradable waste, plastics and paper – and could be worth US$8 billion per year if kept in a circular economy. Addressing the structural deficiencies in waste management and promoting a circular economy that prioritises reuse, recycling and recovery will strengthen local manufacturing, create jobs, reduce unemployment, support inclusive and sustainable local and regional economies, and reduce air pollution and greenhouse gas emissions.

The African Union has set an ambitious target for African cities to recycle at least half of their waste by 2023. Many are still far from achieving this, but according to the UN Environment Programme the goal can be met and even surpassed with a shift of organic waste to composting and bioenergy recovery, along with the refurbishment, repair, reuse and recycling of plastics, paper, metal, glass, tyres and electronic waste.

To do this, the transformation needs to be systemic. It needs to include the informal waste recyclers who are already getting waste back into the African economy, as well as national governments, cities and development partners.

This report sets out a series of recommendations for transition to a sustainable waste management system across Sub-Saharan Africa.

Among them, it recommends identifying the national and local governments, cities, businesses, investors, development partners and partnership programmes that could champion and support this phase-out by mobilising finance and building capacity.

It also recommends strengthening monitoring and assessment of atmospheric pollution in African countries and the impacts on health and the environment. Seed funding, grants and innovation policies and research and development are also needed to advance the transition.

And finally, it recommends expanding the UN High-Level Climate Champions' partnership with Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation, by welcoming other international and regional partners into the work – something we will prioritise in the run-up to November's COP27 in Sharm El-Sheikh and continue supporting over the long term.

Students burn waste from their school in a barrel in Kwa-Muhia, Kenya; © WasteAid (2011).

Executive summary

Executive summary

1. Approximately 180 million tonnes of waste, which is about 9% of the global waste, was generated by Sub-Saharan African (SSA) countries in 2016 (Kaza et al., 2018). Out of this, only about 11% of the waste was disposed of in properly designed and managed sanitary landfills while more than 60% of the waste is disposed of in controlled landfills and open dump sites. As a result, 19 of the world's 50 biggest dumpsites in 2015 were located in Sub-Saharan Africa (UNEP, 2018). Poor waste collection and improper disposal of waste often leads to residential open burning of waste, which is almost always coupled with open burning at dumpsites (Cogut, 2016).

2. Agricultural waste burning, household/ neighbourhood burning and forest fires make significant contribution to the problem of open burning in Africa. However, open waste burning at dumpsites is the main contributor of noxious pollutants to the natural environment. Uncontrolled dumping and open burning of waste are the main methods available to the majority of African cities where it is estimated that up to 90% of waste is openly dumped, and often burned (Cogut, 2016; Kaza et al., 2018; UNEP, 2018).

3. Emissions from open burning of waste which have a direct or indirect health impact include: short lived climate pollutants (SLCPS) such as black carbon (BC) and methane, particulate matter (PM), persistent organic pollutants (POPs), such as, dioxins and furans, and polychlorinated aromatic hydrocarbons (Cogut, 2016; UNEP, 2018; Velis and Cook, 2021). Open burning of waste can produce emissions of a variety of heavy metals including but not limited to cadmium, chromium, manganese, antimony, arsenic, lead and mercury. This depends on the quantity of E-waste in the composition of the waste. Communities living close to dumpsites including children have been found to have higher levels of toxic substances through ingestion and inhalation of contaminants in those environments (Velis and Cook, 2021).

4. Some of the negative impacts to health range from upper respiratory tract infections, dermatological illnesses, immunological, reproductive and developmental abnormalities. It is estimated that over 1.2 million premature deaths occur every year in Africa due to exposure to air pollution (Fisher et al., 2021) to which the waste sector is a significant source of fine particulate matter (PM) contributing approximately (29%) of the global estimates (Wiedinmyer et al., 2014). In addition, Methane generated from decomposing organic waste contributes to ~20% of global methane (Ravishankara et al., 2021), whilst open waste burning accounts for 11% of black carbon. Both Methane and black carbon are short lived climate pollutant contributing to climate change, while the latter is also an important component of PM (Wiedinmyer et al., 2014).

5. According to the African Waste Management outlook report produced by UNEP in 2018, 70–80 per cent of municipal solid waste generated in African cities is recyclable with an estimated economic value of US$8.0 billion per annum (UNEP 2018). These include biodegradable waste, plastics, paper products and other recyclable materials. It is estimated that only about 11% of the waste has been recycled with the informal waste service providers and recyclers handling most of the recovery and recycling operations. This shows the major opportunities that exist from using waste as secondary resources input for generating jobs and sustainable livelihood.

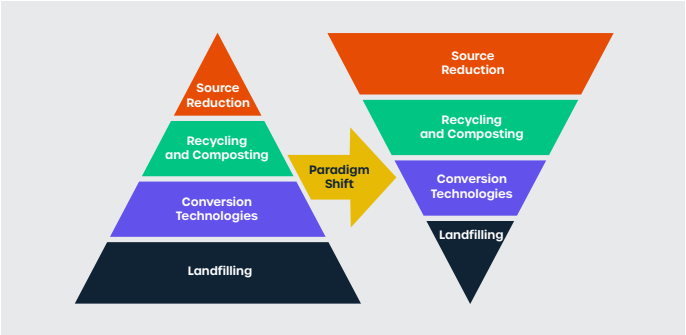
6. Treatment and disposal of waste has gone through different stages of evolution in tandem with the change in consumption and production patterns. This has resulted in various types of waste treatment and disposal technologies and techniques which can be deployed by African countries. The choice of the specific treatment technologies has to be made based on the physical and chemical properties of the waste and the specific resource value to be generated. For instance, utilizing a treatment technology such as the Black Fly Soldier could create significant economic and social opportunities from biodegradable waste. Furthermore, the application of the Fukoka Method[1] for landfill development and management supported with the three R principles of reduce, reuse and recycle could provide a sound basis for developing a holistic and sustainable waste management system.

7. The ten-year implementation plan (2014-2023) for Agenda 2063 of the African Union has set an ambitious aspiration that by 2023 African cities will recycle at least 50 per cent of the waste they generate (AUC 2015). While most African countries are still very far from achieving this goal, UNEP (2018) indicated that even higher rates can be achieved by focusing on (i) the diversion of organic waste away from landfill towards composting, bioenergy recovery and higher value product recovery, followed by (ii) refurbishment, repair, reuse

[1]More on Fukoka Method at: https://www.pref.fukuoka.lg.jp/uploaded/life/542225_60422573_misc.pdf

and recycling of mainline recyclables such as plastic, paper, metal, glass, tyres and e-waste.

8. Attempting to address the problem of open burning through a piecemeal and isolated intervention at one or another point of the waste management system would neither be effective nor efficient. More specifically, phasing out both deliberate and spontaneous open burning of waste would require bringing about a more transformational change in the waste management system in Africa. Such a transition from piecemeal intervention to systemic transformation would need a paradigm shift in the waste management hierarchy towards an integrated waste management system that gives preference to prevention and circularity over treatment and disposal.



9. The systematic integration of the informal waste recyclers who are currently playing a vital role in getting waste back into African economy as secondary resources through reuse, recycling and recovery of end-of-life products would strengthen local manufacturing, create jobs, reduce unemployment, promote circular economy and build more inclusive and sustainable local and regional economies. This would require (Practical Action, 2021): recognizing the vital role they play in the sector, providing the required technical and institutional support to improve their operation and working conditions, building upon their creativity and expertise on waste recycling and reuse and paying attention to gender-based considerations targeting women who are both victims and value-creators.

10. UNEP (2018) identified a lack of public awareness, weak legislation and enforcement, an insufficient budgetary provision for waste collection and disposal, inadequate and malfunctioning operation equipment, lack of effective public participation, and inadequate waste management governance frameworks as the main pressure factors that are affecting the state of waste management in Africa. Addressing these challenges would require action at the following major intervention points in an integrated way.

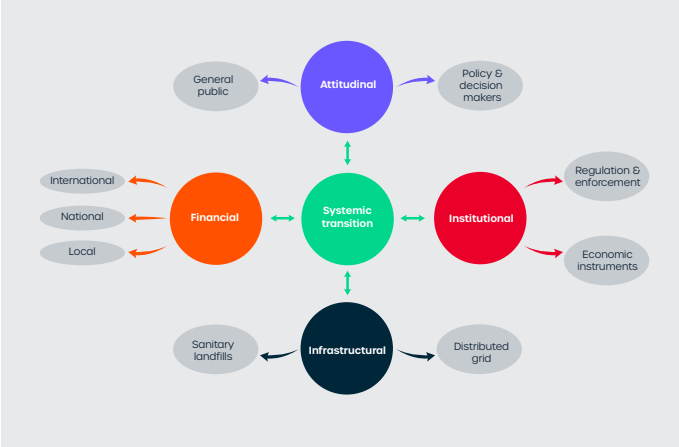
a. ***Attitudinal:*** changing the mindset of the general public, private sector and policy-makers on waste generation and management

b. ***Institutional:*** introducing and enforcing contextual regulation and economic instruments that incentivize waste reduction and utilization as secondary resources (circularity)

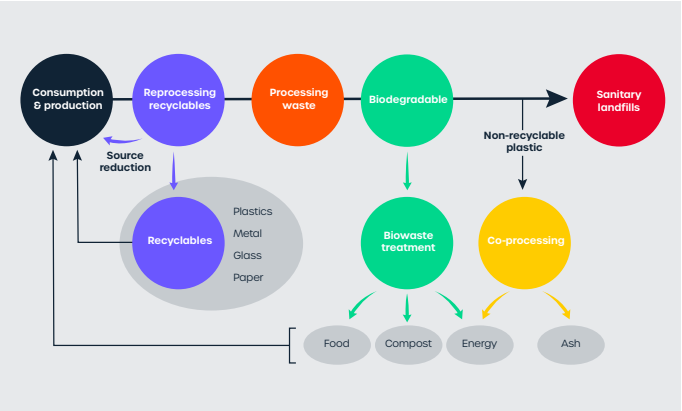
c. ***Infrastructural:*** building efficient infrastructure mix with distributed grid that reduces the environmental and climate impact

d. ***Operational:*** building the required operational and technical skill-sets for implementing integrated waste management hierarchy

11. Integrated implementation of the proposed interventions across the above four pillars is important and all interventions need to be designed and implemented within the context of achieving systemic transformation across the broad consumption and production system. The promotion of circular economy through effective promotion of reusing waste as secondary resource would be an important vehicle of this transformation. This would require that active engagement and contribution of the primary actors and stakeholders in creating an enabling condition for the transition.



12. Phasing out open burning of waste in Africa from systems perspective would require addressing the structural deficiencies that exist in waste management practices. Effective and integrated actions across the above four pillars could lead to systematic reduction of the disposal of waste with higher embedded energy while generating multiple economic, social and environmental benefits through the use of waste as secondary resources input. Such an approach would also lead to more efficient design and investment decision of sanitary landfills besides creating more jobs and providing sustainable livelihood over the waste value chain.



13. Given the current composition and characteristic profile of municipal solid waste, African urban centres could reduce the volume of waste that needs to be disposed of in landfill by up to 60-80 per cent if they manage to reprocess recyclables and biodegradable waste. This could amount to a reduction of open burning of waste by up to 90-100 per cent, as such an approach would practically take out almost all of the combustible elements from the waste stream.

14. Addressing the challenges of waste management in general and open dumping and burning of waste in particular in the African context would require a concerted action by all stakeholders at national and international levels. More specifically, the following three major actors have specific responsibilities to take the necessary actions in their respective areas.

a. National Governments: as signatories of all major international and regional agreements and conventions on environment, climate change and chemical and waste management, national governments have the primary responsibility of creating the enabling conditions through enactment and enforcement of the necessary policy and regulatory instruments. This would include:

   i. Integrating prevention and valorisation of waste into their national sustainable development and green economy strategies;

   ii. Incentivising the adoption of circular economy practices which can offer economic, social and environmental benefits; and

   iii. Mobilising and allocating the necessary financial resource for developing the required institutional and physical infrastructure, including research and development institutions as custodians of data and information, for efficient and integrated waste management system.

b. Cities: as the local governments that are primarily responsible for the provision of waste management services to their habitants, cities are the frontline actors that could and should play a decisive role in phasing out open burning through the development and implementation of an integrated and sustainable waste management system. The required actions would include:

   i. Utilizing available citizens networks and community-based organizations to change public attitude towards open burning and disposal of waste;

   ii. Enacting the necessary regulation and bylaws that prohibit open dumping and open burning and that incentivizes waste segregation, reuse and recycling at the household level;

   iii. Making informed-decisions on waste infrastructure investments that is based on the right mix of the most efficient technologies and techniques that give priority to the use of waste as secondary resource and place people and communities at the centre; and

   iv. Facilitating more active and coordinated engagement and contribution of private sector and informal waste management service providers.

c. Development partners: Both the volume and specific earmarking of development financing for waste management need to change if we wish to achieve the systemic transition in the waste management sector in Africa. The specific areas of support would include:

   i. Building the capacity of national and local governments in creating the required skill-sets for efficient development and implementation of integrated waste management system;

   ii. Facilitating the transfer of knowledge and technologies that are relevant to the context and are responsive to the operational conditions and needs of the countries; and

   iii. Providing investment support that are required to fill the financial gaps for the development of waste management infrastructure.

15. The following are the key recommendations proposed for realizing the phasing out of open waste burning from Africa through systemic transformation of the existing waste management practice that is unsustainable.

a. Widely disseminate the key findings and recommendations of this report through the available channels and forums with

an objective of creating sufficient level of awareness and appreciation about the challenges and opportunities of phasing-out open burning of waste from Africa.

b. Propose a time-bounded goals and targets for phasing-out of open burning of waste from Africa by addressing the structural deficiencies of waste management in Africa based on development and implementation of integrated solid waste management system in Africa.

c. Ensure that the utilization of waste as a secondary resource input for promoting circularity is at the core of the systemic transition through an inclusive engagement and participation of the informal waste service providers as one of the key players.

d. Identify the possible national and local governments, non-state actors and development partners that could champion the phasing out of open burning of waste from Africa through concrete financial mobilization and capacity building support.

e. Prepare a continental commitment for action on phasing out open burning of waste from Africa and solicit their validation and support through relevant continental forums including the Afri-Cities Summit, Africa Climate Week and the African Ministerial Conference on Environment (AMCEN).

f. Identify possible partnership programmes that could support African countries effort to reduce and phase out open burning of waste and thereby reduce and eliminate the associated health, environment and climate impacts.

g. Strengthen the ongoing effort on monitoring and assessment of the state of atmospheric pollution in Africa and its associated impacts on health and the environment with an objective of producing disaggregated data that can support evidence-based policy and decision making at countries level.

h. Avail seed funding and grant that support and encourage innovative policy and technological research and development that are focussed on developing and testing new approaches and ideas that are context relevant to African countries.

i. Launch the multi partnership commitment to reduce and phase out open burning of waste in Africa at the 27th Conference of Parties (COP27) of the United Nations Framework Convention on Climate Change (UNFCCC).

j. Expand the existing partnership between Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation, and the United Nations High Level Champions (UNHLC) by bringing other international and regional partners for ensuring the sustainability of the outcomes and impacts.

Finally, we wish to underline that this report is far from being comprehensive in its coverage as it was not meant to be a detailed assessment of the state of waste management in the continent. However, as a summary report on open waste burning, it highlights the fundamental challenges and opportunities that need to be considered and addressed by African countries and its development partners. It is strongly believed that the effective consideration and implementation of the various steps and recommendations suggested in this report would result in phasing out open burning of waste from Africa. Now, it is time for taking concrete actions that will take us closer to our goal while continuously learning and expanding our knowledge in the field.

Introduction

Introduction

Open burning of waste has been a widely practiced method of solid waste disposal in many regions of the world for centuries. The primary goal of this practice is reducing the volume of waste that needs to be disposed of. However, it has also been used as a way of controlling the spread of seasonal infectious diseases resulting from the decay and decomposition of biodegradable waste. This practice was not a source of concern for many communities until the middle of the 20th century due to the dominant composition of waste, which largely consisted of organic waste. With the change in consumption and production patterns since the 1950s, however, the profile of waste from urban centres has changed significantly both in volume and chemical content. The development of elaborate waste management systems since the 1960s has helped most developed countries move away from open dumping and open burning while it has continued to be widely practiced in developing countries.

Practical Action (2021) estimates that currently two billion people live without any form of waste collection and that more than 90% of waste in low-income countries is openly dumped or burned. As patterns of consumption change, volumes of waste increase and municipal solid waste generation in lower-income cities in Africa and Asia is predicted to double by 2030. Africa is the region that will witness one of the fastest urbanisations in the coming decades (UNECA, 2017). The volume of waste generated by African urban centres is projected to double by 2030 and quadruple by 2050 (UNEP, 2018). This, together with the increasing complexity of waste characteristics, is a major source of concern with the absence of an efficient waste management system. UNEP (2018) underscores that there is an urgent need for African countries to address the current waste management challenges and to prepare themselves for the expected growth in waste generation in the coming decades.

Following the findings of the Global Review on Safer End of Engineered Life which raised the need for urgent action on open burning, Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation, partnered with the United Nations High Level Champions (UNHLC) to launch the open burning initiative to catalyse wider action. The objectives of the initiative include:

- Enhancing awareness and appreciation of the climate and health impact of open burning;
- Strengthening the community of practice and networks with a view to developing a common platform that informs and enables change, both at the policy and the practice levels;
- Coordinating with the Marrakech Partnership community of non-state actors, including the Race to Zero and Race to Resilience Cities campaign to drive concerted action at pace and scale; and
- Developing a set of pathways for systemic change that reduce open burning with the aim of raising the profile of open burning of waste at COP27.

This summary report consolidates existing background information and data on the management of waste in Africa so that it can be used to create awareness and understanding among policy and decision-makers such as national and local governments, non-state actors and development partners operating in Africa. The report consists of the four chapters.

- Chapter one presents the state of waste management in Africa together with the major challenges that African countries are faced with
- Chapter two reviews the associated health and environmental impacts of open dumping and open burning
- Chapter three looks at the evolution of the different phases of waste management, with a focus on the major waste disposal and management methods
- Chapter four sets out the most recent paradigm shifts observed in the field of waste management and the associated benefits that African countries could harness in dealing with the growing challenges of waste management.

Approach and methodology

Approach and methodology

The key approaches and steps followed for the implementation of the UNHLC Initiative on Open Waste Burning in Africa is presented with the schematic diagram in Figure 1 that consists of four distinct, but interrelated, milestones supported with a number of side events and forums. At the core of this approach is the need to develop the final outcome through broader consultative process based on the most recent available data and knowledge in the field of waste management in Africa. The production of this summary report on open waste burning provides the knowledge foundation for the implementation of the UNHLC Initiative on Open Waste Burning in Africa.

The production of this report on open burning of waste in Africa is based on a desktop review of the most relevant publications and research reports on waste management practices in Africa in general and open waste burning and its impacts in particular. Despite the maximum effort made, the review process cannot be claimed to be exhaustive due to time constraints. Lack of country specific data, particularly on the state of open burning of waste and its associated impacts, has also been another source of limitation for the report. In spite of these limitations, the report provides valuable insights into the challenges and opportunities related to open waste burning and could serve as a solid basis for creating a sufficient level of understanding and appreciation of the critical need to take action.

Figure 1: Key approaches and methodology

Knowledge product	• Production of summary report on open waste burning in Africa • Production of communication materials including flyers, presenations and video clips • Organisation of side events and webinars in collaboration with key partners
Goals and targets	• Definition of possible goals and targets on phasing out open burning of waste in Africa • Identifying key elements of the commitments for action and the possible champions for its fullfillments • Validation of the elements of the goals and targets through side events of key forums including Africities summit (May 2022) and the Africa Climate Week (July 2022)
Commitment for action	• Preparation of the draft commitment for action for phasing out open burning in Africa through a multistakeholder partnership • Validation of the draft commitment for action through a side event at the Regular Session of the African Environmental Conference on Environment (AMCEN), September 2022
Partnership on OWB	• Preparation of a multi partnership and time-bounded declaration for phasing out OWB from Africa • Launching the partnership on phasing out open waste burning in Africa

1

Waste management in Africa

1 Waste management in Africa

Africa is one of the fastest urbanising regions in the world. The volume of waste generated by African urban centres has grown by many folds over the past few decades. This section presents a broad overview of the state of waste generation trends and waste management practices in Africa.

1.1 Waste generation and collection in Africa

The Sub-Saharan African (SSA) region produced 184 tonnes of waste in 2016 (see Figure 1.1), approximately 9% of the two billion tonnes a year of global waste (Kaza et al, 2018). This was projected to nearly quadruple by the year 2050 (Kaza et al, 2018), given the drivers of fast population growth and urbanisation rates, coupled with economic growth (UNEP, 2018). Furthermore, changing consumption patterns on the continent brought on by access to second-hand goods, obsolete technologies (UNEP, 2018) and single-use plastics (Velis and Cook, 2021) puts pressure on a system that is severely burdened and least able to deal with it, for a population that is poorly informed on the impacts of improper waste management. Moreover, the global COVID-19 pandemic has brought with it a sudden increase in the volume of health care waste. This has highlighted a weakness in health care waste management systems everywhere as non-essential personal protective equipment (PPE) constitutes slightly less than half of all the PPE shipped (WHO, 2022).

COVID-19 has had various adverse impacts on informal waste service providers and waste pickers. A study conducted by WIEGO (2021), which surveyed 499 waste pickers across nine cities in Africa, Asia and the Americas, concluded that waste pickers experienced a sudden and dramatic decline in average daily earnings as the cost of operating their business increased in the first six months of 2020. It also revealed that most informal waste pickers reported increased occupational health hazards as the pandemic progressed, which impacted them, their families and communities, and that economic recovery was slower for female than for male waste pickers.

Nearly two billion people on the planet live without any form of waste collection (UNEP, 2016; Practical Action, 2021). SSA experiences some of the lowest waste collection coverage. In urban areas less than half of the waste generated is collected (44% collection coverage and in rural areas there is less than 10% coverage. However, most of the waste generated in African urban centres could be recycled as 53% is biodegradable and around 15% is recyclable (for example plastics and metals).

Figure 1.1: Share of waste per region (Source Kaza et al, 2018)

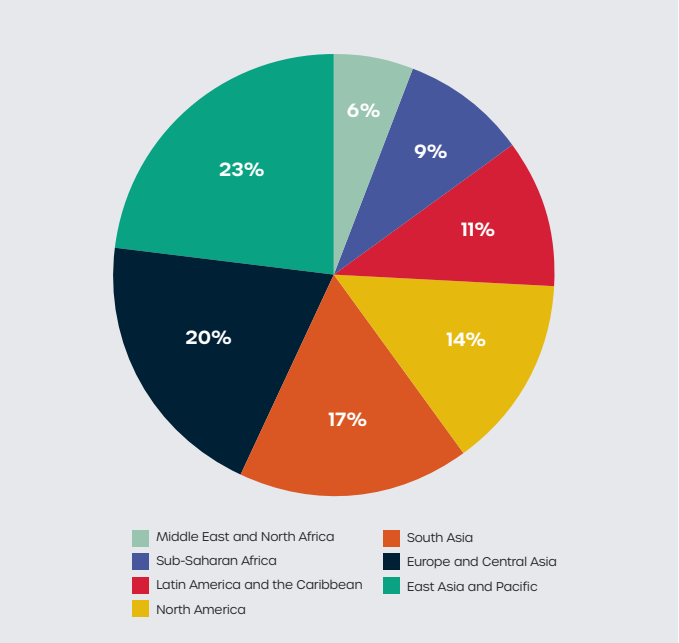


Figure 1.2 shows the waste composition in Africa.

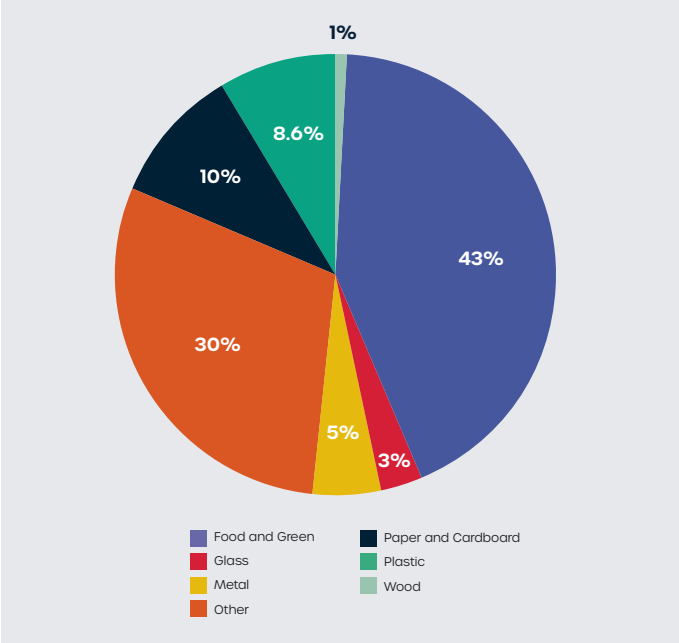


Table 1.1 shows the waste composition for eight cities in Africa. As shown in the table, the waste collection coverage across cities ranges from 37% for Dar es Salaam to 99.9% for Cape Town. Kigali is the city that has the second highest collection coverage among the eight cities with a collection coverage of 88%. Looking at waste composition, Kampala and Kigali have the highest organic content with 71% and 70% respectively, while Maputo, Dar es Salaam and Nairobi have the highest plastic content with 16% . The metal content of waste in all cities is below 5% , indicating the possibility of higher recycling of metals.

Table 1.1: Waste composition and coverage in eight African cities

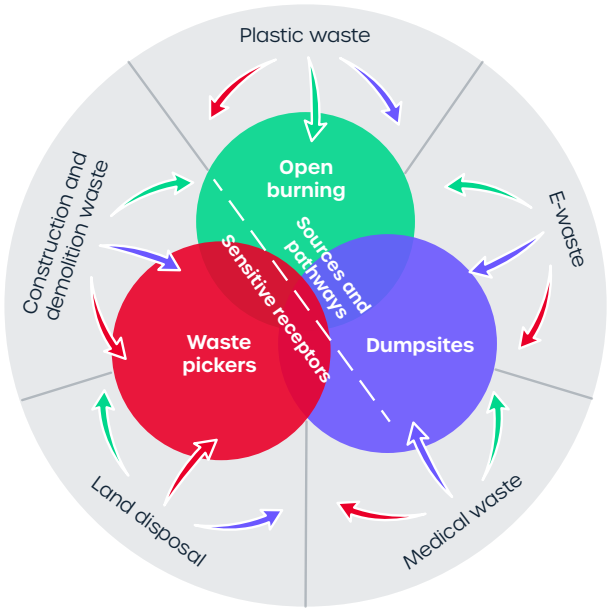
	Maputo	Kampala	Dar es Salaam	Kigali	Nairobi	Addis Ababa	Cape Town	Cairo*
Waste collection coverage								
	75%	65%	37%	88%	52%	70%	99.9%	77%
Waste composition								
Organic	65%	71%	49%	70%	59%	62.6%	27.8%	56%
Paper	9%	7%	8%	6%	18%	5.7%	13.2%	10%
Plastic	16%	8%	16%	5%	16%	5.4%	14.3%	13%
Metals	5%		5%	3%	2%	2.7%	2%	2%

Source of data: (Ibrahim and Mohamed, 2016; Kabera et al, 2019; Greencape, 2021; UN-Habitat, 2021; Xie and Mito, 2021)

1.2 Waste management in Africa

The Engineering X Global Review on Safer End of Engineered Life (Cook, 2020) identified five thematic areas distilled to three cross-cutting and interconnected themes from the perspective of the end-of-life fate of complex engineered materials. The thematic areas, which are mainly the major components of waste that are of concern related to open burning, are (Figure 1.3): plastic waste, e-waste, construction and demolition waste, medical waste and land disposal infrastructure. The interconnecting themes are: open burning and dumpsites, which are identified as sources and pathways; and waste pickers, who are part of the informal waste service providers and identified as sensitive receptors. The report further notes that people in developing countries suffer greater exposure to solid waste and its derivatives and have less capacity and capability to protect themselves from potential hazards, thereby increasing their vulnerability.

Figure 1.3: Interconnected themes, Cook et al, 2020



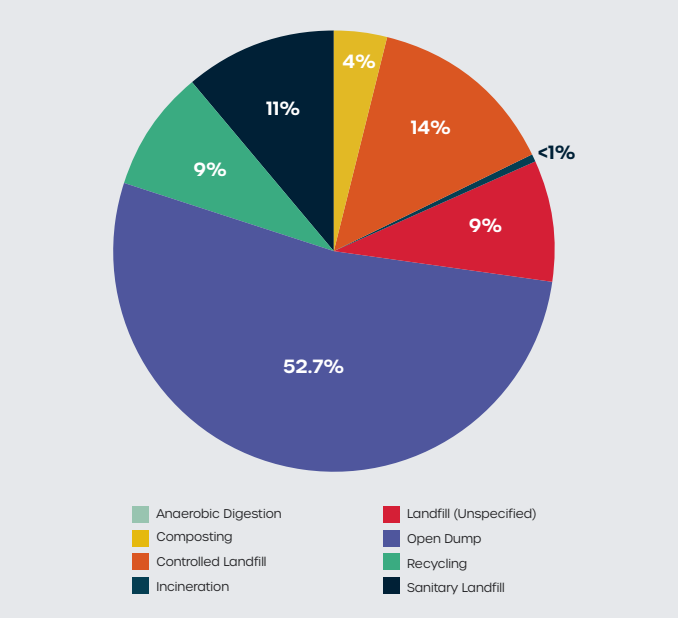
This identifies that addressing the problem of uncontrolled disposal and open dumping while giving due consideration to the informal waste service providers is critical when dealing with the challenges of open burning in Africa. During the COVID 19 pandemic, waste pickers in particular have been forced to take increasing risks in a context where their incomes have not yet reached pre-COVID 19 levels, their savings have been depleted and their access to other resources is limited (WIEGO, 2022). The gender dimension of these factors on women have been multi-faceted with lasting shocks and impacts.

Uncontrolled dumping and open burning of waste are the main methods of waste disposal available to the majority of African countries where it is estimated that up to 90% of waste is openly dumped, and often burned (Cogut, 2016; Kaza et al, 2018; UNEP, 2018). Figure 1.4 gives a snapshot of how waste is managed in

the SSA region. In addition to this estimate, most municipalities rely on uncontrolled landfills which are often left unattended or without further controls, so they serve as open dumps. Only 11% of the waste is disposed of in properly designed and managed sanitary landfills, meaning that more than 60% of the waste is sent to landfills and open dump sites. Only around 10% of the waste is recycled, where the recovery and recycling is mostly handled by the informal waste sector. This means that there are opportunities to increase resource recovery, inclusive of the informal sector in Africa, as 20-84% of households in the global south separate waste to give or sell to traders (Practical Action, 2021).

Despite the variation between cities and countries, African countries face common challenges of waste management that consist of infrastructure, institutional and financial challenges. Although rarely examined, there is also the attitudinal challenge that needs to be examined through the lens of the needed behavioural change. The institutional challenges in waste management stem from lack of capacity, poor coordination and limited resources. In many countries in Africa, the implementation of an integrated waste management system is the mandate of city and local municipalities that are often under resourced and have a big lag in service provision. In contrast, the municipal budgets for low-income countries are twice those of high-income countries (Kaza et al, 2018). However, despite having a higher budget share allocation, there is still a large budget shortfall for waste services indicating the significant gap needed to be filled to build waste management infrastructure where none exists.

Figure 1.4: Sub-Saharan Africa waste treatment and disposal, Kaza et al, 2018



Advanced technologies for waste disposal are often touted as a panacea that will solve most of Africa's waste challenges. Yet, most municipalities are hard pressed to finance the shortfall already existing. This means that undertaking projects with significant budget allocations leads to additional borrowing and spending, with the burden often passed on to users who can ill afford it. Therefore, behaviour change to inform essential process, such as sorting the waste at source and incorporating the informal sector, could ensure an increase in collection, sorting and recycling if supported. While African countries are faced with a combination of challenges that affect the development of an efficient waste management system, cities across the continent are making efforts to provide efficient waste management services with varying degrees of success. The following are selected cases that show the efforts that have been made by cities in recent years.

Case study 1: Assessing waste inclusivity in Kigali

Kigali is often celebrated as the cleanest city in Africa. This speaks to a measure of success of the city's solid waste management programme. In an analysis of six cities in Africa, the stand-out result was the high collection coverage across Kigali, estimated at 88% (Kabera et al, 2019). The success is mirrored in other spheres: strong economic growth, improvement in access to services and a decline in maternal mortality (World Bank, 2021). These successes can be mainly attributed to political stability since the Rwanda genocide in 1994 and deliberate strategy, including the seven-year National Strategies for Transformation (NST1)(Republic of Rwanda, 2017) . In this, clear strategic interventions are laid out including the access to waste management systems developed in cities, towns and rural areas (Republic of Rwanda, 2017). Key to this is the construction of modern landfills in all districts as well as waste treatment facilities.

The City of Kigali's waste management programme was assessed using the Wasteaware methodology, which includes detailed analysis of the city's combined solid waste management and recycling system, including both the formal and the informal city system (Kabera et al, 2019). The framework used in the Wasteaware methodology is presented in Figure 1.5. This is simplified into two triangles combining waste related data and background information. For each, a key quantitative indicator is defined: collection coverage; controlled treatment or disposal; and the recycling rate. These are

complemented by qualitative assessments of the quality of collection, treatment and disposal and the '3Rs' (reduction, reuse and recycling). In addition, the assessment includes a criteria to assess governance aspects that are key to understanding inclusivity from the user's perspective.

The results of the Wasteaware Assessment for determining the degree of user inclusivity in Kigali is shown in Table 1.2. This shows an indicator for user inclusivity, which assesses the degree of citizens' and other waste generators' inclusion in the waste management system. The overall assessment in Kigali was found to be medium to high. Users' access to services was found to be generally good, with various avenues for citizens to feedback to an environmental committee on their concerns at four levels of local government. In addition, there was also opportunity to pass on information less formally through the monthly 'Umuganda' community service day.

Figure 1.5: Framework for Wasteaware Methodology UNEP, 2016; Kabera et a., 2019

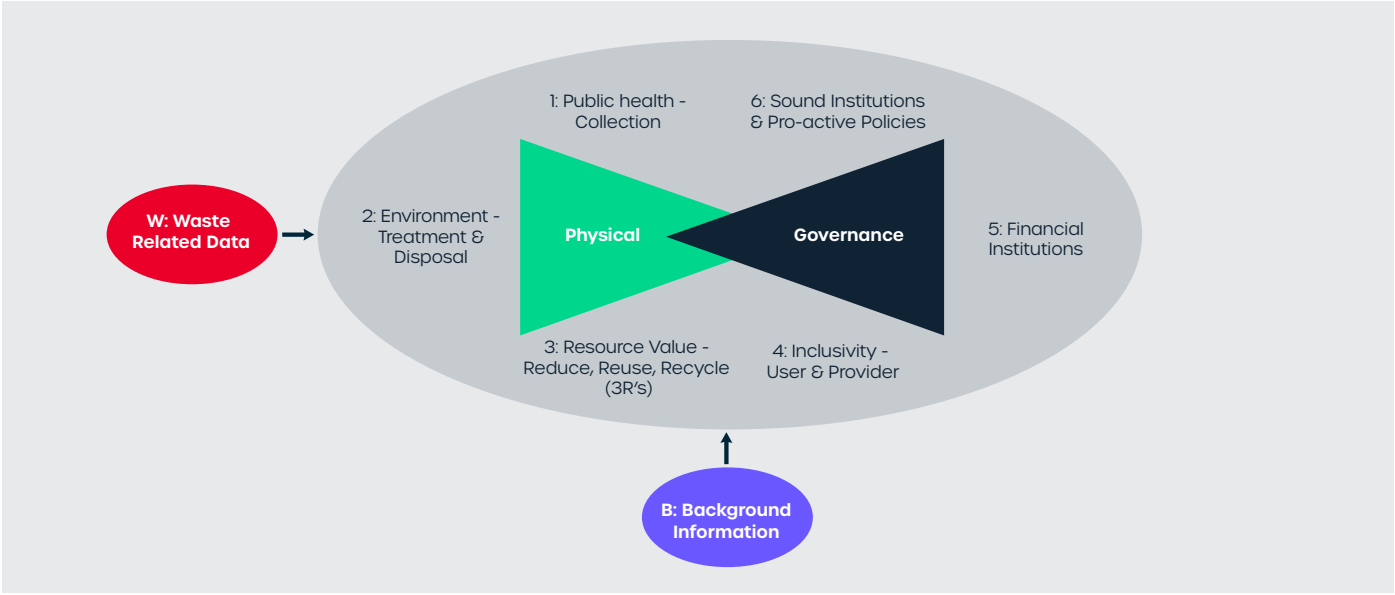


Table 1.2: Wasteaware assessment for the degree of user inclusivity in Kigali. Source (Kabera et al., 2019)

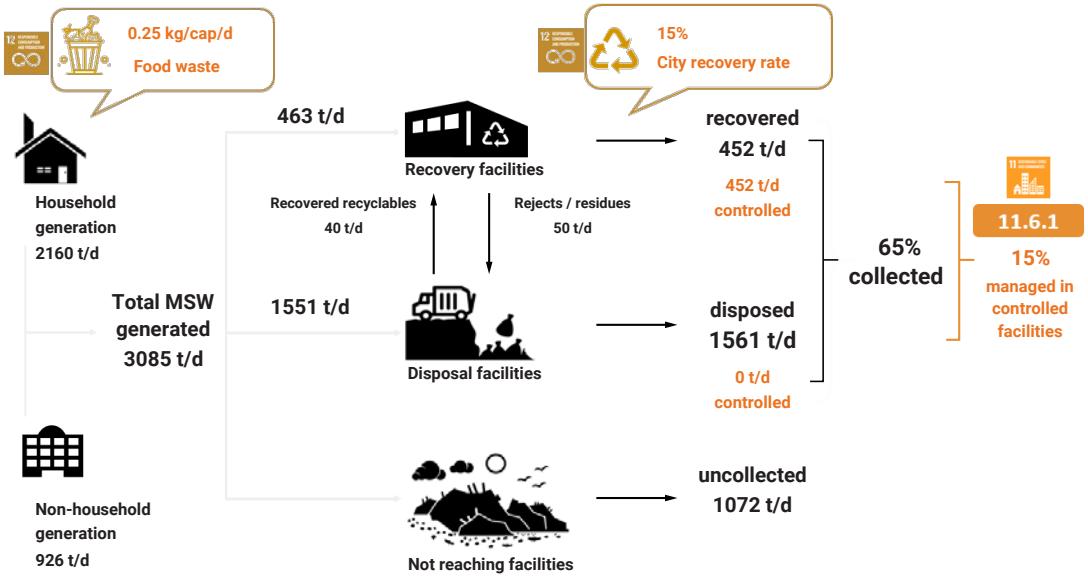
Number	Short name	Score	Observations
4U.1	Equity of service provision	15	All citizens receive a 'good' level of service regardless of their social class - the poorest get a free service. But some marginal neighbourhoods, which are difficult to access, do not receive a service.
4U.2	The right to be heard	15	Obligation from the government to ask for stakeholders' opinion in the solid waste management (SWM) systems.There are environmental committees from cell level up (ie. cell, sector, district and city). These include local people; address environmental problems including SWM.
4U.3	Level of public involvement	10	Local environment committees raise their concerns when they meet authorities on the last Saturday of each month during the *'Umuganda'* community service, and also once a month (usually Wednesday) when citizens meet the executive secretary of the sector.
4U.4	Public feedback mechanisms	15	Feedback mechanisms are in place, including media (mostly radio), monthly community services *'Umuganda,'* local environment committee meetings and their regular monthly meetings with officials.
4U.5	Public education and awareness	15	City level Health and Environment Unit in charge of education and raising awareness on SWM. Uses the media (radio, television and newspapers), community gatherings, and parents' evenings. But both staff resources and budgets are limited.
4U.6	Effectiveness in achieving behaviour change	15	Success of publc education evidenced by high concern for the environment, high participation rates in the SWM system and the cleanliness of the city. The ban on plastic bags in 2008 has helped to raise awareness.
4U	Total score Normalized score	85 71%	Gives an overall assessment of medium/high (M/H)

Notes: for a summary of the scoring system, please refer to the introduction to the Supplementary Information, or for more details to Wilson et al. (2015a) and/or to the detailed user manual (Wilson et al, 2015b). Each qualitative criterion (e.g. 4U.1, 4U.2, etc.) is assessed by the user against a standardized, five-fold scoring system following guidance in the user Manual: no compliance scores 0, low compliance scores 5, medium 10, medium/high 15 and high 20.

Case study 2: Nairobi City County Sustainable Management Action Plan 2020-2022

The Nairobi City County Sustainable Management Action plan was developed by the African Clean Cities Platform (ACCP) a network supporting the creation of healthy and clean cities. The network was founded by the Ministry of the Environment Japan, the Japan International Cooperation Agency (JICA), the City of Yokohama and UN Environment and UN-Habitat. ACCP supported the pilot testing of the Waste Wise Cities Tool (WACT) in Nairobi, together with another 11 cities in nine countries in Africa. The tool enables a rapid waste assessment based on SDG indicator 11.6.1 parameters consisting of seven steps that guide cities to collect data on municipal waste generation, collection and management based on a household survey, questionnaire and observations. The collected data is consolidated in a Waste Flow Diagram (WFD), shown in Figure 1.6 for Nairobi. Nairobi County utilised the evidence generated from the piloting of the WACT to formulate the Nairobi City County Sustainable Waste Management Action Plan (NCCG, 2022).

Figure 1.6: Nairobi Waste Wise Cities Tool (Source UN-Habitat, 2021)



The Nairobi City County Sustainable Management Action plan gives a short-term strategy and guide with time bound targets and actions that were developed for each strategy via a consultative process with key stakeholders to ensure efficient operation of waste management and recycling activities in the city. The consultation process identified the following intervention areas: reduction of waste generated; expansion of waste collection services; enhanced recycling, targeting organic waste as a priority; and the improvement of the Dandora Waste Disposal Site. Dandora Waste Disposal is one of the largest dumpsites in SSA and one of the 50 largest dumpsites in the world. The dumpsite is in close proximity to informal settlements where communities eke out a living scavenging and recovering waste resources, exposing themselves to a myriad of health risks (Muindi et al, 2014). There have been efforts to shut down or relocate the Dandora site, but these have not been successful.

The city action plan highlights the characterisation of waste, categorised into different economic groups, and incorporates a circular economy approach prioritising value recovery. In value recovery the role of the informal sector is acknowledged. In addition, extensive key stakeholder mapping is included. However, the specific processing or disposal technologies identified in this strategy and action plan needed to be finalised after reviewing their practical applicability to Nairobi's financial, environmental, social and cultural context. The strategy for implementation identified six areas for interventions:

- Introduction of separation at source;
- Upgrading collection and transport logistics;
- Investing in recovery and disposal facilities;
- Education and public awareness;
- Strengthening governance, institution and financing;
- Interventions in sustainable production for waste prevention

Case study 3: Reforming the waste sector in Senegal

Senegal produces more than 2.4 million tonnes of waste per year: around 45% of the waste is uncollected and disposed of in the only dumpsite in Dakar, called Mbeubeuss, which is the tenth largest dumpsite in West Africa. The dumpsite has no controls to treat the waste, but there is informal waste recycling to recover objects such as plastics, cardboard, metals and glass. Senegal is one of the countries working with the climate and clean air coalition (CCAC) as well as other strategic partners, including the World Bank, to improve waste management. The CCAC project (shown in Figure 1.6) in Senegal is at a later stage of work plan development. This is aimed at addressing climate change and reducing SLCPs through waste related activities and creating awareness and building capacity, making it one of a handful of countries in Africa prioritising the waste sector by revising their NDCs to include SLCPs.

The waste reforms have been a success partly due to sensitisation, using local media to communicate to citizens, and the use of an innovative web-based system to optimise waste collection routes. There has also been a deliberate effort to engage with young professionals, leveraging innovation and emerging technologies to ensure the sustained development of the waste sector. This, in turn, has brought interest from potential investors and donors ensuring there is continued financial support and resources for the waste sector.

Figure 1.7: A map of the CCAC Projects on Waste Management in Africa including a project in Senegal (Climate and Clean Air Coalition, 2021)

2

Open burning in Africa

2 Open burning in Africa

The open burning of municipal solid waste is a widespread practice with a catastrophic impact on human health, the environment and climate. Its effects are particularly acute across the African continent contributing to significant environment degradation. Environment pollution is related to one in every four deaths (Landrigan et al., 2018). There is limited information from local, national and regional studies on the extent, characterisation and contribution of open burning in Africa to climate, health and environmental pollution (Okot-Okumu, 2012; UNEP, 2018). However, a global study by Wiedinmyer et al, 2014 found that a significant number of African countries severely underestimated GHG and SLCP inventories, most likely by omitting or undervaluing the contribution of open waste burning. Furthermore, the burden of improperly managed waste that results in open dumping and open burning is unfairly distributed so that the biggest impacts are felt by vulnerable members of society. By 2015, 19 of the world's 50 largest dumpsites were located in SSA (UNEP, 2015). Poor waste collection and disposal often reinforces residential open burning of waste, which is almost always coupled with open burning at dumpsites (Cogut, 2016).

There is a positive correlation between income levels and waste generation. The other side of this coin is countries like those in Africa experiencing rapid economic growth, urbanisation and change in consumption patterns where residents have the highest probability of being the most negatively affected by open burning of waste, but have the least resources to stop it. Open burning in Africa is often the result of a lack of awareness of alternative disposal options, high levels of poverty and lack of environmental regulation or enforcement (UNEP, 2018). It is also often the only available method to dispose of waste in some areas. Open burning in Africa can be divided into: residential/household open burning; open dump site burning; and agricultural processing waste.

2.1 Main sources of open burning

While there could be many other minor sources of open burning, the following are identified as the major sources of open burning in Africa.

Household burning: Most open waste burning occurs residentially, is completely unregulated and, consequently, is nearly impossible to measure (Cogut, 2016). The most common household waste management methods identified are waste burning and backyard burying or indiscriminate open dumping (Okot-Okumu, 2012). Communities without access to waste services in urban centres often resort to burying, burning, dumping in public spaces or using some of the green waste as animal feed. It is the latter practice that may see significant reductions in volumes as green waste accounts for nearly half of the waste generated.

Open dump site burning: Waste collected in Africa mostly winds up in uncontrolled dumpsites that have few to no controls or any technologies. These landfills often have fires deliberately set to reduce the volume of waste. However, due to a large percentage of the waste being organic and conditions ideal for anaerobic decomposition, methane is generated and this is a source of spontaneous fires. The fires from some of the world's largest dumpsites can be seen from space and the untold damage from these fires in Africa, where so many live in close proximity to the dumpsite fires, is one that needs to be paid close attention to as it jeopardises the social-economic and health of millions.

Agricultural waste: Agricultural waste examined in this report is largely comprised of processing waste from rice, coffee, cassava and cocoa, all major crops produced for export across the region. Cocoa production is a major activity in West Africa, where around 66% of the world's cocoa beans are produced. Commercial production of the beans leads to the generation of large quantities of waste cocoa pods, which are mostly left on the farm to naturally decay (Antwi et al, 2019). These contribute significantly to GHGs, SLCPs and air pollutants as they are left on the farms in heaps where they undergo uncontrolled anaerobic digestion, or in some cases they are immediately burned. Either way, the end result of this waste product is open burning and forms an untapped source of pollutants in West Africa.

Forest fires: Isolated burning of shrubs and forests to clear land for agriculture has been one source of open burning widely practiced as the region is home to approximately 70% of the global area burned each year (Hickman et al, 2021). This, together with wild forest fires that are triggered by both negligence and climate-induced factors, is occurring with increased frequency and strength across different parts of Africa. The recent wildfires in North African

countries have caused significant damage to natural habitats as well as polluting the environment

2.2 Impacts of open burning

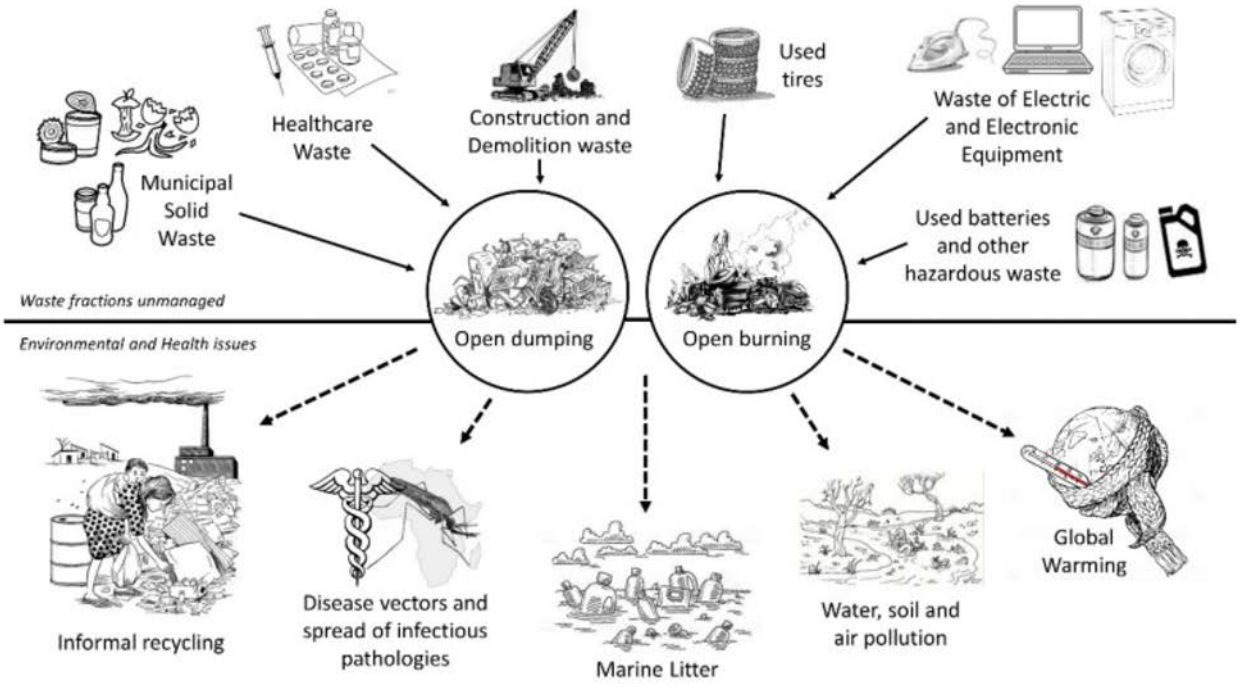
Emissions from open burning of waste that have a direct or indirect health impact include: GHGs, short lived climate pollutants (SLCPS), such as black carbon (BC) and methane, particulate matter (PM), persistent organic pollutants dioxins, polychlorinated aromatic hydrocarbons (Cogut, 2016; UNEP, 2018; Velis and Cook, 2021). Open burning of waste can also produce emissions from a variety of heavy metals, including but not limited to, cadmium, chromium, manganese, antimony, arsenic, lead and mercury. This depends on the quantity of E-waste in the composition of the waste. Communities living close to dumpsites, including children, have been found to have higher levels of toxic substances in their systems due to the ingestion and inhalation of contaminants in the environment (Velis and Cook, 2021). Therefore, open waste burning disproportionately affects marginalised communities and communities living in close proximity to waste dumpsites and those relying on their livelihoods from the informal waste sector. Some of the negative impacts to health range from upper respiratory tract infections, dermatological illnesses, immunological, reproductive and developmental abnormalities.

It is estimated that more than 1.2 million premature deaths occur every year in Africa due to exposure to air pollution (Fisher et al, 2021) with the waste sector contributing a significant source of fine PM, contributing approximately 29% of the global estimates (Wiedinmyer et a., 2014). In addition, waste contributes to climate change as the GHGs from solid waste emissions, driven by open dumps and landfills, account for approximately 5-12% of total global GHG emissions.Methane generated from decomposing organic waste contributes to ~20% of global methane (Ravishankara et a., 2021), while open waste burning accounts for 11% of black carbon. Both methane and black carbon are short lived climate pollutants that contribute to climate change, while the latter is also an important component of PM (Wiedinmyer et al. 2014).

There are limited studies conducted in Africa on the impact of waste burning. A study in South Africa found domestic waste burning could result to up to 20 times World Health Organization (WHO) limits for PM (Hersey et al, 2015). Another study in Zimbabwe on the health effects of living in close proximity to waste collection points found a prevalence of health effects associated with exposure to waste, including diarrhea, dyspnoea, dry cough, eye irritation and asthma (Munyai and Nunu, 2020). In Nigeria, a study on the environmental impact of open burning in municipal solid waste dumps found elevated levels of carbon monoxide (CO), 9 parts per million (ppm) and carbon dioxide 700 ppm (Daffi et a., 2020). Another study in Cotonou, Accra and Lagos indicated that open burning, as an informal electronic waste-handling method, resulted in negative impact on soil quality increasing toxicity (Eze et al, 2022). Therefore, actions to reduce open waste dumping and burning will reduce toxic emissions, GHGs and SLCPs significantly to improve human health, create a cleaner environment and reduce its contribution to climate change.

Black carbon is a particularly serious air pollutant emitted from the uncontrolled burning of waste in open fires because it has a global warming potential (GWP) up to 5,000 times greater than carbon dioxide (CO2) and is also linked to detrimental health impacts (Reyna-Bensusan et al, 2019).

Figure 2.1: Open dumping and open waste burning and its impacts source (Ferronato and Torretta, 2019)



Open burning of solid waste results in a hazardous cocktail of emissions being released into the atmosphere and onto land, posing risk to populations, workers and the environment (Cook 2020). Kodros et al(2016) noted that the emissions from open waste burning produce significant contaminants to the environment exacerbating soil, water, and air pollution responsible for approximately 270, 000 premature deaths worldwide.

Large waste fire burns on an unknown dumpsite; © WitthayaP .

3

Systems solution for open burning

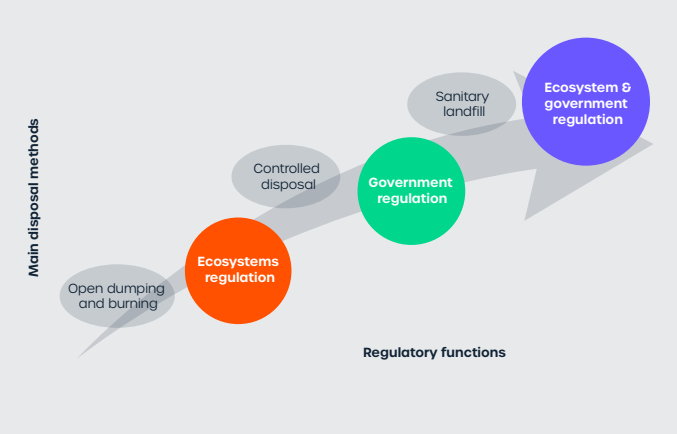
3 Systems solution for open burning

The issue of open burning can only be effectively addressed based on a full understanding of its genesis from a systems perspective. Waste is an inherent product of any production and consumption activity and has been part of our life for millennia and will continue to be for eons. What has changed is the way human society has managed the waste generated. In this context, the evolution of waste management from a systems perspective provides the basis for addressing open burning effectively. The first step is understanding the socio-economic and socio-ecological context of waste management practices that are determined by the prevailing consumption and production patterns. This section starts with a synoptic review of the evolution of waste management methods in relation to the volume and characteristics of the waste generated. This is followed by a summary of the major categories of waste treatment technologies. It finally looks at the paradigm shift observed within the past few decades that have led to the reversal of the waste management hierarchy from the perspective of reducing and eliminating open burning at the source.

3.1 Evolution of waste management

Emissions from open burning of waste that have a direct or indirect health impact include: GHGs, short lived climate pollutants (SLCPS), such as black carbon (BC) and methane, particulate matter (PM), persistent organic pollutants dioxins, polychlorinated aromatic hydrocarbons (Cogut, 2016; UNEP, 2018; Velis and Cook, 2021). Open burning of waste can also produce emissions from a variety of heavy metals, including but

Figure 3.1: Main disposal methods and their regulatory function



Looking back in history, dispersion in the natural environment, regulated by the assimilation function of ecological systems, has been the dominant way of dealing with any form of human waste for millennia. The practice of dumping concentrated, mixed waste on land is the oldest method of disposal and is still predominant throughout many developing countries. Tragically, besides the various associated environmental emissions, more than 31 people have died each year since 1992 due to recorded waste-slope failures at dumpsites (Cook, 2020). These are caused when overwhelming quantities of waste become mobile as shear stability breaks down at the interface between the sub-soil and the waste matrix.

As the number of large settlements increased with the agricultural transformation, it required change in the management of the increasing volume of waste generated by society. This led to the practice of burning the waste, with the objective of reducing the volume of waste into manageable sized ash and smoke. In this context, open burning of waste can be considered as the earliest and crudest form of waste treatment and management in human history. The open burning of waste is still considered as the most practical solution for many communities in developing countries and in rural areas. In some cases, communities have been using open burning of waste to eliminate disease and fight epidemics that have caused numerous losses of life, or epidemics resulting from uncollected waste blocking drains and creating breeding grounds for disease vectors, as described in Box 3.1. UNEP (2015) noted that open burning of waste is widely practised across Africa as it provides a means of reducing the volume of accumulated waste where waste collection services do not exist, or managing waste in dumpsites. In today's world, open burning is often the result of a lack of awareness of alternative disposal options, high levels of poverty and lack of environmental regulation or enforcement (Cointreau 2006; Oelofse and Musee, 2008; Al-Khatib et al, 2009; Narayana, 2009; Hilburn 2015; Jerie, 2016).

Box 3.1: Smoking out November (Hidar Sitaten)

Addis Ababa, the capital city of Ethiopia, was at the early stage of formation when the great influenza epidemic of 1918, also known as Spanish flu, ravaged the whole world. Addis Ababa, as the largest urban sprawl within the country, was severely hit and, as a result, tens of thousands of Ethiopians died due to this epidemic. The city administration took all measures that are currently taken to fight COVID 19 including: lock-downs, quarantine of infected people and a mandatory requirement to wear face covers in public spaces. At the peak of the epidemic in the city, November 2018, the administration ordered all residents to clean their neighbourhood and burn all waste collected as part of measures to contain the epidemic. Since the month of November is recognised as the month of cold and flu, the practice of open burning of waste continued in subsequent years and became a city-wide annual practice that happens every year. The 21st day of November was recognised as the day for carrying out this tradition and it has become known as the date for 'Hidar Sitaten' , which means 'Smoking out November' in the Amharic language.

A study published by Bulto (2020) showed that the emission of PM2.5 from the open burning of refuse was the main source of air pollution in Addis Ababa city on Hidar Sitaten day. The highest PM2.5 concentration recorded was 215ug/m3 on Hidar Sitaten day at 9pm in 2019, while the highest mean PM2.5 concentration recorded was 44.17ug/m3 on 21 November 2017. On the other hand, the mean concentration of PM2.5 recorded was 27.7ug/m3 on Hidar Sitaten days. This data also showed that the mean concentration of PM2.5 on Hidar Sitaten was higher than the WHO air quality guideline limits from August 2016 to November 2019. The study concluded that the concentration of PM2.5 on 21 November 2019 was 8.6 times higher than the permissible WHO level.

In recent years, some efforts have been made by the municipality, environmental institutions and civil societies to educate residents about the adverse effects of such practices. However, the practice has continued to date and every year on the 21st day of November, Addis Ababa is a city with the worst air quality because of the smoke and haze produced by the citywide burning of waste (Bulto 2020).

Until the advent of the industrial revolution, the volume and characteristics of waste generated by countries was largely biodegradable and manageable within the limit of the absorption and assimilation capacity of the natural ecosystem. Therefore dispersion of waste, either through unregulated neighbourhood dumping or burning, had been the dominant way to dispose of waste. With industrialisation gaining momentum, however, urban sprawls consisting of large populations became increasingly common, changing the characteristics of waste. The dispersion of waste through open dumping or burning in such urban sprawls became a major nuisance and source of health hazards. This led to the establishment of designated waste dumping sites so that there could be controlled waste disposal. While this created better conditions for those in society covered by waste collection and disposal services, it led to significant environmental and health hazards for poor and vulnerable groups not covered by waste collection services or living around designated disposal sites. Seasonal occurrence of spontaneous open burning of waste is also common, particularly in waste disposal sites located in tropical zones.

The unprecedented pace of industrialisation since the beginning of the twentieth century, more specifically since the end of the second world war, significantly changed the volume and characteristics of waste across the developed world. This, coupled with the unacceptable level of air pollution in many urban centres, forced many of the industrialised countries to move away from open burning of waste by developing new waste disposal and treatment methods. This led to the development of sanitary landfills as the main method of waste management. The design and management of sanitary landfills has gone through various stages of improvement from an engineering design perspective since the 1970s, with an objective of reducing their overall environmental impacts. The following are some of the key technical factors to consider in the design

and operation of sanitary landfills (Kaza et al, 2018):

- The bottom of a landfill has to be made of a low absorbing soil material, such as clay, and/or a synthetic material, such as plastic, to prevent leachate from seeping into the groundwater or nearby waterways;
- The landfill should be designed with a network of pipes and synthetic material (drainage net) around it to collect the leachate from the bottom of the landfill;
- A landfill gas recovery system needs to be installed to capture the combustible gas resulting from the organic waste decomposition;
- A properly designed storm water management system needs to be included where there is excessive precipitation to divert water from landfills;
- Waste should be compacted daily with specialised equipment to maximize the space available for disposal.

The 'Fukuoka Method' landfill and solid waste management system that was jointly developed by Fukuoka University and Fukuoka City government in the 1970s is another landfill method that has been widely used in recent decades[2]. In this method, a leachate collection and discharge system consisting of stone rubble and perforated pipes is installed at the bottom of the landfill, so leachate in the waste layers is promptly drained to the leachate treatment system and thermal convection occurs due to fermentation heat generated by the decomposition of waste inside the layers. This design reduces the moisture content inside the layers, with air being naturally supplied from the leachate collection/discharge pipes, which promotes the decomposition of waste while maintaining the interior in an aerobic state.

In other words, compared to a conventional anaerobic landfill method, this technique improves the water quality of leachate, suppresses greenhouse gas emissions, reduces the amount of hydrogen sulphide and volatile organic compounds generated and enables the early stabilisation of landfills. The Fukuoka method was approved by UNFCCC as a climate compatible method in 2011 and could be applicable for new construction, rehabilitation, improvement and closure of dump sites.

With the development of the this technology, most developed countries have largely moved towards sanitary landfills, while the majority of developing countries and countries in transition have continued practicing a mix of all three waste disposal methods. Open dumping and burning is still the most dominant waste management practice in most Sub-Saharan African countries (Practical action, 2021). As shown in Chapter 2 of this report, the majority of African countries are still at the stage of open dumping and controlled disposal, while a few of them have reached the stage of having sanitary landfill. This has created a fertile ground for the widespread occurrence of both spontaneous and deliberate open burning across Africa.

The progression from open dumping to controlled disposal and sanitary landfills in African countries would naturally result in the closure of open dumps and uncontrolled disposal sites, which are significant sources of livelihoods for many waste pickers. In this context, any such transition process must begin with a comprehensive plan that considers the needs of the informal workers who are already engaged in gathering, sorting and recycling waste (WIEGO, 2018). This should lead to the development of alternative livelihood provision for waste pickers and recyclers with their involvement as equal partners in all phases of planning and implementation.

[2]https://www.pref.fukuoka.lg.jp/uploaded/life/542225_60422573_misc.pdf.

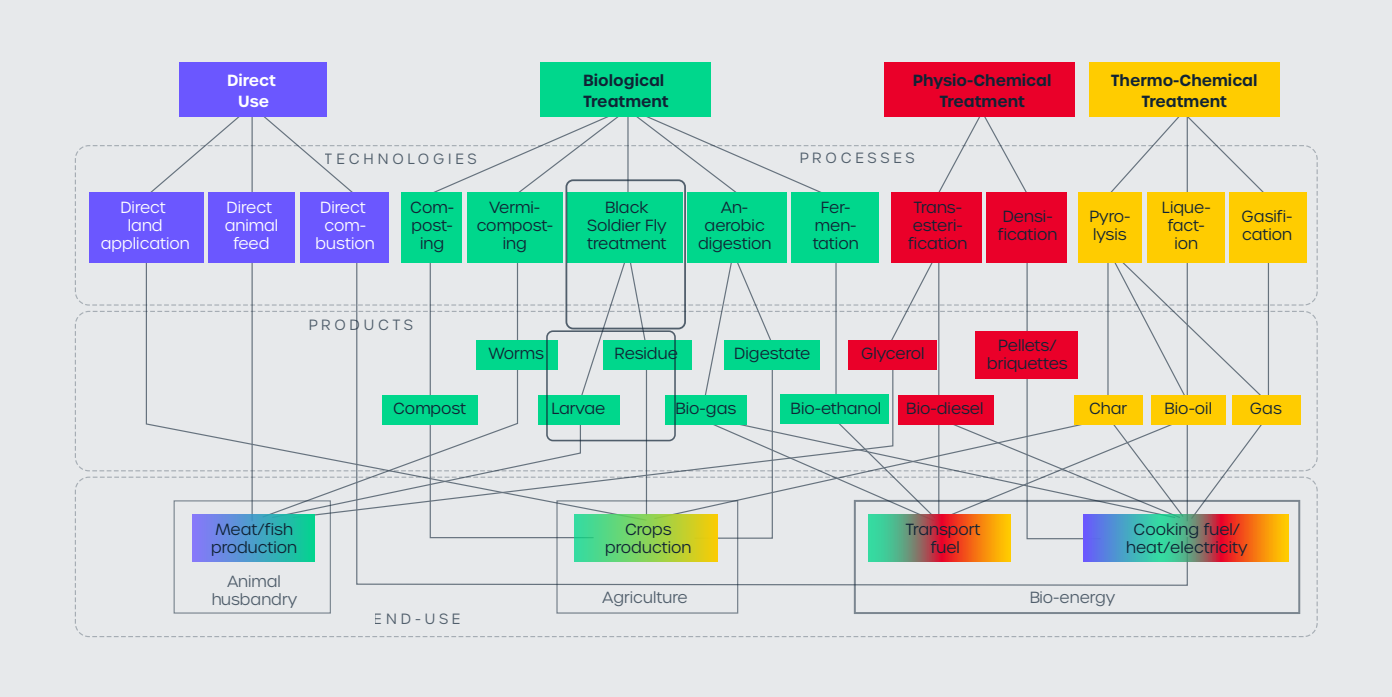
3.2 Waste treatment technologies

Sanitary landfills were found to be the most effective waste management solution for some decades. However, the volume of solid waste generated by urban centres increased by many folds as the use and throw away consumption lifestyle became dominant in many developed countries. This, coupled with an increasing shortage of urban land for sanitary landfill in developed countries, made the disposal of large volumes of waste in sanitary landfills increasingly unviable. In subsequent decades, developed countries have succeeded in establishing higher treatment and recovery intensity and diverting a larger proportion of municipal waste away from landfill than developing countries (UNEP, 2018). This has been driven by a combination of policies (regulatory, financial and economic) coupled with specific local market factors (Soos, 2017).

Besides a number of structural limitations for the viability of large-scale waste to energy conversion technologies, incinerators do not only generate few jobs, but they also directly threaten the livelihoods of thousands working in the recovery and processing of recyclables (IJgosse, 2019). In parallel with these measures, varieties of treatment technologies have been developed and used for the treatment of biodegradable waste generated from urban centres (see Figure 3.2). These could be categorised into the following broad categories.

- Direct use: These are largely applicable for agricultural biomass waste and mainly involve the direct application of the waste on agricultural land. Examples include manure; direct animal feed; such as stalks and kernels; direct combustion; and using agricultural biomass waste for household cooking.

Figure 3.2: Categories of waste treatment technologies Source: Lohri, C. R. et.al 2017



As part of this development, industrialised countries promoted controlled burning of waste in large incinerators with the primary objective of reducing the volume of waste that needs to be disposed of. Incineration combined with co-generation of heat and energy made it a more economically viable solution for countries located in the temperate zone to some degree. Recycling of post-consumer waste, including aluminium cans, plastic and paper products, has also been promoted since the 1970s in many countries. This development resulted in most of the incineration plants becoming obsolete white elephants.

- Biological treatment methods: Treatment methods that are used to convert biodegradable waste of any sort into animal feed, fertiliser and/or fuel that could be used for different purposes. These include composting, which results in materials that could be applied as fertiliser, and anaerobic digestion and fermentation, which results in biogas and bioethanol respectively. More recently, vermicomposting and black soldier fly treatment methods, which results in worms and larvae that could be used as animal feed and residue that could be applied as fertiliser,

have become more widely tested and applied.

- Physicochemical treatment methods: These include physical densification of mainly agricultural biomass to produce pellets or briquets that could be used for cooking and heating and transesterification of municipality waste to produce glycerol and bioethanol.
- Thermochemical treatment methods: This covers treatment methods such as pyrolysis, liquefaction or gasification of waste that result in the production of different types of energy products that can be used for transportation and cooking. These treatment methods are more capital and energy intensive than the other categories.

In recent decades, the application of the Black Soldier Fly (BSF) biological treatment method has gained more recognition as a viable and profitable waste management technology (Lohri et al, 2017). The BSF waste treatment method is an emerging biowaste management technology used to valorise organic waste into frass biofertiliser while generating larvae for animal or human feed (Ojha et al, 2020). Box 3.2 presents one BSF case study from Kenya.

Open burning of waste and the decomposition of high volumes of organic waste in uncontrolled dumpsites generates many atmospheric pollutants. According to UNEP (2018), eliminating uncontrolled dumping and open burning of waste in Africa and diverting organic waste away from landfill towards alternative waste treatment technologies, such as composting and anaerobic digestion, have the potential to create significant positive benefits for Africa, including reduced GHG emissions. Besides the many environmental and health impacts, burning and disposal of biodegradable waste that could be used as a secondary resource results in huge economic loss. Utilising existing treatment technologies for biodegradable waste could create significant economic and social opportunities for most developing countries. The choice of treatment technologies, however, is mainly dependent on the physical and chemical properties of the waste and the specific resource value to be generated.

Box 3.2: Application of the Black Soldier Fly system

Sanergy (https://www.sanergy.com/) is a Kenyan enterprise that has been using Black Soldier Fly (BSF) systems to treat and upcycle organic waste into agricultural products and biomass briquettes. As a social enterprise, Sanergy was created in 2011 in response to inadequate access to safe sanitation and waste management services experienced by Nairobi residents living in slums. Sanergy also saw an opportunity to develop agricultural inputs, such as insect-based protein for animal feed and organic fertiliser. Sanergy uses a full value chain approach and the BSF technology was initially trialled in Kenya through a partnership with the Bill & Melinda Gates Foundation in 2013. The company utilises BSF larvae and thermophilic composting to treat and upcycle faecal sludge, agricultural waste and market and kitchen food waste. Faecal sludge is contained in Fresh Life Toilets (a container-based system used for the storage of human waste) in Nairobi. These toilets are designed to reduce the moisture content of the sludge by separating urine and faeces. As of December 2019, Sanergy had installed a total of 3,247 Fresh Life Toilets in 11 informal settlements, serving more than 80,000 urban residents.

The BSF larvae break down organic material and return nutrients to the soil. The BSF system harnesses this process to convert organic materials – such as manure, agricultural waste, food waste and human sludge – into usable by-products. At Sanergy facilities, the BSF larvae feed on decomposing organic material and the larvae grow from a few millimetres to around 2.5 cm in 14 to 16 days, while reducing the wet weight of the waste by up to 80%. The BSF larvae are 'harvested prior to the prepupal stage using a mechanical agitator to separate them from organic wastes.' Due to the high protein (approximately 35%) and fat (approximately 30%) content of the larvae, they are used as animal feed. The frass residue (excrement from insect larvae) is mixed with carbon sources from plant waste in thermophilic composting windrows to produce organic fertiliser. Sanergy's recycling factory is the largest in East Africa. It has been adapted to use technologies developed in-house by Sanergy's team of engineers.

Source: ISF-UTS and SNV, 2021.

While the use of waste as a secondary resource to generate more value is the preferred option, there are circumstances where recycling would neither be economically viable or socially beneficial. This is particularly true when dealing with a large volume of waste that has mixed characteristics. For example if mixed plastic waste consists of several types of polymers, they would need to be separated . Co-processing of waste has been promoted as one option in countries where there is a large volume of such waste and in which there are energy intensive industries, such as cement and steel, that use coal as an input. Co-processing technology is based on using waste with relatively high energy content, such as clinker production from cement kilns.

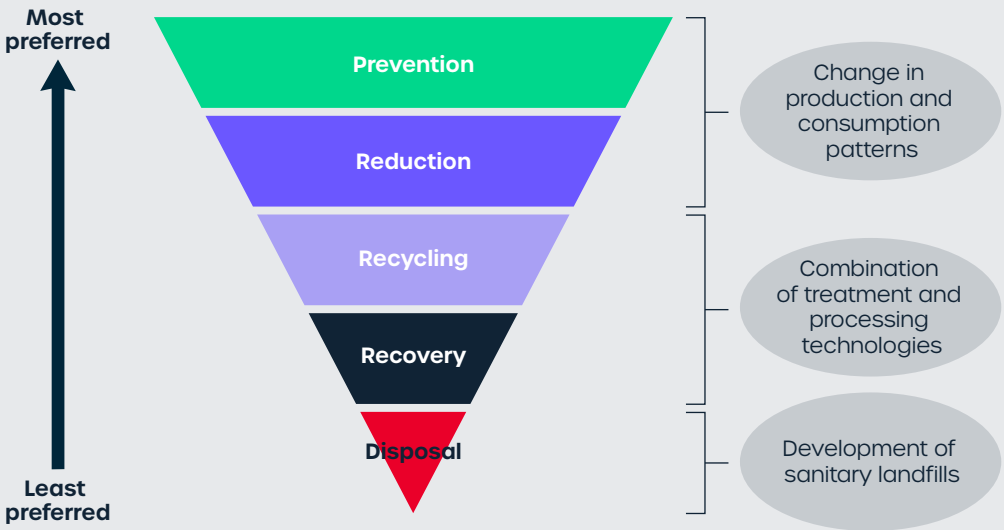
Such a process is considered a better option compared to a standalone waste to energy incinerator as it makes the residual ash part of the product as well as utilising the energy content of the waste. For instance, Norway has managed to replace around 75% of its coal with waste, including plastic, and the country has never built a dedicated incinerator for hazardous waste. This approach of co-processing non-recyclable plastic waste in cement industries is being piloted in five Asian countries through a Norwegian partnership programme Ocean Plastic Turned into an Opportunity in Circular Economy (OPTOCE)[3].

This approach could also be considered by some African countries that have large volumes of non-recyclable plastic waste and cement industries that use coal as a primary energy input.

3.3 The paradigm shift: waste to resource conversion

The 'Three R' principles of reduce, reuse and recycle championed by Japanese cities and government institutions was the first national level effort that placed an emphasis on promoting circularity through waste to resource conversion. This was further reinforced by the cleaner production concept that was developed by the United Nations Environment Programme in 1990, which focused on the prevention and minimisation of waste generation at the source. The progress made in developing various technical tools and guidelines for the promotion and implementation of the 'Three R' principles and cleaner production provided the foundation for reversing the emphasis given to end-of-pipe treatments and waste disposal by conventional waste management practices. Figure 3.3 presents the waste management hierarchy that places more emphasis on preventing waste generation at the source, followed by the revalorisation of waste with the objective of reducing the volume of waste that needs to be treated and disposed of.

Figure 3.3: Integrated waste management hierarchy



[3]More information on OPTOCE is available at: https://optoce.no/

The integrated waste management hierarchy provides the basis for more effective resource utilisation and waste management interventions at the following three levels.

- Prevention and reduction of the generation of waste at the source through a combination of interventions that promote more resource efficient production and consumption patterns;
- Transformation of production and consumption waste into secondary resources that could be used in the economic system through the application of the necessary treatment and waste processing technologies; and
- Safe and efficient management and disposal of waste, including hazardous waste that requires special handling, through improved sanitary landfill design and management methods.

The change in waste management hierarchy was further reinforced by the increased policy recognition and promotion of resource efficiency and circular economy observed since the turn of this century. The launching of the African Circular Economy Alliance (https://www.aceaafrica.org/) by African countries and development partners in November 2019 is one development that could make a significant contribution to the effective management of waste in Africa. A circular economy is an industrial system that is restorative or regenerative by design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products andsystems and, within this, business models (UNEP, 2015). The Organisation for Economic Cooperation and Development (OECD, 2020) seeks to:

- Maximise the value of the materials that circulate within the economy;
- Minimise material consumption, paying particular attention to virgin materials; hazardous substances; and waste streams that raise specific concerns (such as plastics, food, electric and electronic goods);
- Prevent waste from being generated and reduce hazardous components in waste and products.

The reuse, recycling and recovery of end-of-life products has the potential to create significant socio-economic opportunities for Africa. Lessons learnt from work by the SWITCH Africa Green[4] Programme in six African countries supports this view (UNEP, 2020). Growing a secondary resources economy in Africa could inject at least an additional US$8 billion into the economy every year from secondary resources that are currently being thrown away as waste in dumpsites and landfills (UNEP, 2018). The ten-year implementation plan (2014-2023) for Agenda 2063 of the African Union has set an ambitious aspiration that by 2023 African cities will recycle at least 50% of the waste they generate (AUC, 2015). While most African countries are still very far from achieving this goal, UNEP (2018) indicated that even higher rates can be achieved by focusing on (i) the diversion of organic waste away from landfill towards composting, bioenergy recovery and higher value product recovery, followed by (ii) refurbishment, repair, reuse and recycling of mainline recyclables, such as plastic, paper, metal, glass, tyres and e-waste. The report cautions against the appropriateness of large-scale thermal treatment technologies, such as incineration, given the high organic waste (moisture) content and high resource value within Africa's waste streams.

The Global Waste Management Outlook report produced by UNEP (2015) recommended that countries develop and implement a two-pronged strategy that focuses on: i) bringing waste under control; and ii) harnessing the opportunity of waste as a resource. This requires expanding the concept of 'waste management' to become 'waste and resource management', including waste prevention and minimisation and also aspects of resource efficiency and sustainable consumption and production (SCP).

Figure 3.4: Two-pronged waste management strategy

[4]Switch Africa Green (https://www.unep.org/switchafricagreen/) is a programme that supports the development of green businesses and eco-entrepreneurship in six African countries with support from the European Union.

The African Waste Management Outlook report (UNEP, 2018) further elaborated this strategy into specific actions of which the following are directly relevant to the issue of open burning:

- Develop and implement a comprehensive, reliable and regular city cleansing and controlled disposal of waste programme that eliminates uncontrolled dumping and open burning of waste; and
- Unlock the socio-economic opportunities of waste as a resource by moving waste up the waste management hierarchy, away from disposal and towards waste prevention, reuse, recycling and recovery.

UNEP (2018) noted that of the 125 million tonnes of MSW generated in Africa in 2012, only 4% was recycled, with the bulk of the waste disposed of in open dumps, often associated with open burning. It further noted that 70–80% of MSW generated in African cities is recyclable, with a conservative estimate of a value of US$8.0 billion per annum. It is important to note the need to avoid second generation impacts as a result of promoting the use of waste as secondary resources. For instance, E-waste reclamation specialists often use heating, combustion or acid/alkali leaching to recover metals and components, exposing them to considerable quantities of potentially hazardous substances that are released during these processes (Cook, 2020). All efforts of promoting circularity through the use of waste as a secondary resource needs to have the necessary provision for mitigating the associated occupational hazards, particularly when this impacts the most vulnerable groups.

Practical Action (2021) notes that opportunities in Africa to develop a 'waste as secondary resource' approach is still largely unexplored. It adds that the systematic integration of informal waste recyclers, who are currently playing a vital role getting waste back into the African economy as secondary resources through reuse, recycling and recovery of end-of-life products, would strengthen local manufacturing, create jobs, address unemployment and build more inclusive and sustainable local and regional economies. This means recognising that (Practical Action, 2021):

- Informal waste workers are at the frontline of recycling. These workers are often the only actors in a city to recover materials from waste, supplying larger formal recyclers;
- Informal waste workers face very poor working conditions and operate under limited coordination with municipal services that focus on collection and dumping;
- Failing to build on the expertise and contribution of informal waste workers would be a major failure on the part of local authorities; and
- Gender-based consideration targeting women, who are both victims and value-creators, is key in addressing the waste challenge in African countries.

The story of Taka Taka Solutions[5] in Kenya one good example of this informal-formal transition in the field of using waste as a secondary resource. Taka Taka Solutions started its operation in 2011 with waste collection by handcarts and a small-scale composting plant in Kangemi, Nairobi. At that time, it had 10 staff and was collecting 500kgs of waste per day. Information from its website shows that it currently manages more than 60 tonnes of waste per day, from which it recycles 95%. It has more than 350 full time staff and operates: three sorting sites, one composting plant, two plastic recycling plants (containers and flexibles), one incinerator and three buy-back centres. Besides its core waste management and recycling services, Taka Taka Solutions supports afforestation programmes, provides waste management services to schools and hospitals and contributes to policy and legislation processes related to waste management.

SoleRebels[6] is a footwear company in Ethiopia that was established by a female entrepreneur in 2005 as a small community-based enterprise that produces different footwear for the local market made from used tyres and locally available renewable resources. Today, SoleRebels is an internationally recognised brand that sells its footwear products online and through outlet shops in selected cities across the world. The operational philosophy of the company is based on principles of ethical production that ensure decent jobs and benefits, including offering wages three times the industry average to its employees, and the use of sustainable materials including organic cotton, recycled tyres, artisan loomed fabrics, plant-based fibres and sustainable leather. SoleRebels is touted as the planet's fastest growing African footwear brand, the world's first and only World Fair Trade Organisation [WFTO] FAIR TRADE certified footwear company and the very first global footwear brand to emerge from a developing nation.

[5]Information sourced from: https://takatakasolutions.com/. [6]Information sourced from: (https://www.solerebels.com).

4

Enabling conditions for action

4 Enabling conditions for action

The African Waste Management outlook (UNEP, 2018) identifies population growth, rapid urbanisation, unsustainable economic development, changing consumption patterns and global trade as the primary drivers of change in the volume and characteristics of waste in Africa. Existing data on the state of waste management and emerging trends of population growth and urbanisation underscore the urgency for taking comprehensive and integrated action on open dumping and open burning of waste in Africa. The key foundations for action are:

- Understanding the scope of the problem and its associated adverse impacts, particularly on the most vulnerable groups in African society;
- Appreciating the multidimensional benefits of addressing the problem of open burning at the source through an integrated solid waste management system, with a primary focus on waste-to resource conversion;
- Recognising the need for multi-partnership action that puts people at the centre and promotes a just transition towards inclusive and climate resilient societies; and
- Acknowledging the urgency of addressing the open burning issue in the context of the demographic momentum and fast pace of urbanisation in Africa.

4.1 Systemic transformation

Attempting to address the problem of open burning through a piecemeal and isolated intervention at one or another point in the waste management system would neither be effective nor efficient. Similarly, phasing out both deliberate and spontaneous open burning of waste would require bringing about a more transformational change in the waste management system in Africa. Such a transition from piecemeal intervention to systemic transformation needs a consistent application of the integrated waste management hierarchy that prioritises prevention and circularity over treatment and disposal. Such an approach not only leads to a reduction of pollution load to the environment, but also to numerous economic savings through resource saving and valorisation as well as social benefits through job creation and livelihood provisions.

UNEP (2018) identified lack of public awareness, weak legislation and enforcement, insufficient budgetary provision for waste collection and disposal, inadequate and malfunctioning operation equipment, lack of effective public participation and inadequate waste management governance frameworks as the main pressure factors that are affecting the state of waste management in Africa. Addressing these challenges would require action at the following major intervention points in an integrated way.

Attitudinal: Changing the mindset of the general public on waste generation and open burning and creating sufficient level of awareness across policy-makers and decision-makers at national and local levels respectively is the first intervention point that needs to be taken by all actors. Besides presenting the significant health, environment and climate impacts caused by open burning of waste, this intervention should consistently include demonstrating the potential economic and social benefits of utilising waste as secondary resource inputs. This could also contribute to the broader effort of promoting a circular economy in Africa that may result in more job creation and provision of sustainable livelihoods for community groups. The role of media institutions and civil societies in bringing about these attitudinal changes is crucial.

Institutional: Having an appropriate policy and regulatory framework in place and ensuring effective enforcement informed by integrated waste management principles is the key to reducing and eliminating open burning and dumping of waste. This includes the introduction of direct regulations and economic instruments for the prevention and efficient management of all forms of production and consumption waste. A review of solid waste management in Africa found that a number of countries have regulations and policies on how waste should be managed (Bello et al, 2016). However, despite strong legislation in some countries, the implementation and enforcement of this legislation remains weak (UNEP, 2016). The use of economic instruments became more prominent with the paradigm shift towards an integrated waste management system. Economic instruments in the waste sector are typically used to reduce waste generation or divert waste away from landfill towards recycling and recovery (Nahman and Godfrey, 2010).

Figure 4.1: Examples of economic instruments. Source: Nahman and Godfrey (2014), UNEP 2018

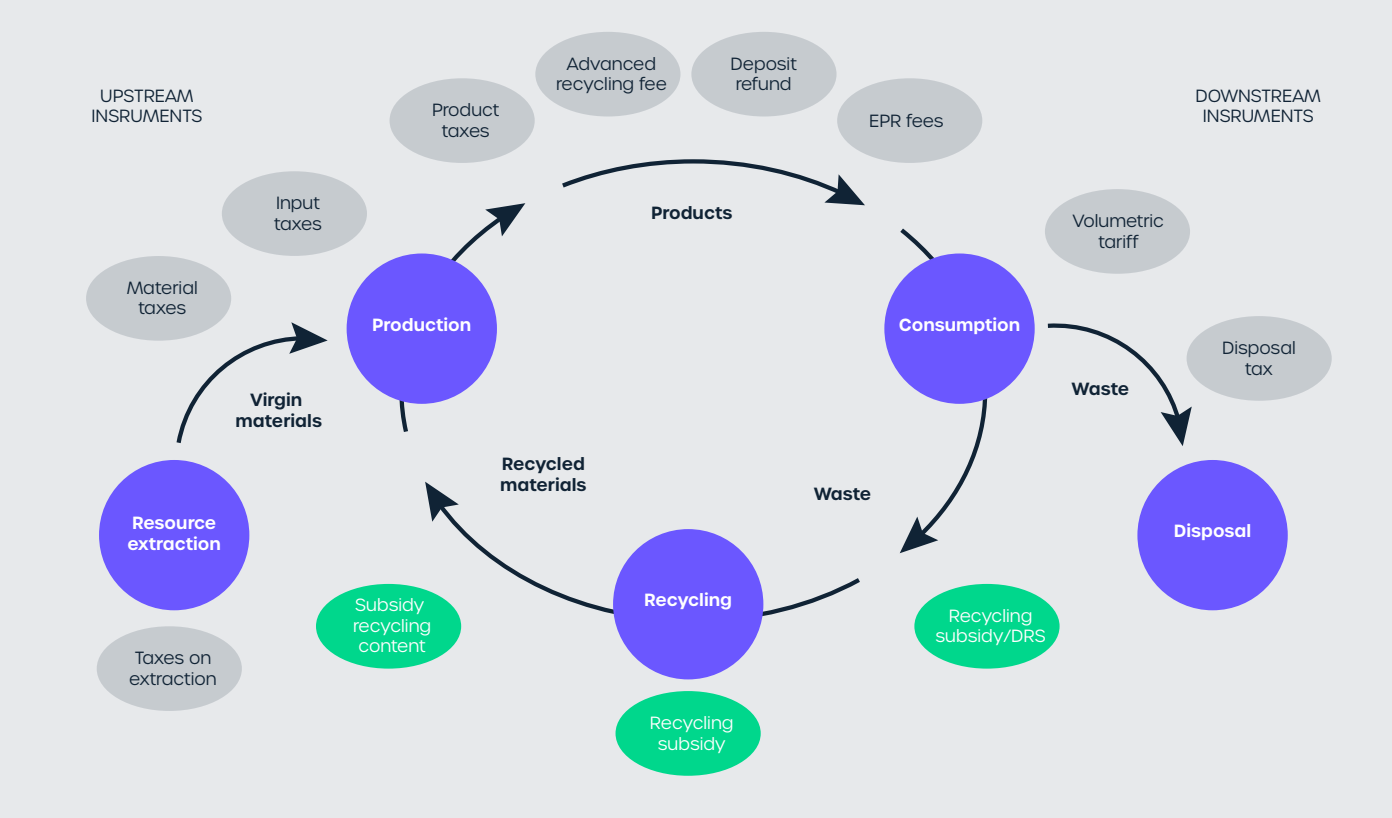
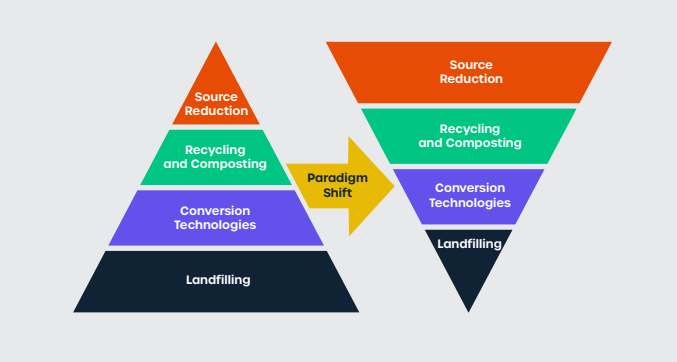


Figure 4.1 presents the variety of economic instruments that could be introduced to promote efficiency, reduce generation of waste and encourage waste reuse and recycling across the production and consumption cycle. The choice and application of specific economic instruments needs to be determined within the broader context and objective of creating an efficient and integrated waste management system that is inclusive, resource efficient and climate-resilient. It will also be useful to take into account the required institutional mechanisms and human capacity for their effective implementation and to take due care to avoid unforeseen distortionary effects that may affect the overall efficiency of the system.

Infrastructural: The absence of properly designed and managed sanitary landfills and lack of efficient waste management service providers are the major infrastructural factors that need to be addressed by African countries. In order to overcome the infrastructural challenge, African countries may consider developing their waste management infrastructure based on distributed grids (UNEP, 2018). Distributed grids involve breaking the centralised grid down into smaller autonomous cells, known as microgrids, which allows a community to operate its systems autonomously. These microgrids are then connected to other microgrids and to the main waste management grid to form distributed grids. A typical solid waste microgrid system would consist of source reduction, separation of different fractions of waste, on-site treatment where possible (for example composting) and collection and transportation to recycling and resource recovery facilities. Such an approach would significantly reduce the volume of waste that needs to be disposed of in sanitary landfills while also facilitating the transition of the informal waste recyclers into formal waste service providers.

Figure 4.2: The paradigm shift



Financial: The overall infrastructure gap in Africa is estimated to be around US$50 billion per year (AfDB et al, 2017), while the estimated cumulated investment needed to develop waste management infrastructure for cities above one million inhabitants was US$2.2 billion for 2015, growing to US$4.5 billion in 2030 (UNEP, 2018). Investments in waste management infrastructure in Africa are often considered as high-risk for a number of reasons. One is the primary focus given to the development of sanitary landfills in the absence of an integrated waste management system, which results in inflated investment and operation costs. As a result, despite the continued effort to develop new infrastructure and expand existing infrastructure, millions of people in Africa still do not have access to essential infrastructural services (UNEP, 2018). In this context, there is a need to shift the focus of investment in waste management primarily to developing distributed waste management grids that could facilitate the reuse of waste as secondary resources and reduce the volume of waste that needs to be disposed of. This would require judicious allocation and use of financial resources by local authorities, national governments and international development partners.

While the integrated implementation of the proposed interventions across the above four pillars is important, all interventions need to be designed and implemented within the context of achieving systemic transformation across the broad consumption and production system. The promotion of a circular economy through effective promotion of reusing waste as a secondary resource would be an important vehicle for this transformation.

Phasing out open burning of waste in Africa from a systems perspective should address the structural deficiencies that exist in waste management practices. Effective and integrated actions across the above four pillars could lead to the systematic reduction of waste disposal with higher embedded energy, while generating multiple economic, social and environmental benefits through the use of waste as a secondary resources input. Key elements of promoting circularity over the waste value chain are: reduction of waste at the source (households and businesses); separation and reprocessing of recyclable materials, such as plastic, glass, metal and paper products; processing of biodegradable waste, either through co-processing for energy utilisation or biowaste treatment for producing energy, food and compost as a fertiliser.

Figure 4.3: Integrated intervention for systemic transition in waste management

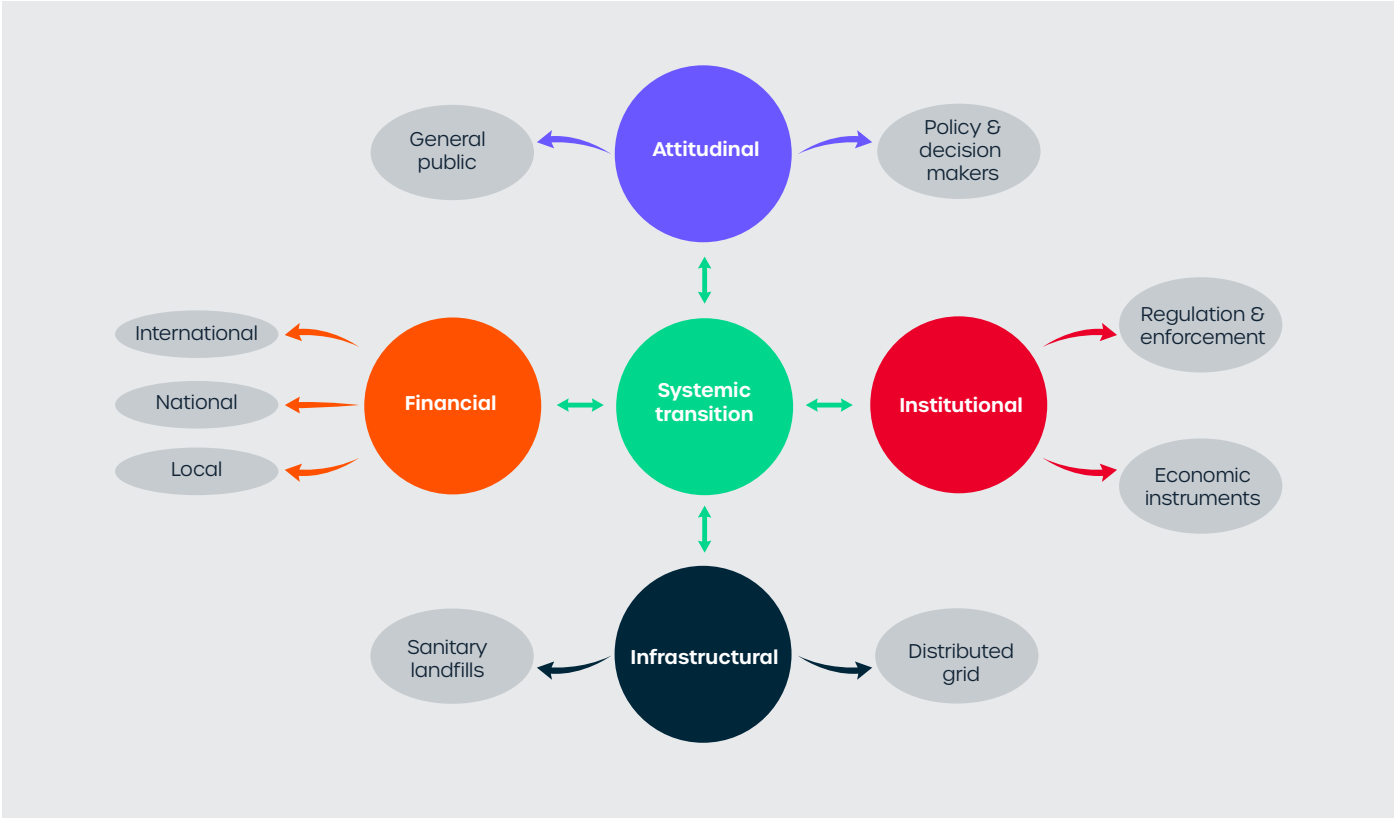
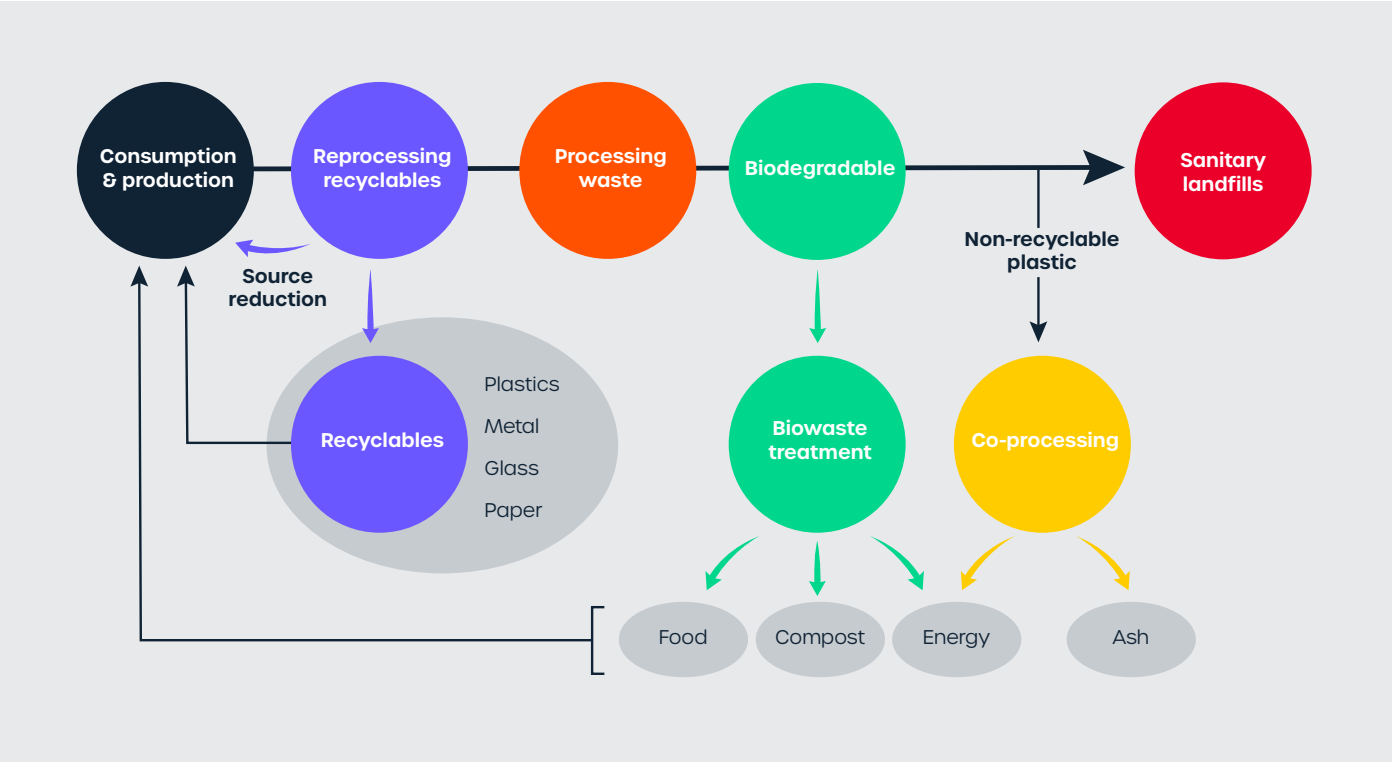


Figure 4.4: Circularity over the waste value chain



Such an approach would also lead to more efficient design and investment in sanitary landfills, with a reduced volume of waste that needs to be disposed of, as well as creating more jobs and providing sustainable livelihoods over the waste value chain. The implementation of such a systemic transition would require the active engagement and contribution of the primary actors and stakeholders to create an enabling condition for the transition. Given the current composition and characteristic profile of municipal solid waste, African urban centres could reduce the volume of waste that needs to be disposed of in landfills by up to 60-80% if they manage to reprocess recyclables and biodegradable waste. This could amount to a reduction of open burning of waste by up to 90-100% as such an approach would take out almost all of the combustible elements from the waste stream.

4.2 Creating enabling conditions

Addressing the challenges of waste management in general and open dumping and burning of waste in particular, in the African context this requires a concerted action by all of the major actors. For the purpose of this paper, the major actors considered are: national government, local governments and municipalities, development partners and the informal waste service providers who are currently filling the major gap that exists in waste management service provision. This section highlights the major actions that need to be considered by national governments, local governments and development partners to phase out or reduce open burning in Africa.

a. **National Governments:** As signatories of all major international and regional agreements and conventions on environment, climate change and chemical and waste management, national governments have the primary responsibility of creating the enabling conditions through enactment and enforcement of the necessary policies and regulatory instruments. To reduce and phase out open dumping and open burning of waste, national governments need to give particular attention to:

   i. Integrating prevention and valorisation of waste into their national sustainable development and Green Economy strategies to provide strong policy signals to all sectors;

   ii. Incentivising the adoption of circular economy practices that can offer a triple win by creating: a clean and healthy urban environment; jobs for the most vulnerable; and a contribution towards the fulfilment of their nationally determined commitment

(NDC) on climate change; and

iii. Mobilising and allocating the necessary financial resources for developing the required institutional and physical infrastructure for efficient and integrated waste management systems.

b. **Cities:** As local governments are primarily responsible for providing waste management services for their habitants, cities are the frontline actors that could and should play a decisive role in phasing out open burning through the development and implementation of an integrated and sustainable waste management system. The actions that could be taken by cities include:

i. Utilising available citizen networks and community-based organisations to change public attitudes towards open burning and disposal of waste in favour of an integrated waste management system;

ii. Enacting the necessary regulation and bylaws that prohibit open dumping and open burning and that incentivise waste segregation, reuse and recycling at the household level and ensure effective enforcement at a city level;

iii. Making informed decisions on waste infrastructure investments based on the right mix of the most efficient technologies and techniques that give priority to the use of waste as a secondary resource and place people and communities at the centre; and

iv. Facilitating more active and coordinated engagement and encourage contributions from the private sector and informal waste management service providers in the development and implementation of an integrated waste management system.

c. **Development partners:** The Global Waste Management Outlook report (UNEP & ISWA, 2015) shows that development finance for waste management systems in developing countries in 2012 was US$510 million of the total development finance of US$230 billion during the same year. The report shows that most of this financing was given in the form of loans to middle countries for building sanitary landfills. Both the volume and earmarking of development financing for waste management need to change if we wish to achieve a systemic transition. The technical and financial support of international development partners, including the United Nations System, development financing institutions and bilateral development partners, is critical for phasing out open burning and transforming the waste management system in Africa. The specific areas of support would include:

i. Building the capacity of national and local governments to create the required skillsets for efficient development and implementation of integrated waste management systems;

ii. Facilitating the transfer of knowledge and technologies that are relevant to the context and are responsive to the operational conditions and needs of the countries; and

iii. Providing investment support that is needed to fill financial gaps for the development of waste management infrastructure.

Plastic at a recylcing centre, Nairobi, Kenya

Box 4.1: SWITCH Africa Green: promoting circularity

SWITCH Africa Green is a programme that supports micro, small and medium sized enterprises (MSMEs) in six African countries by building their capacity in green business and eco-entrepreneurship. This includes promoting circularity through integrated waste management and industrial symbiosis, which implies the use of waste as a secondary resource input. These are the key results from the first four years of implementation (UNEP, 2020):

- 83% of the surveyed enterprises reported improved business skills and 74% recorded increased sales turnover;
- 68% of the surveyed MSMEs reported that new jobs had been created during the implementation of the SWITCH Africa Green programme. Based on the survey data, 2,683 new jobs were created during the implementation of the programme, with 63% of the new jobs created in the industrial symbiosis;
- 70% of the MSMEs implemented 3R interventions. Some of the environmentally friendly interventions adopted include reuse and recycling, sale of waste, segregation at source and better disposal; and
- In Burkina Faso, 3,700 tonnes of waste were diverted from uncontrolled dumpsites, of which 2,200 tonnes went to composting and recycling activities. In Ghana, 20,000 tonnes of e-waste were recycled, benefiting directly and indirectly around 2,100 Ghanaians living in Accra. In Mauritius, 2,677 tonnes of waste were diverted annually from landfills and used locally as raw materials in the IS subsector.

SWITCH Africa Green provides a valuable insight into the kind of support that development partners could provide in promoting the reduction and use of waste as secondary resources and promotion of the transition to a circular economy.

4.3 Inclusion of the informal waste management sector

In Africa, where municipalities are struggling to implement collection services, informal collectors, small-scale entrepreneurs and private businesses have stepped in to provide a service. The informal waste sector has been shown to be very effective and efficient in collecting waste, in particular valuable recyclable material that can be sold (UNEP 2018, 2020). Most of these informal waste recyclers are creative and innovative in terms of developing and implementing the most appropriate collection and recycling techniques. The case in Box 4.2 presents one example of such an innovative collection mechanism developed by an informal group of waste recyclers in Nigeria.

There is growing consensus that the informal sector, which is the seedbed for social innovation, must be taken into account when improving waste management systems in developing countries (Ali, 2006). However, almost all workers in informal waste businesses face forms of discrimination and abuse and are at risk when dealing with hazardous waste without sufficient protective equipment or safe processes (Practical Action, 2016). This needs a significant shift in our institutional and personal mindsets about the role and contribution of informal waste service providers and recyclers. Informal waste recyclers also have a key role to play reshaping the 'end-of-life' of products. Beyond appropriate waste disposal techniques, waste pickers need to be supported in waste valorisation processes to expand their livelihood sources and encourage a culture of reusing, redesigning and reimagining waste (WIEGO, 2018). Therefore, encouraging circularity principles and strategies as an added approach to value creation in waste picking can be incorporated into the waste picker formalisation processes.

In this context, Practical Action (2021) notes that there is an urgent need to bring people back to the heart of the narrative to reduce the impacts they suffer and highlight the potential they hold for more effective solutions. It further suggests refocusing on systems that work for people in terms of quality of service, accessibility, affordability, better working conditions and resource recovery that bring more value to the poorest in waste value chains. To overcome the

major challenges in this area and achieve a more people-centred approach, Practical Action suggests the following four areas of action (Practical Action, 2021):

- Monitoring waste management as a people-centred service by adopting a ladder of access to waste services and disaggregating by wealth and gender to clearly identify where action is needed;
- Tackling the waste that affects people the most by encouraging household source separation, supported by new options for waste streams that are the most polluting or hazardous for people, in particular women and children;
- Improving the lives and working conditions of informal waste workers by recognising the contribution of informal waste collection, recycling and trading businesses and promoting new public–private partnerships and systems that create space for the expertise and dynamism in this sector; and
- Integrating the voices of those most affected at all levels by ensuring that waste policies do not only focus on environmental benefits, but also on improving the lives of the poorest communities and workers.

Improving safety conditions for informal waste workers is a complex undertaking. Past efforts by governments and businesses have often focused on exclusion and prohibition, leaving some of the world's poorest and most marginalised people without the materials that they rely upon for their income (Cook, 2020). Evidence from previous research advocates for the efforts of informal waste workers to receive greater recognition through their inclusion and integration into formal, municipal solid waste management plans (Velis et al, 2012). If successful, inclusion and integration can result in improved safety outcomes for informal waste workers, as their income is stabilised, and wider stakeholders (for example, municipalities) also take an interest in their overall wellbeing as critical service providers (Cook, 2020).

Box: 4.2 Wecyclers, Lagos, Nigeria

In Nigeria, a small company Wecyclers (http://wecyclers.com) was started in 2012 by a young female entrepreneur as a for-profit social enterprise to address the waste management challenge facing the city. At the time, only 40% of Lagos' waste was collected and only 13% was recycled. In addition, recycling firms in Lagos faced supply constraints and were unable to access adequate supplies of quality recyclable material, often operating at 50–60% below capacity. Wecyclers uses low cost, environmentally friendly cargo bicycles or 'wecycles' to provide convenient collection services for recyclable waste.

©Weycyclers

According to the company: "Wecyclers gives households a chance to capture value from their waste while providing a reliable supply of materials to the local recycling industry". Waste volumes in programme areas in Lagos, Nigeria, have been reduced by more than 35% thanks to this social entrepreneurial innovation. The principle is simple and adaptable to other communities in Africa.

Source: UNEP, 2018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Conclusions and recommendations

Conclusions and recommendations

Open burning of waste is the most widespread waste management practice across African countries and has a significant impact on health and the environment. It is also a significant contributor to climate change due to the release of short-lived climate pollutants. And yet, it is one of the least recognised challenges in global, regional and national environmental discourses and policy frameworks. This is largely due to lack of understanding and appreciation about the scope of the problem and its adverse impact on human health and the environment. The problem and its related impacts are much more aggravated in African countries due to the serious lack of efficient waste management infrastructure in urban centres. This means that the problem associated with open burning of waste can only be effectively addressed by building the necessary institutional and infrastructural capacity for efficient waste management in Africa.

There is no single blueprint on how to develop such systems as countries and cities have a wide range of variations. However, it has been identified that around 60% of waste generated in most African urban centres is biodegradable, while another 20% is made up of recyclable materials such as plastics and paper. This provides a solid basis for developing and implementing integrated solid waste management systems that promote the use of waste as a secondary resource. Such an approach could also be a valuable vehicle for creating jobs and providing sustainable livelihoods for local communities as well as reducing environmental pollution and greenhouse gases. The effective development and implementation of such a system needs a major attitudinal change on waste, both at an institutional and the general public level. Open burning of waste can be fully phased out of Africa if local and national government, private sector and international development partners commit to the development and implementation of an integrated solid waste management system that has circularity at its core. The following are the key recommendations proposed for achieving the phasing out of open waste burning from Africa through systemic transformation of the existing waste management practice that is unsustainable.

1. Widely disseminate the key findings and recommendations of this report through the available channels and forums with an objective of creating a sufficient level of awareness and appreciation about the challenges and opportunities for phasing-out open burning of waste from Africa.
2. Propose time-bounded goals and targets for phasing-out open burning of waste from Africa by addressing the structural deficiencies of waste management in Africa, based on the development and implementation of an integrated solid waste management system in Africa.
3. Ensure that the utilisation of waste as a secondary resource input to promote circularity is at the core of the systemic transition through the inclusive engagement and participation of the informal waste service providers as one of the key players.
4. Identify the possible national and local governments, non-state actors and development partners that could champion the phasing-out of open burning of waste from Africa through concrete financial mobilisation and capacity building support.
5. Prepare a continental commitment for action on the phasing-out of open burning of waste from Africa and solicit its validation and support through relevant continental forums, including the Africities Summit, Africa Climate Week and the African Ministerial Conference on Environment (AMCEN).
6. Identify possible partnership programmes that could support African countries' efforts to reduce and phase-out open burning of waste to reduce and eliminate the associated health, environment and climate impacts.
7. Strengthen the ongoing effort monitoring and assessing the state of atmospheric pollution in Africa and its associated impacts on health and the environment, with an objective of producing disaggregated data that can support evidence-based policy and decision making at a countries level.
8. Make available seed-funding and grants that support and encourage innovative policy and technological research and development that is focused on developing and testing new approaches and ideas that are context relevant to African countries.
9. Launch the multi-partnership commitment to reduce and phase-out open burning of waste in Africa at the Twenty Seventh Conference

of Parties (COP27) of the United Nations Framework Convention on Climate Change (UNFCCC).

10. Expand the existing partnership between Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Registered Foundation, and the United Nations High Level Champions (UNHLC) by bringing together other international and regional partners to ensure the sustainability of the outcomes and impacts.

Finally, we wish to underline that this report is far from being comprehensive in its coverage as it was not intended to be a detailed assessment of the state of waste management in the continent. However, as a summary report on open waste burning, it highlights the fundamental challenges and opportunities that need to be considered and addressed by African countries and its development partners. It is strongly believed that the effective consideration and implementation of the various steps and recommendations suggested in this report would result in phasing-out open burning of waste from Africa. Now, it is time to take concrete actions that will take us closer to our goal, while continuously learning and expanding our knowledge in the field.

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Annex one:
About the partners

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United Nations High-Level Champions

The United Nations High-Level Champions (UNHLC) for Climate Action was established at COP21 and has a UN mandate to work with the non-state actor community (businesses, investors, cities, regions and civil society) to strengthen ambition, accelerate action and facilitate collaboration between parties and non-parties to achieve the goals of the Paris Agreement. The UNHLC launched the following two flagship initiatives with the objective of fulfilling its mandate.

- **The Race to Zero:**[7] A global campaign to rally leadership and support to secure commitment of state and non-state actors to achieving zero emissions as soon as possible - and by 2050 at the very latest; and
- T**he Race to Resilience:**[8] Aims to catalyse action by non-state actors that builds the resilience of four billion people from groups and communities who are vulnerable to climate risks by 2030. The decommissioning, dismantling and disposal of products and structures at the end of their life can damage the environment and squander scarce resources if not carried out responsibly.

Engineering X Safer End of Engineered Life (SEEL) programme

Engineering X[9] is an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation that brings global experts together to engineer change. We collect evidence, create diverse and global expert communities around the challenge and amplify unheard voices. Our programmes bring together partners from around the world to tackle the most pressing engineering, safety and sustainability problems and develop practical, sustainable and accessible solutions for the engineering profession worldwide.

Our Safer End of Engineered Life (SEEL) programme[10] seeks to address the safety challenges that occur when the billions of tonnes of engineered structures and products reach the end of their useful life. One of the issues the programme has sought to address is the burning of waste, building on the findings of the Global Review on Safer End of Engineered Life carried out by the University of Leeds and partners. Since the report launch in 2021, the Safer End of Engineered Life has been building awareness of open burning and the need for urgent action. We are building communities around this challenge and raised open burning in an official UN side event at COP26 with our partners the International Solid Waste Association, the Climate & Clean Air Coalition (CCAC), the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), WasteAid, Emory University and the Institute for Global Environmental Strategies (IGES).[11]

[7]For more information, you may visit: https://racetozero.unfccc.int/.

[8]For more information, you may visit: https://racetozero.unfccc.int/race-to-resilience-launches/.

[9]For more information, visit: https://www.raeng.org.uk/global/international-partnerships/engineering-x

[10]For more information, visit: https://www.raeng.org.uk/global/international-partnerships/safer-end-of-engineered-life

[11]Watch the COP26 side event here: https://www.raeng.org.uk/global/international-partnerships/engineering-x_/safer-end-engineered-life/cop26-side-event

Lists

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List of Acronyms

3Rs	Reduction, Reuse, Recycling
ACCP	African Clean Cities Platform
AfDB	Africa Development Bank
AMCEN	African Ministerial Conference on the Environment
AUC	Africa Union Commission
BC	Black Carbon
BSF	Black Soldier Fly
CO2	Carbon Dioxide
COP	Conference of Parties
CCAC	Climate and Clean Air Coalition
GHGs	Greenhouse Gases
GWP	Global Warming Potential
ISF UTS	Institute of Sustainable Futures, University of Technology Sydney
JICA	Japan International Cooperation Agency
MSW	Municipal Solid Waste
NDC	Nationally Determined Contributions
NCCG	Nairobi City County Government
OWB	Open Waste Burning
PM2.5	Fine Particulate Matter with particles size diameter less or equal to 2.5 micrometers
PM	Particulate Matter
PPE	Personal Protective Equipment
POPs	Persistent Organic Pollutants
RAEng	Royal Academy of Engineering
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goal
SEEL	Safer End of Engineered Life
SLCPs	Short Lived Climate Pollutants
SNV	Netherlands Development Organisation
SSA	Sub-Saharan Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNHLC	United Nations High Level Climate Champions
UN Habitat	United Nations Human Settlements Programme
WACT	Waste Wise Cities Tool
WFD	Waste Flow Diagram
WHO	World Health Organization

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Lloyd's Register Foundation is an independent global charity with a unique structure and an important mission: engineering a safer world.

We reduce risk and enhance the safety of the critical infrastructure that modern society relies upon in areas such as energy, transport and food. We do this by supporting high quality research, accelerating technology to application and through education and public outreach.

Our unique structure comes from the fact that we own a significant trading company, Lloyd's Register (LR). We share the same mission and work together to make the world a safer place.