# Organic Waste Sorting Manual


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CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
A UNEP sponsored initiative
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## Disclaimer

This manual was written as part of the Strategy for Organic Waste Management – Uganda (SOWU) project under the agreement 24-019-UG-23-005. The information, documentation, and figures available in this deliverable were written by the SOWU project consortium and do not necessarily reflect the views of the entities involved.

## Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise.

Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both.

Generative AI (Google Gemini) has been used to assist with text drafting and infographic preparation.

## Acknowledgements

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We are grateful to NEMA for facilitating high-level stakeholder consultations, which brought together representatives from the Ministry of Energy and Mineral Development, the Ministry of Local Government, various local municipalities, and other key governmental entities. These dialogues were fundamental in ensuring that the strategies proposed herein are aligned with Uganda's national priorities and local operational realities.

The authors also wish to acknowledge the logistical support provided for the site visit to the Kiteezi landfill. Observing the current waste management challenges in person was a critical step in grounding this research and underscores the urgency of the transition toward source segregation and organic waste valorisation.

Finally, we acknowledge the Climate and Clean Air Coalition (CCAC) for their funding and strategic partnership under the Strategy for Organic Waste Management – Uganda (SOWU) project, without which this work would not have been possible.

## Acronyms

| | |
|---|---|
| AD | Anaerobic Digestion |
| BC | Black Carbon |
| BSF | Black Soldier Fly |
| C:N | Carbon-to-Nitrogen |
| CCAC | Climate and Clean Air Coalition |
| CDM | Clean Development Mechanism |
| CH4 | Methane |
| CNG | Compressed Natural Gas |
| CO2 | Carbon Dioxide |
| CO2e | Carbon Dioxide Equivalent |
| ECDCs | Early Childhood Development Centres |
| FOG | Fats, Oils, and Grease |
| GAIA | Global Alliance for Incinerator Alternatives |
| GHG | Greenhouse Gas |
| GKMA | Greater Kampala Metropolitan Area |
| GWP | Global Warming Potential |
| KCCA | Kampala Capital City Authority |
| KNOW | Knowledge in Action for Urban Equality |
| LNG | Liquefied Natural Gas |
| MRF | Material Recovery Facility |
| MSW | Municipal Solid Waste |
| NDCs | Nationally Determined Contributions |
| NEMA | National Environment Management Authority |
| NWSC | National Water & Sewerage Corporation |
| OFMSW | Organic Fraction of Municipal Solid Waste |
| PM | Particulate Matter |
| PPE | Personal Protective Equipment |
| RDF | Refuse-Derived Fuel |
| SLCPs | Short-Lived Climate Pollutants |
| SOWU | Strategy for Organic Waste Management – Uganda |
| UDBP | Uganda National Domestic Biogas Programme |
| US EPA | United States Environmental Protection Agency |
| WHO | World Health Organisation |

# SOWU

# Strategy for Organic Waste Management Uganda

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|---|---|
| **Activity Number** | 3.1.1 Integrate the insights from the activities related to outcome 1 and 2 into the development of the waste sorting manual |
| **Related Output** | 3.1 Organic waste sorting manual |
| **Related Outcome** | 3. National and subnational government authorities in Uganda have a demonstrated increased capacity for organic waste management by the end of the project. |
| **Date** | 12 March 2026 |
| **Document description** | The organic waste sorting manual aims to provide guidance to food waste generators to implement proper food waste segregation to increase its recyclability/treatment. The manual will highlight that the primary and more important strategy is the reduction of food waste generation. The segregation of food (and garden) waste from non food waste streams is crucial to ensure the successful implementation of any treatment/recycling activity. |
| **Dissemination level** | Funder and consortium |
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# Executive Summary

This manual provides a comprehensive strategic framework for the optimisation of organic waste management in developing urban contexts, with a primary focus on Uganda. As organic waste comprises the largest fraction of the municipal solid waste stream, representing approximately 75 per cent of the 2020 baseline, its effective management is the single most significant lever for improving public health and achieving climate goals.

**The environmental and public health imperative.** Mismanagement currently leads to a dual crisis: open burning and uncontrolled dumping. Open burning in dense urban areas like Kampala releases carcinogens, such as dioxins and furans, as well as fine particulate matter ($PM_{2.5}$), with levels consistently exceeding WHO guidelines by up to 12 times. Furthermore, the anaerobic decomposition of uncollected waste in landfills is a major source of methane ($CH_4$), a potent short-lived climate pollutant. Without intervention, Uganda's methane emissions from waste are projected to nearly triple, rising from 1.7 $MtCO_{2e}$ in 2020 to 4.9 $MtCO_{2e}$ by 2050.

**A scalable, pillar-based collection strategy**. The manual rejects a "one-size-fits-all" approach, instead tailoring infrastructure to the urban scale. Successful collection relies on three foundational pillars:

- **Decentralised primary collection**, involving the use of agile vehicles, such as tricycles and handcarts, for door-to-door service in dense, informal settlements.
- **Centralised community collection**, focusing on the strategic placement of 120–240 litre bins in higher-density areas.
- **Secondary transport**, to ensure the efficient transfer from primary vehicles to larger skip bins at transfer stations for final bulk transport.

**Technical sorting and valorisation**. To achieve high-quality outputs for the circular economy, the manual establishes a Technical Sorting Matrix for organics. This guide ensures that waste properties are matched to the specific requirements of the two primary valorisation technologies:

- **Composting**, which prefers "Greens" (scraps) and "Browns" (leaves and twigs), avoiding meat and dairy to prevent pests and odours.
- **Anaerobic Digestion** (AD), thriving on soft, energy-dense organics such as fats, proteins, and starches, while "woody" lignin-rich materials like twigs and stalks are not suitable for AD.

**Implementation and Social Integration.** The transition to a two-container system, separating organics from residual waste, is the recommended starting point for households. Success depends on four actionable steps:

- The establishment of **low-cost**, pest-deterrent **containers**.
- The prioritisation of **high-recovery fractions**, specifically food scraps and yard trimmings.
- The strict **prevention of contamination** from "alien" fractions, such as plastics and batteries.
- The **formal-informal integration** by acknowledging and empowering informal waste pickers, whose efficiency increases significantly when waste is segregated at the source.

**Strategic Outlook**. While the organic fraction is projected to decrease slightly by 2050 as plastic and paper fractions rise, organic recovery remains the **priority** for decentralised urban resilience. By shifting from waste disposal to **resource recovery**, Ugandan cities can reduce greenhouse gas emissions, improve air quality, and generate valuable soil conditioners and renewable energy.

# 1. Introduction

This Organic Waste Sorting Manual, part of the Strategy for Organic Waste Management – Uganda (SOWU), is supported by the Climate and Clean Air Coalition (CCAC). The project aims to develop a comprehensive strategy for managing organic waste in Uganda, aligning with existing policies and regulations and strengthening national and subnational capacities. Its goals include promoting waste separation, diverting organic waste from landfills, and extracting value from organic waste.

In Uganda, organic waste management poses a significant environmental and health challenge due to inadequate waste collection and treatment infrastructure. Only about 50% of municipal solid waste in urban areas is collected and disposed of, often in uncontrolled dumpsites, while the rest is openly dumped or burned.[1] Organic waste accounts for approximately 80% of landfilled municipal solid waste and, when untreated, contributes substantially to methane emissions. Dumpsites and landfills account for about 20% of direct anthropogenic methane emissions via the anaerobic decomposition of organic waste.[2] In 2020, Uganda generated an estimated 243 kg of municipal solid waste per capita, of which 75% was biodegradable fractions, resulting in emissions of 1.7 $MtCO_2e$. Driven by socio-economic development, municipal solid waste generation is projected to increase to 283 kg/cap/year by 2035 and 335 kg/cap/year by 2050. If current practices continue, methane emissions are expected to rise to 3.1 $MtCO_2e$ by 2035 and 4.9 $MtCO_2e$ by 2050. These trends show the urgent need for enhanced organic waste management strategies that go beyond current policies to mitigate these impacts effectively.

Uganda has pledged to cut its national carbon emissions by 24.7% below business-as-usual levels by 2030, in line with its updated Nationally Determined Contributions (NDCs).[3] To tackle these environmental challenges, the National Environment Management Authority and the Ministry of Water and Environment launched the *Strategy for Organic Waste Management – Uganda* (SOWU) project, in partnership with the Climate and Clean Air Coalition. The SOWU project aims to develop a national strategy to reduce short-lived climate pollutants (SLCPs) and improve the sustainability of the waste sector through collaboration with national and local stakeholders.

Measures such as food-waste prevention, source-separated collection, composting, anaerobic digestion, and Black Soldier Fly projects are key to reducing methane emissions and generating value from organic waste. Uganda can cut Short-Lived Climate Pollutants (SLCPs), improve public health, and promote sustainable growth by setting clear goals and using innovative solutions. Tackling SLCPs supports Uganda's climate goals and delivers benefits including renewable energy, improved soil fertility, and local economic opportunities.

A pressing priority for Uganda is to address its dumpsites by either closing those beyond recovery or upgrading existing sites to sanitary landfills, incorporating energy recovery where possible. These measures not only benefit the climate by reducing emissions but also significantly decrease air and water pollution. Ensuring the structural integrity of landfills is vital to preventing catastrophic events such as landfill slides, which have caused loss of life, property damage, and environmental harm in Kampala. By taking these steps, Uganda can protect its communities, advance sustainable waste management, and meet its climate mitigation and adaptation goals.

This manual provides comprehensive guidance on implementing these strategies, drawing on best practices and lessons learned from the region. It serves as a valuable resource for policymakers, practitioners, and community leaders seeking to enhance organic waste management and contribute to a more sustainable future.

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[1] *GIZ, Sector Brief Uganda: Waste and Recycling.*

[2] *Gómez-Sanabria et al., 'Potential for Future Reductions of Global GHG and Air Pollutants from Circular Waste Management Systems'.*

[3] *Ministry of Water and Environment, Uganda's Updated Nationally Determined Contribution (NDC).*

# 2. Understanding organic waste – local context and proof of concept

## 2.1 Definitions and types of organic waste

Organic or biodegradable waste is generally defined as "*any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food, garden waste, agricultural waste, animal waste, paper and paperboard*".[4]

This definition is comprehensive and also includes fractions that are not generally managed as part of the Organic Fraction of Municipal Solid Waste (OFMSW).

For this reason, this Manual refers to the more targeted definition of **biowaste**: "*biowaste comprises only biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants*".[5]

The difference between organic waste and biowaste is explained in Figure 1.

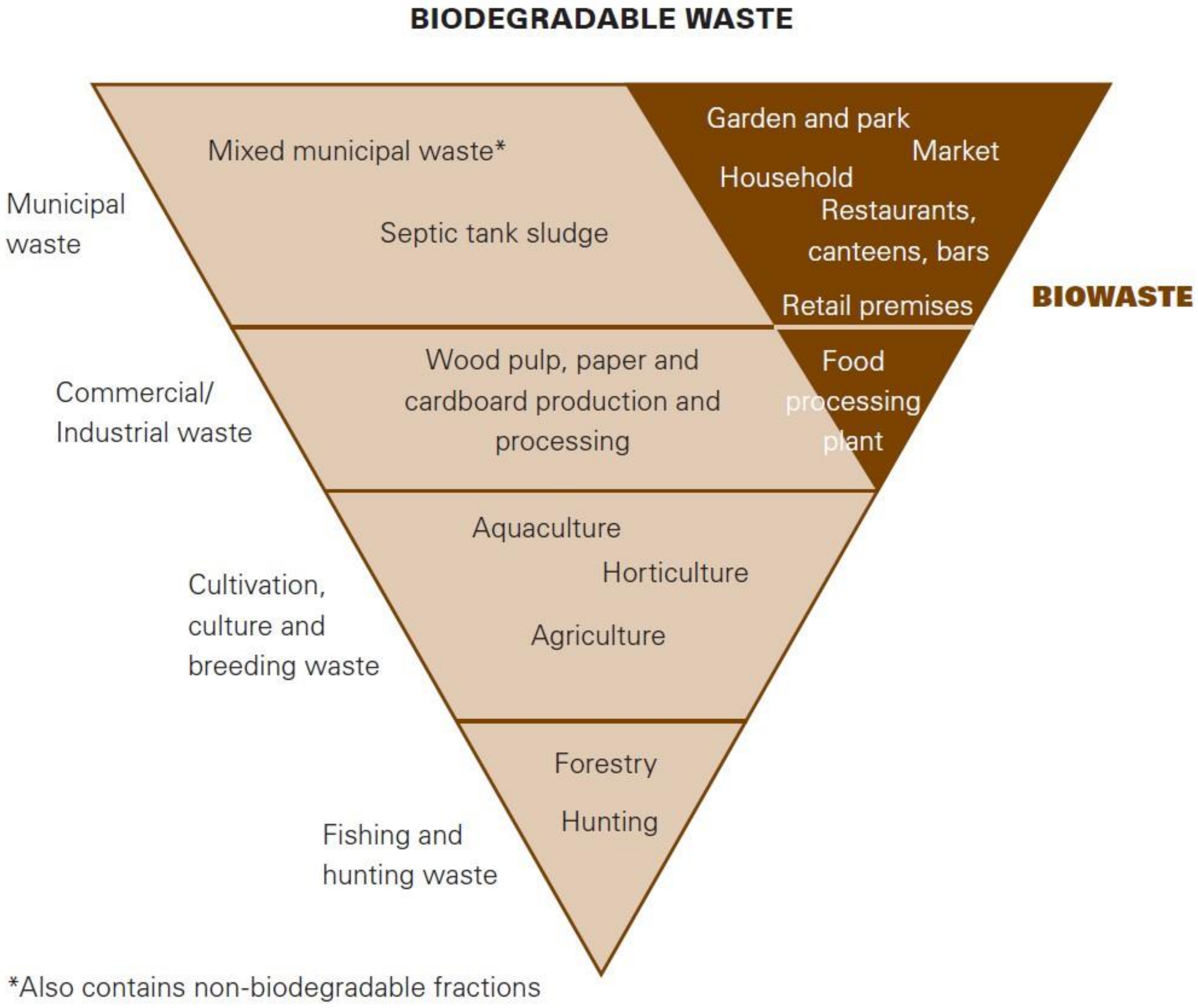


*Figure 1 – Potential sources of biodegradable waste and biowaste (Zabaleta et al., 2020)*

[4] *Zabaleta et al.*, Selecting Organic Waste Treatment Technologies. SOWATT.
[5] *Ibid.*


*Figure 2 - Classification of green and brown organic waste suitable for home composting (created with Google Gemini, based on US EPA, 2020)*

In turn, biowaste can also be classified into **brown waste** (carbon-rich materials) or **green waste** (nitrogen-rich materials).[6]

The most common types of biowaste found in the municipal solid waste streams are:

- Food scraps and kitchen waste
- Yard trimmings and garden waste
- Wood waste

Understanding the characteristics of these biowaste streams is essential because they require different management strategies. In fact, while fractions such as fruit and vegetable scraps are appropriate for most organic waste treatment methods, lignocellulosic biomass (e.g., wood waste) requires specific degradation conditions to be processed effectively. Moreover, although home and commercial composting follow the same principles, home composting operates at much lower temperatures than commercial composting. As a result, items such as meat, fish, bones, cheese and dairy products, fats, oils, grease, cooked food (in large quantities), and compostable bags are not suitable for home composting.[7]

All fractions of organic waste can be treated to recover high-value outputs. Examples of marketable end products include compost from composting, biogas and fertilisers from anaerobic digestion, and animal feed from Black Soldier Fly farming. However, producing high-quality, commercially valuable output depends on the waste stream being sufficiently clean and free of impurities beforehand. This manual provides guidelines for household waste separation, ensuring that different waste fractions remain uncontaminated during collection and processing.

## 2.2 Composition of organic waste in Uganda

Uganda produces substantial amounts of organic waste, mainly from agriculture, households, and markets, the sectors that dominate the national economy and daily life.[8] The high proportion of organic material in the waste stream poses a

[6] *US EPA, 'Composting At Home'.*
[7] Ibid.
[8] *Ssepuuya et al., 'Food Waste Supply and Behaviour towards Its Alternative Uses in Kampala City, Uganda'.*

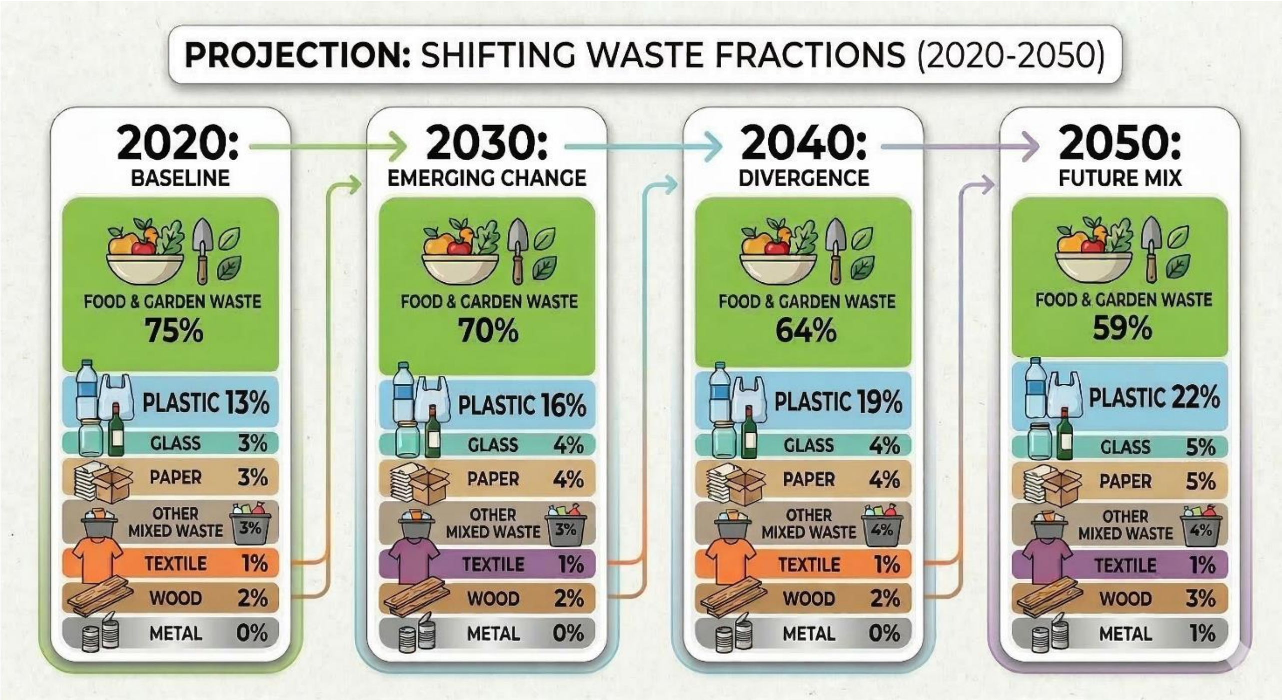


*Figure 3 - Projected MSW composition in Uganda (created with Google Gemini, based on Gomez Sanabria et al., 2024)*

significant environmental challenge but also offers a considerable opportunity for resource recovery.

In 2020, Uganda generated an estimated 243 kg of municipal solid waste (MSW) per capita annually. The majority of this waste is biodegradable, primarily food and garden waste, as shown in waste characterisation at disposal sites: organics account for 92.1% of the waste at the Kiteezi landfill in Kampala and exceed 80% at sites such as Hoima, Kabale, and Fort Portal.

It has been estimated that food and garden waste made up 75% of the national MSW generation by mass in 2020, while plastics accounted for 13%.[9] However, national projections anticipate that this composition is subject to future change. The proportion of food and garden waste is expected to decline to 59% by 2050, while the plastic fraction is projected to rise significantly to 22%.[10]

In contrast, the same forecasts indicate that the volume of organic waste will increase substantially due to socioeconomic development and population growth. The total production of food and garden waste is expected to grow by 132% by 2050, reaching 17 million tonnes annually.[11] By 2050, the Central, Western, and Eastern regions are each projected to produce between 4.5 and 5 million tonnes of food and garden waste annually. This substantial anticipated increase highlights the urgent need for prevention and valorisation strategies to reduce its impact on greenhouse gas (GHG) emissions.

## 2.3 The environmental and health costs of organic waste mismanagement

Inappropriate management of organic waste poses a significant risk to Uganda's environment and to efforts to combat climate change. It is estimated that only 40% of the MSW generated in Kampala is collected, with the remaining 60% either being open-burned or indiscriminately dumped outside of dedicated facilities.[12]

Open burning of solid waste, a standard disposal method in Uganda, significantly harms the

[9] *Ministry of Water and Environment, Uganda's Updated Nationally Determined Contribution (NDC).*
[10] *Gómez-Sanabria et al., National Inventory Report - Short-Lived Climate Pollutants (SLCPs) from the Organic Waste Sector.*
[11] *Ibid.*
[12] *Jalalipour and Namutebi, 'Addressing Municipal Solid Waste Mismanagement Through Data-Driven Action Planning'.*

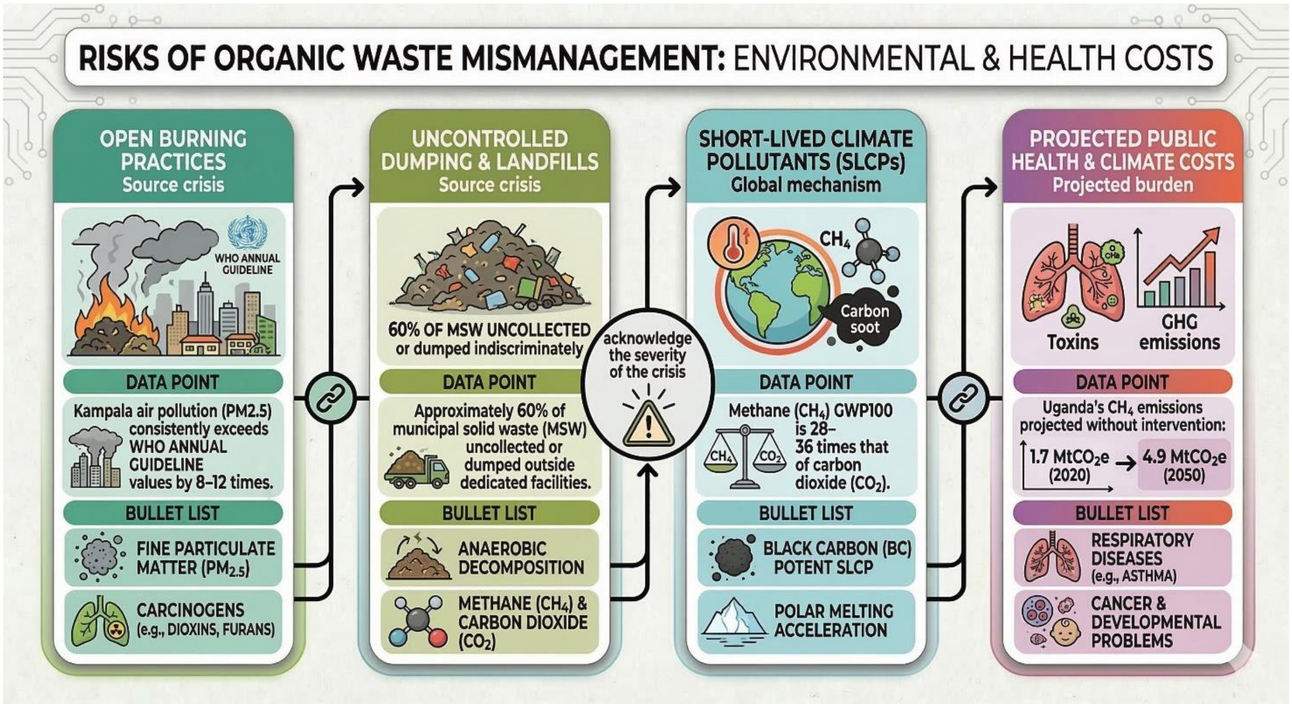


*Figure 4 - Environmental and health costs of organic waste mismanagement (created with Google Gemini)*

environment and public health, particularly in Kampala, where air pollution consistently exceeds WHO annual guideline values by 8–12 times.[13] This improper disposal releases a mixture of air pollutants, including carcinogens such as dioxins and furans, as well as fine particulate matter ($PM_{2.5}$). Exposure to these substances is a leading cause of premature death and is linked to numerous health issues, including respiratory diseases (like asthma), cancer, and developmental problems. Moreover, open waste burning emits Black Carbon (BC), a potent Short-Lived Climate Pollutant (SLCP), which even deposits on snow and ice, accelerating melting in polar regions.

Burning occurs in various settings, including unauthorised dumpsites, streets, and households, often because formal disposal options are unavailable or unreliable. For residents, particularly in low-income areas, burning may be perceived as necessary to reduce the growing volume of waste or manage odours. The government has acknowledged the severity of the crisis, with the National Environment Management Authority of Uganda (NEMA) warning the public against open burning, citing its contribution to air pollution and the resulting increase in respiratory and other health-related diseases.

When waste is not openly burned but instead reaches a final disposal site, inadequate management has detrimental environmental effects. In uncontrolled dumpsites and landfills, the lack of oxygen in the waste mass leads to anaerobic decomposition of organic fractions, generating methane ($CH_4$) and carbon dioxide ($CO_2$). Methane is an SLCP and a greenhouse gas (GHG) whose 100-year global warming potential (GWP100) is 28–36 times that of carbon dioxide.[14] Dumpsites and landfills collectively account for approximately 20% of global direct anthropogenic methane emissions through this process. Uganda emitted 1.7 $MtCO_2e$ in 2020 and, without intervention, its methane emissions are projected to increase to 4.9 $MtCO_2e$ by 2050.[15]

## 2.4 Previous Ugandan initiatives

To address the waste crisis and reduce GHG emissions, Uganda previously attempted large-scale mitigation measures through the World Bank's Clean Development Mechanism (CDM)

[13] *Okure et al., 'Case Study of Participatory Data-Driven Approaches to Improve Urban Air Quality in Kampala, Uganda'.*
[14] *EPA, Understanding Global Warming Potentials.*
[15] *Gómez-Sanabria et al., National Inventory Report - Short-Lived Climate Pollutants (SLCPs) from the Organic Waste Sector.*

program. The program supported the implementation of 12 CDM composting plants across various urban councils in Uganda, designed to divert organic waste and process it through aerobic windrow composting technology.[16]

However, the issues encountered during this ambitious initiative demonstrated the non-negotiable importance of source separation.

Despite a total capacity of 70 metric tonnes at 12 facilities, none operated effectively in 2024. The main problem was poor sorting of organic material before arrival: mixed municipal waste made manual processing costly and caused severe heavy metal contamination, reducing compost quality and hindering market off-take, as farmers were reluctant to use such a low-quality product on their croplands.[17]

The failure of these centralised facilities demonstrates that source segregation of waste is a foundational requirement for successful organic waste valorisation, particularly at a large scale.[18] Without robust source separation, even well-funded infrastructure projects are rendered ineffective.

On the other hand, despite widespread challenges, local initiatives and private-sector entities are effectively valorising organic waste in small-scale, decentralised, community-based setups that convert organic residues into valuable byproducts, supporting sustainable energy, the circular economy, and waste diversion.

One notable example is the Waste Recycling Initiative established by the Kampala Capital City Authority (KCCA) in the Wankoko Industrial Area, which processes market-generated organic waste into animal feed and manure.[19] Additionally, briquettes made from organic waste offer an environmentally friendly alternative to firewood and charcoal.[20]

Another emerging strategy is Black Soldier Fly (BSF) farming, which transforms biowaste into larval biomass (animal feed) and fertiliser. It is currently implemented by both large-scale commercial enterprises (e.g., Marula Proteen) and small-scale farmers who rely on kitchen and crop waste. [21]

Lastly, anaerobic digestion (AD) is a well-known method to break down organic waste into resource-rich outputs, such as methane-rich biogas and digestate, which can be used as fertiliser. In Uganda, aside from a few large-scale plants (such as Kakira Sugar Limited and the National Water & Sewerage Corporation (NWSC) anaerobic digester in Bugolobi), small-scale biodigesters that primarily treat animal dung are more common. Since 2009, the Uganda National Domestic Biogas Programme (UDBP) has facilitated the construction of more than 13,000 household biogas digesters nationwide, mostly in rural areas of Central, Western, and Eastern Uganda.[22]

The success of these localised, decentralised solutions, often involving community-scale composting and biodigesters, shows that a strategy combining both centralised and decentralised approaches is vital for effective waste management and sustainable development in Uganda, as demonstrated by previous experiences around Africa.[23]

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[16] *United Nations Framework Convention on Climate Change, 'PoA 2956: Uganda Municipal Waste Compost Programme'.*
[17] *Ministry of Energy and Mineral Development, NAMA on Integrated Waste Management and Biogas in Uganda.*
[18] *Dell'Orto and Trois, 'Simulation of Insertion of Double-Stage Anaerobic Digestion as an Effective Waste Diversion and Carbon Emission Reduction Strategy: The Case of a Large South African Municipality'.*
[19] *Gómez-Sanabria et al., National Inventory Report - Short-Lived Climate Pollutants (SLCPs) from the Organic Waste Sector.*
[20] *Namutebi and Jalalipour, 'Circular Entrepreneurship'.*
[21] *Climate and Clean Air Coalition, Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.*
[22] *Makumbi et al., 'Current Status of Biogas Technology Adoption in Uganda'.*
[23] *Trois et al., 'Application of the WROSE Model for Promoting Effective Decision-Making and Sustained Climate Change Stabilization in the South African Waste Sector'.*

# 3. Organic waste sorting guidelines

## 3.1 Importance of source segregation

Source segregation, the practice of separating waste at the point of generation, is the most crucial component of an organic waste management strategy. Without it, the entire downstream system collapses, undermining national climate and economic goals.

Source segregation significantly reduces organic waste contamination, allowing the production of high-quality by-products. This step is vital because contamination of compost led to the failure of Uganda's previous CDM composting plants. Clean, source-separated organic waste produces high-quality compost or digestate that are safe and effective for agricultural use, promoting soil health and boosting agricultural productivity.

In addition, diverting organic waste through effective sorting lessens the load on landfills, prolonging their life and reducing methane emissions. This practice directly supports Uganda's climate mitigation objectives and reduces the significant costs associated with environmental clean-up and health problems.

Source segregation also promotes resource recovery and recycling. It provides an appropriate and reliable feedstock supply for valorisation technologies such as anaerobic digestion (which produces biogas and fertiliser), Black Soldier Fly (BSF) farming (for animal feed), and composting (compost), leading to the creation of green jobs in the waste management sector.

## 3.2 Step-by-step guide for sorting organic waste

This guide provides the simple, actionable steps for households and small businesses to implement separation immediately. It comprises four steps:

**Step 1 – Establish a two-container, low-cost system**

All sorting efforts need to focus on **keeping organics away from other waste fractions**. For this reason, it is advisable to implement a separation system based on two sets of containers:

1. **Organics**: a large bin with a heavy lid storing the contents of the kitchen bin and garden waste until collection. The aim of this bin is to reduce moisture and leachate and deter pests.
2. **Residual fractions**: a residual large bin storing all non-biodegradable materials (plastics, metals, glass, textiles), preventing contamination of the organics and of the recyclable fractions, which can be effectively separated at a later time.

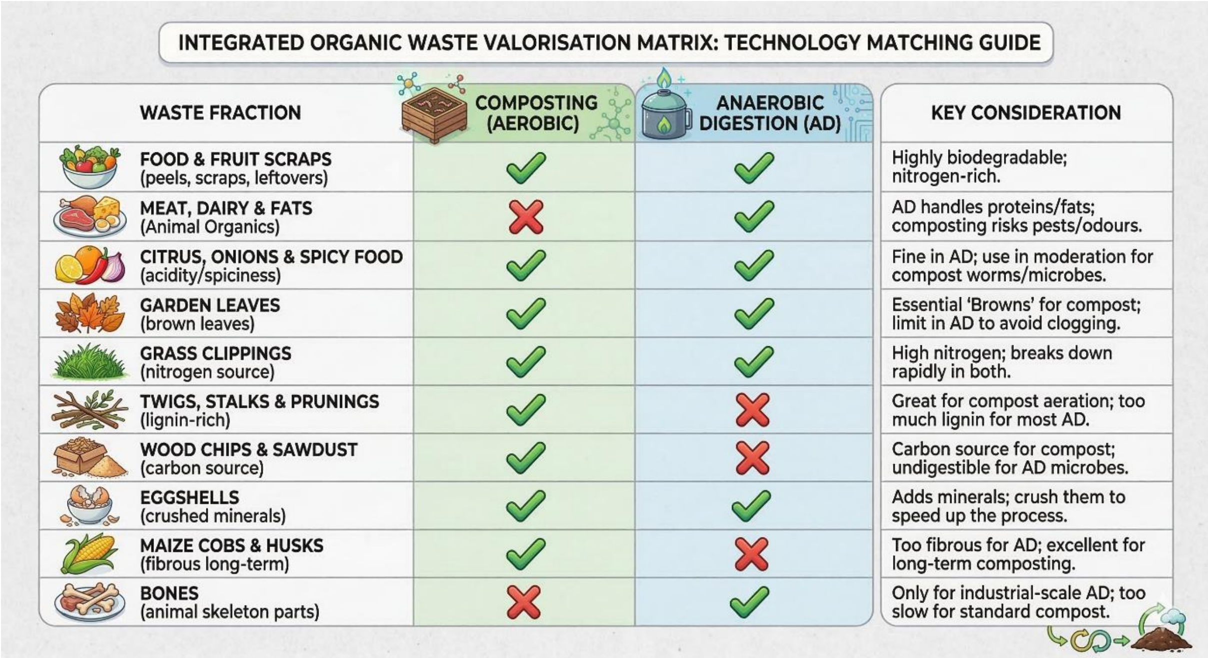
Wherever possible, it is recommended to add a small (10- or 20-litre capacity) kitchen bin to store daily food scraps (peels, spoiled food, leftovers) during preparation and immediately after consumption, to contain odours and facilitate compliance.

Once the source-separating habit has formed, municipalities can consider introducing a third bin for the collection of valuable recyclable fractions, such as plastics, glass, and metals, to be sent to a recycling plant devoid of impurities.

**Step 2 – Know your Organic Waste priorities and labels**

The aim of sorting must be to prioritise waste with high recovery potential, such as

- Food scraps (matooke, cassava, maize peelings, etc.)
- Market waste (expired vegetables and fruits, and offcuts)
- Yard trimmings (leaves, grass)



INTEGRATED ORGANIC WASTE VALORISATION MATRIX: TECHNOLOGY MATCHING GUIDE

| WASTE FRACTION | COMPOSTING (AEROBIC) | ANAEROBIC DIGESTION (AD) | KEY CONSIDERATION |
|---|---|---|---|
| FOOD & FRUIT SCRAPS (peels, scraps, leftovers) | ✓ | ✓ | Highly biodegradable; nitrogen-rich. |
| MEAT, DAIRY & FATS (Animal Organics) | ✗ | ✓ | AD handles proteins/fats; composting risks pests/odours. |
| CITRUS, ONIONS & SPICY FOOD (acidity/spiciness) | ✓ | ✓ | Fine in AD; use in moderation for compost worms/microbes. |
| GARDEN LEAVES (brown leaves) | ✓ | ✓ | Essential 'Browns' for compost; limit in AD to avoid clogging. |
| GRASS CLIPPINGS (nitrogen source) | ✓ | ✓ | High nitrogen; breaks down rapidly in both. |
| TWIGS, STALKS & PRUNINGS (lignin-rich) | ✓ | ✗ | Great for compost aeration; too much lignin for most AD. |
| WOOD CHIPS & SAWDUST (carbon source) | ✓ | ✗ | Carbon source for compost; undigestible for AD microbes. |
| EGGSHELLS (crushed minerals) | ✓ | ✓ | Adds minerals; crush them to speed up the process. |
| MAIZE COBS & HUSKS (fibrous long-term) | ✓ | ✗ | Too fibrous for AD; excellent for long-term composting. |
| BONES (animal skeleton parts) | ✗ | ✓ | Only for industrial-scale AD; too slow for standard compost. |

*Figure 5 - Organic waste valorisation matrix (created with Google Gemini)*

In addition, all fresh fruit and vegetable waste suitable for animal feeding must be kept separately and provided to local farmers.

Visual education is essential to guarantee proper separation. Equipping bins with clear pictorial signs and labels (translated into the major local languages) proved effective in explaining to consumers which streams can go into that bin and which must be discarded in another.

**Step 3 – Prevent contamination and manage storage**

Avoiding the disposal of alien fractions and contaminants (e.g., plastic bags, broken glass, batteries, metals, ash) in the organic bin is essential. Any contamination in a waste batch complicates or even prevents its use in valorisation plants, undermining all previous separation efforts.

In addition, municipalities must ensure the timely collection of organic waste. Markets, restaurants, and retailers that generate substantial organic waste need to be serviced daily or every second day, while household collection must be guaranteed at least 2-3 times per week. Following this guideline prevents odour nuisance and insect breeding, and guarantees high-quality waste for high-priority systems such as anaerobic digestion and BSF farming.

**Step 4 – Coordinate the collection between the formal and informal sectors**

The formal system must acknowledge the existing informal waste management structure in Uganda.

Formal collection must strictly adhere to the schedule set by the local government or the private contractor. Where possible, coordination with organic waste disposal facilities will ensure an appropriate final destination for sorted waste and highlight the beneficial effects of proper sorting and separate collection.

Informal waste pickers must be acknowledged and integrated into this system. It is especially important to emphasise the advantages of source-segregation of organic waste for these workers. Household-level separation efforts produce cleaner residual waste, making it easier for informal waste collectors to recover cleaner, higher-quality recyclables.

In addition, community monitoring at the neighbourhood level is encouraged to provide constructive feedback, build accountability, and ensure effective segregation. Wherever possible, a system that includes incentives for proper separation and penalties for non-compliance should be implemented.

## 3.3 Common mistakes to avoid

It is crucial to emphasise that contamination must be avoided at all costs. A single contaminated container can ruin the quality of an entire batch of compost. Here are the most common mistakes and how to prevent them.

- **Mixing Organic and Non-organic waste**: The most important aspect of source separation is avoiding the mixing of organics and non-organics. Items such as plastic bags, glass, metals, or batteries must be kept out of the organic waste bin. The presence of these unwanted fractions ruins the entire batch and prevents its valorisation into products such as compost, biogas, or BSF larvae for feeding.
- **Using non-biodegradable bags:** Organic waste should not be placed in plastic bags. It should be stored in compostable bags or tossed directly into the organics bin to avoid the complications and extra costs of removing plastic from the organics before processing.
- **Allowing prolonged accumulation**: Organic waste must be collected daily or every other day. If not collected frequently, biowaste can decompose in the bin, producing odour and attracting insects and rodents, posing a health threat to household or neighbourhood residents.
- **Failing to train and monitor**: Separation efforts may fail if users do not receive sufficient training. However, one-off training is
- insufficient. Ongoing monitoring and enforcement are essential to ensure proper waste separation.

## 3.4 Tools and equipment for effective sorting

Effective sorting does not require high-tech tools: significant results can be achieved with appropriate tools adapted to the local context.

- **Kitchen sorting**: Household sorting can be made easier by using small (10-20 litres) kitchen bins with tight-fitting lids to immediately store food preparation waste before transferring it to the main organics bin. Suitable options for low-income areas include inexpensive plastic buckets with lids, properly labelled to prevent contamination.
- **Storage and collection**: Effective separation can be improved by clearly labelling each garbage can. Colour-coded bins (e.g., green or brown for organics, and black for residual waste) quickly indicate which waste goes in each container. Additionally, pictorial signs and illustrations of acceptable waste can offer clear guidance to users when needed, regardless of their literacy level.
- **Community and on-site options**: The use of on-site composting units, such as “compost boxes”, should be promoted in households or communities to handle food and yard waste locally, decreasing the amount of waste that needs collection.

# 4. Collection and transportation of organic waste

## 4.1 Collection methods and frequency

The success of a source-segregation programme depends entirely on having separate collection systems for each fraction. Avoiding the mixing of previously separated waste ensures that separation efforts are worthwhile and that the inherent value of organics can be recovered.

In Uganda, the primary collection system must rely on small, agile vehicles that can navigate dense neighbourhoods and informal settlements, unlike large trucks. The system must be based on three pillars:

- **Decentralised primary collection**: door-to-door systems, ideally through handcarts or tricycles, to collect waste directly from houses and small businesses in narrow streets.
- **Centralised primary collection**: community bin collection in higher-density areas, where larger bins (120-240 litres) can be placed in strategic areas to facilitate the collection.
- **Secondary transport** from transfer stations to disposal or valorisation sites: primary collection vehicles can unload their contents into larger skip bins placed at suitable transfer stations. From there, larger vehicles can transport the skip bins to the destination facility, depending on the fraction.

The two primary collection systems are complementary and not in contrast. The selection of a specific collection system must be planned in advance based on the characteristics of the served area.

In every step of the process, organics and residual fractions are collected by different vehicles and kept separate at all times. The trucks collecting biodegradable waste must not be compactors to prevent leachate formation during transport. In contrast, large collection trucks for recyclables and residual fraction can be compacted to minimise the number of trips needed to collect all the waste produced.

The collection method does not influence its frequency. Organics should be collected daily or at least three times per week to prevent excessive decomposition, odours, and pests. Recyclables and residual waste can be collected once or twice weekly. The collection routes should be efficiently planned through prior mapping to minimise fuel consumption and reduce transportation costs.

## 4.2 Proper containers for organic waste storage

Choosing the right container can simplify the collection process and reduce health risks, but it depends on the correct identification of the appropriate setting:

- **Household level**: 10-20 litre capacity bins. Tight-fitting lids are recommended to contain odours.
- **Community level**: 120-240 litre wheeled bins with lids.
- **Commercial customers**: 660-1100 litre wheeled containers.
- **Large markets and industrial customers**: 6-11 $m^3$ skip bins, ideal to contain large amounts of food processing waste and expired fruits and vegetables for daily collection.

Waste bins must be lidded or covered to reduce odours. Different types of bins can be combined if needed: commercial customers might benefit from using a 120-litre bin for organics and a 660-litre bin for residual waste. The bins must be colour-coded and clearly labelled to facilitate the disposal of the correct fraction in the appropriate container. A potential solution is to use brown for organics, green for recyclables, and black for residual waste.

Community bins must be strategically located to ensure easy access for community members and to guarantee the separation of organics from non-biodegradable waste.

Bins and skips must be regularly cleaned to prevent odour and leachate formation and to deter rodents, insects, and other pests.

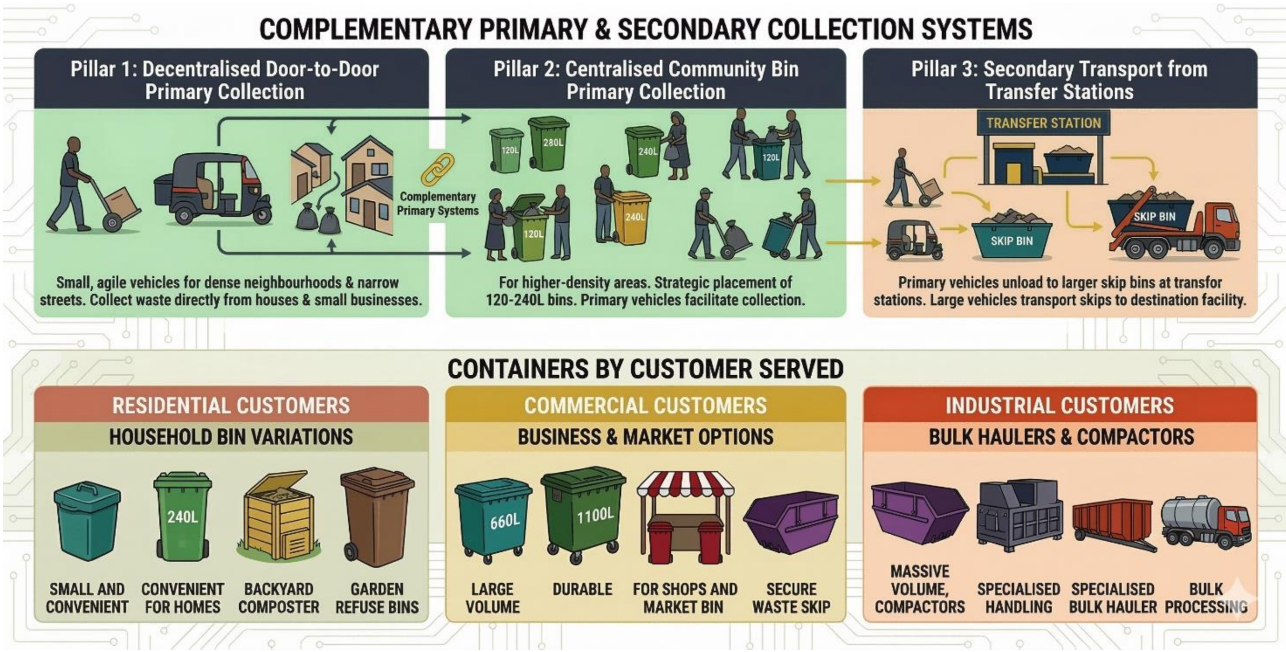



*Figure 6 - Waste collection systems and containers (created with Google Gemini)*

## 4.3 Vehicle requirements for organic waste transport

Transportation of waste depends on the producer's waste volume and the road configuration.

Decentralised primary collection must rely on smaller vehicles, such as tricycles, handcarts, and small trucks (1-3 tonnes), allowing for door-to-door pickup and transit through narrow streets. For centralised primary collection of community bins, medium trucks (5-10 tonnes) are recommended.

Bulk collection from commercial producers and secondary transport from transfer stations to processing facilities will require larger trucks in the 10-20 tonnes range.

It is recommended to keep organic waste covered in all these vehicles to prevent spillage and control odours. Whenever possible, vehicles should be equipped with leachate collection systems to prevent liquid waste from dripping onto public roads.

All trucks should be fitted with hydraulic lifts to make the process of emptying bins easier and quicker. Equipping trucks with GPS tracking systems is recommended to assist fleet management. Accurate information on transportation routes and distances driven can help reduce costs and optimise collection and logistics systems.

## 4.4 Best practices for temporary storage and safety measures

Temporary storage areas must be planned for periods when waste cannot be sent directly to a processing facility. Designated storage facilities should be situated in suitable areas where the passage of large trucks is feasible.

It is recommended to set up temporary storage in areas paved with impermeable material, such as concrete, and equipped with appropriate drainage systems to collect leachate before sending it to a wastewater treatment plant. Leachate has a very high organic content and can contaminate soil and water resources if released into the environment. Organic waste must be covered to contain odours and prevent pests from accessing it. Pest control measures are also recommended to deter rodents and insects from staying around the storage area.

Biodegradable waste must be kept in a storage area for no more than 24 hours before being moved to a processing facility.

All workers must receive regular training on the safety protocols and wear adequate Personal Protective Equipment (PPE), including gloves, masks, and boots, at all times while handling waste.

# 5. Processing and treatment options

## 5.1 Food recovery hierarchy

The United States Environmental Protection Agency (US EPA) developed the Food Recovery Hierarchy to identify priority actions that can help prevent food waste and maximise material or energy recovery before final disposal.[24]

The Hierarchy represents the most sustainable approach to organic waste, which can be transformed into resources if properly managed. It is represented as a triangle pointing downwards, with the top level being the preferred option and the priority level decreasing to the bottom, which represents the options to avoid as much as possible. These levels will be described in the following paragraphs.

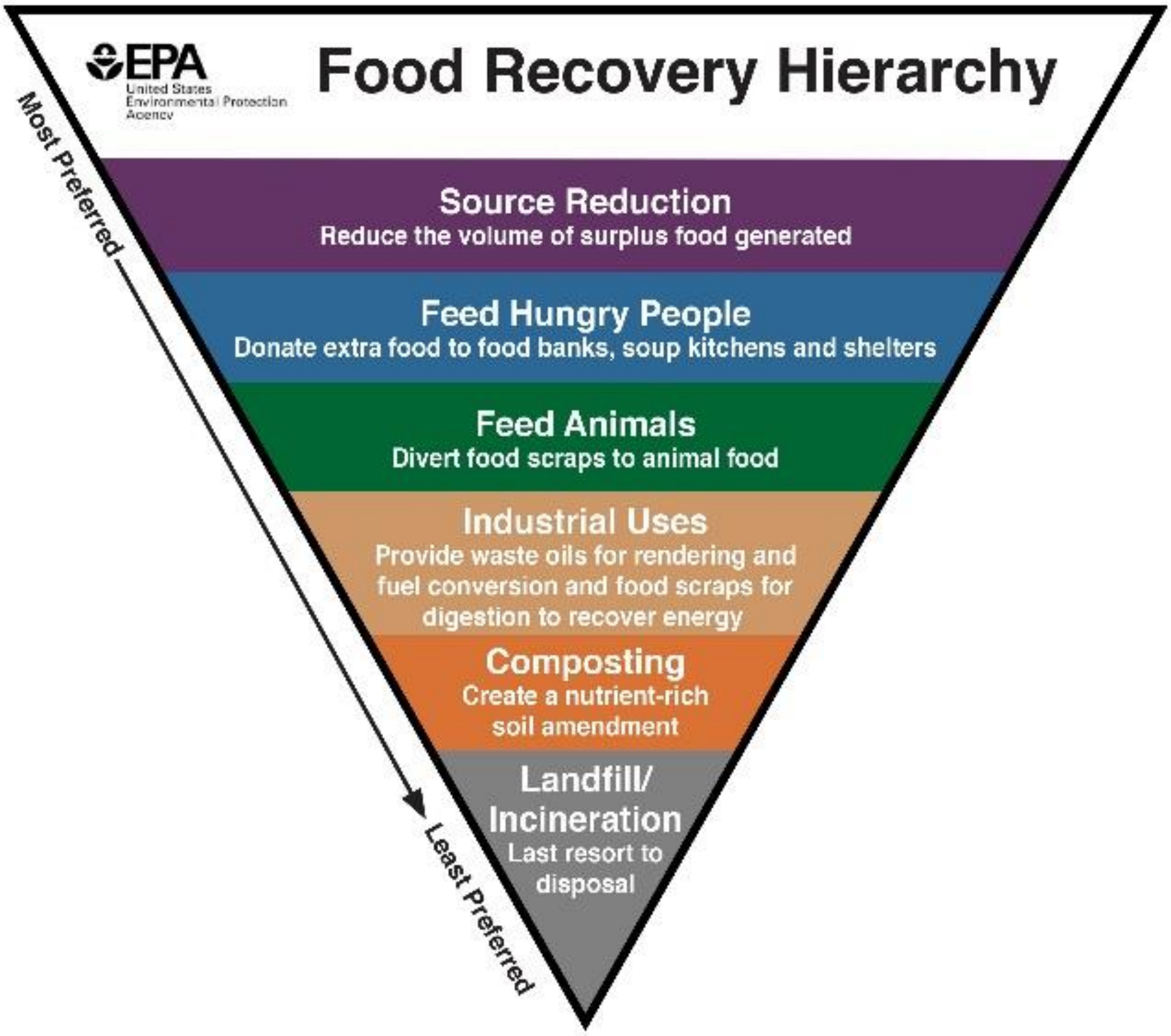



*Figure 7 - The Food Recovery Hierarchy (US Environmental Protection Agency)*

[24] *US EPA, 'Food Recovery Hierarchy'.*

## 5.2 Source reduction

Organic waste management starts even before food becomes waste: prevention at the source is the first level and the most impactful action of the Hierarchy. Reducing the generation of food waste at the source has several tangible benefits for companies and individuals:

- Feeding more people, given the increased availability of food.
- Saving money, when consumers and businesses only buy what they need, while municipalities can reduce their disposal costs.
- Saving energy, given the reduced needs for production, preparation, transportation and refrigeration.
- Saving water and land, due to the reduced need for growing food.
- Preventing pollution, due to the lower amounts of fertilisers and pesticides needed to grow fewer crops.
- Reducing methane emissions, since less food waste decomposes inside dumpsites or landfills.

While reducing food waste is simpler at the household level, it involves more organisational steps for businesses. Some of the beneficial habits include:

- Ensuring proper storage of food.
- Examining food preparation practices to reduce the surplus of preparation waste.
- Using kitchen scraps in new dishes (e.g., vegetable trimmings in soups, stale bread for croutons, and fruit as dessert toppings)
- Adjusting menus to suit customer preferences and minimise uneaten food.
- Considering customer ordering patterns when purchasing stock.

## 5.3 Feed hungry people

The second tier of the Food Recovery Hierarchy focuses on feeding people in need. Restaurants, hotels, supermarkets, and caterers regularly throw away fresh, healthy food, including surplus perishables. These businesses can help reduce food waste by sharing surplus food with organisations dedicated to food donations. Some examples of food banks operating in Uganda are:

- Action Against Hunger[25]
- Haba Na Haba Food Bank[26]
- The Hunger Project[27]

Food donations must follow strict procedures to ensure consumer safety. Donating food not only feeds people and supports local communities but also reduces landfill waste and harmful carbon emissions.

## 5.4 Feed animals

Diverting organic waste for animal consumption is the third tier of the Food Recovery Hierarchy. When surplus food is no longer suitable for humans, these organic materials can often be safely used as livestock feed. Implementing this practice offers significant economic and environmental benefits. It generates financial savings for farmers, reduces transportation and landfill costs associated with municipal waste disposal, and lowers greenhouse gas emissions from the decomposition of untreated waste.

In Uganda, several successful initiatives currently collect organic waste for animal feeding. A prominent example is the Bikuuta group, which routinely collects between 800 and 1,000 sacks of banana peels daily. This operation effectively diverts an estimated 40 tonnes of organic waste per day from commercial producers, such as restaurants and fresh produce markets in the Kawempe and Central divisions of Kampala. The collected material is then transported to farms located outside the Greater Kampala Metropolitan Area (GKMA).

Additionally, various smaller groups and individual farmers conduct similar recovery operations, particularly near municipal marketplaces. The

[25] *Action Against Hunger, 'Hunger Relief in Uganda'.*
[26] *HabaNaHaba, 'The Leading Food Bank in Uganda'.*
[27] *The Hunger Project, 'The Hunger Project - Uganda'.*

Kampala Capital City Authority (KCCA) also participates in this recovery method by collecting organic waste specifically to supply its urban farm in Nansana.

However, quantifying the exact volume of organic waste recovered through these local networks remains difficult due to the many stakeholders involved. Achieving a highly accurate estimate would require a comprehensive study of the entire value chain to assess market capacities and operational challenges. Despite this lack of complete data, conservative calculations suggest an additional 25 tonnes of organic waste are diverted daily from Kampala's markets. Consequently, the total estimated organic waste recovered for animal feeding within the GKMA reaches 65 tonnes per day.

## 5.5 Industrial uses and energy recovery

The fourth tier of the Food Recovery Hierarchy prioritises industrial uses and energy recovery from organic waste. Diverting food waste to produce biofuels and bio-products offers a sustainable approach to mitigating the environmental and economic impacts of waste disposal. Consequently, there is growing interest in leveraging alternative energy technologies to extract value from biodegradable fractions while supplementing traditional power sources.

### Anaerobic Digestion (AD)

Anaerobic digestion is a biological process in which complex organic materials are broken down by microbial communities in the absence of oxygen. This naturally occurring degradation takes place in sealed, oxygen-free vessels known as digesters.

The technology is highly versatile and can process a wide range of organic feedstocks, including food scraps, animal manure, fats, oils, greases, industrial organic residuals, and sewage sludge.

The anaerobic digestion process relies on a coordinated sequence of biochemical reactions, specifically hydrolysis, acidogenesis, acetogenesis, and methanogenesis, to convert organic matter into valuable outputs.[28] The efficiency of this microbial breakdown is heavily influenced by critical operational parameters. Process stability and gas production depend on maintaining optimal temperatures (ranging from mesophilic to thermophilic), regulating pH and alkalinity, and controlling the organic loading rate and hydraulic retention time. Furthermore, anaerobic digestion systems can be configured in various ways, such as batch or continuous flow, single-stage or multi-stage, and wet or dry digestion, depending on the moisture content and specific characteristics of the feedstock.

The biological degradation within the digester yields two primary high-value by-products: biogas and digestate. Biogas is a renewable energy source composed predominantly of methane and carbon dioxide, alongside trace amounts of water vapour and hydrogen sulphide. The utilisation of biogas depends significantly on its quality and the level of purification applied to remove trace contaminants. Lower-quality biogas is typically combusted in internal combustion engines to produce mechanical power, heat, or electricity, including in combined heat and power systems. Conversely, when biogas is upgraded by removing carbon dioxide and other impurities, it becomes biomethane. This high-quality gas can be injected directly into natural gas pipelines or compressed into compressed natural gas (CNG) and liquefied natural gas (LNG) to fuel vehicles.

In addition to biogas, the process produces a nutrient-rich residual material known as digestate. Digestate is typically separated into solid and liquid fractions, both of which possess substantial agricultural value. When appropriately processed, it can be utilised as a soil amendment, an organic fertiliser, or even as livestock bedding and base material for biodegradable products. Emerging technologies also enable the extraction of concentrated nutrients, such as nitrogen and phosphorus, to produce commercial fertilisers.

**Advantages**

- Mitigates greenhouse gas emissions
- Reduces the volume of waste destined for landfills

[28] *Dell'Orto et al., 'Advances in Combined Biohydrogen and Biomethane Production Processes from Municipal-Based Lignocellulosic Waste at Small Scale'.*

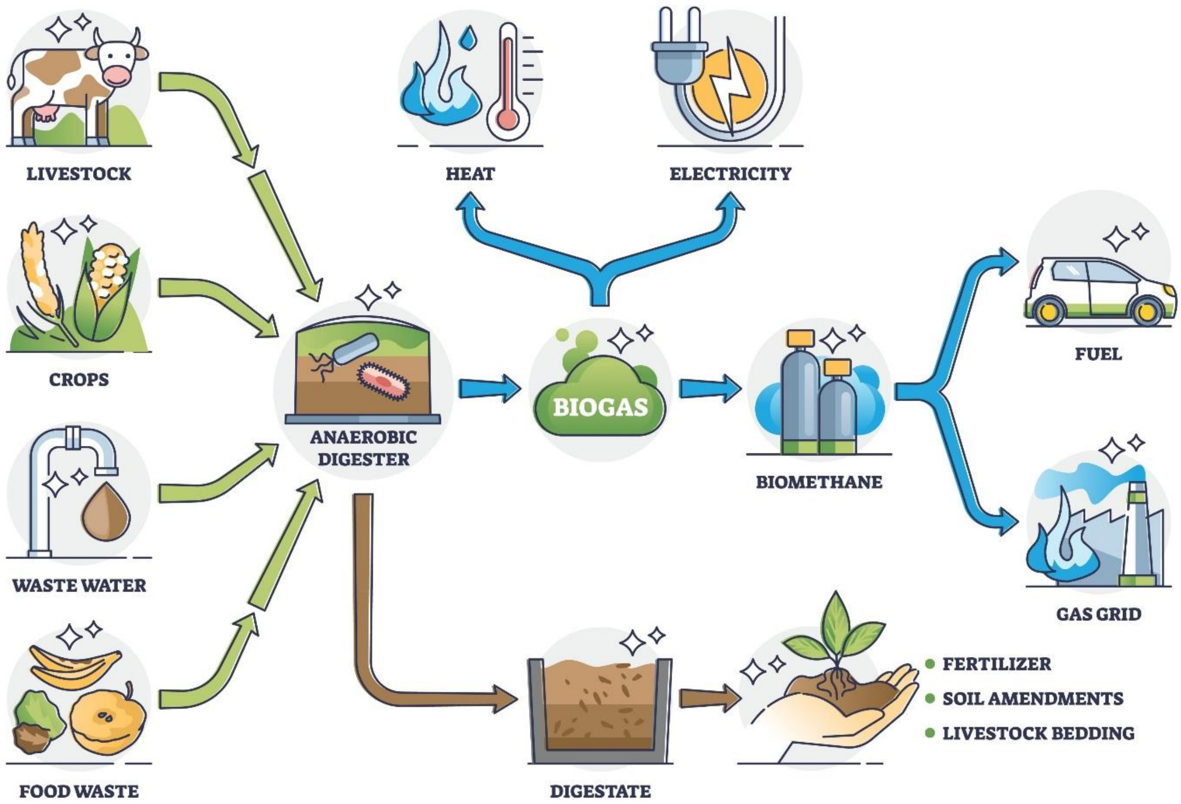



*Figure 8 - Overview of the anaerobic digestion process, illustrating the biological conversion of organic feedstocks into renewable biogas and nutrient-rich digestate (created with Google Gemini)*

- Provides an efficient method for resource recovery, transforming a disposal problem into a decentralised, renewable energy solution and a sustainable source of fertiliser.

**Challenges**

- Capital expenditure for the required infrastructure, including large digester tanks and gas handling equipment, is often substantial.
- Additionally, anaerobic digestion systems demand stringent operational control because the microorganisms are sensitive to environmental fluctuations;
- improper management can lead to process instability, prolonged retention times, and potential odour nuisances.

**Success stories**: Several successful implementations across Africa highlight the viability of anaerobic digestion for the management of organic waste. In South Africa, the Bio2Watt[29] plant in Bronkhorstspruit operates as a commercial facility, co-digesting manure from a cattle feedlot with organic waste from local municipalities and food-processing industries to generate up to 4.4 megawatts of electricity. Similarly, in Nigeria, the Cows-to-Kilowatts[30] initiative in Ibadan successfully utilises an anaerobic fixed-film digester to process abattoir waste, providing household biogas to thousands of local families while significantly mitigating local water and air pollution. Additionally, South Africa has successfully implemented micro-biodigesters across rural areas of KwaZulu-Natal. Notably, the integrated biogas provision and sanitation systems implemented at five Early Childhood Development

[29] *Oelofse et al., 'Waste as Resource: Unlocking Opportunities for Africa'.*
[30] *United Nations, Innovation for Sustainable Development.*

Centres (ECDCs) show potential for replicating a similar initiative in Uganda.[31]

These examples demonstrate that, despite the initial capital and operational challenges, anaerobic digestion can be effectively tailored to diverse African contexts to produce clean energy and advance sustainable waste management.

### Industrial uses of fats, oil, and grease

Liquid fats, oils, and grease (FOG), along with solid meat products, constitute a fraction of organic waste that requires specialised disposal to prevent infrastructure damage. Discharging these materials into the sanitary sewer system causes coagulation, clogs pipes, triggers sewer overflows, and compromises water quality. Consequently, FOG must be diverted towards rendering, biodiesel production, or anaerobic digestion. The rendering industry utilises these residues as raw materials to manufacture animal feed, cosmetics, and soaps. Alternatively, waste cooking oil can be converted into biodiesel, a renewable, biodegradable, and non-toxic fuel that significantly mitigates greenhouse gas emissions, sulphur dioxide, and soot compared to conventional fossil fuels. Furthermore, FOG can be introduced into anaerobic digesters at wastewater treatment facilities to enhance biogas generation.

**Advantages**

- Prevents municipal sewer blockages
- Generates non-toxic, clean energy
- Reduces atmospheric pollutants

**Challenges**

- Logistical complexity of widespread collection
- Costs associated with chemical conversion processes

**Success story**: Small-scale potato crisp manufacturers in Rwanda effectively repurpose waste cooking oil to produce biodiesel for local electricity generation and transport.[32]

### Briquettes

The conversion of organic waste into refuse-derived fuel (RDF), specifically biomass briquettes, presents a viable energy recovery strategy. Processing involves drying, crushing, and compacting organic residues into dense solid fuels. Ensuring strict quality parameters, such as low moisture content and high calorific value, is critical for combustion efficiency and marketability.

Within the Greater Kampala Metropolitan Area (GKMA), several small and medium-scale initiatives process at least 3 tonnes of organic waste per day into briquettes. A prominent example is the Lubaga Charcoal Briquettes Cooperative Society Limited (Luchacos), which processes approximately 0.6 tonnes of waste, primarily banana peels, daily.[33] Similar decentralised operations, frequently supported by the Knowledge in Action for Urban Equality (KNOW) programme, are active across the Entebbe, Central, and Makindye divisions.[34]

**Advantages**

- Provides an affordable, low-emission alternative to wood charcoal
- Creates local green employment
- Reduces urban deforestation

**Challenges**

- Reliance on open-air drying, which is highly vulnerable to heavy rainfall
- Lack of adequate spatial infrastructure for scaling up production capacities

**Success story**: The Luchacos cooperative and KNOW programme initiatives in Kampala successfully commercialise briquettes from market waste.

### Other technologies

Advanced thermochemical treatments, such as pyrolysis and gasification, decompose biomass at high temperatures to produce valuable syngas, bio-oil, and biochar.

Pyrolysis involves the thermal decomposition of organic matter at elevated temperatures in the

[31] *Trois,* Case Study: Decentralised Micro-Biodigester Systems for Rural South Africa.
[32] *FAO, Supporting the Greening of Small Food Enterprising in Rwanda.*
[33] *Mbabazi and Kisembo, 'Co-Identifying and Co-Analysis of Energy Briquettes Capacity Gaps and Needs in Kampala – Urban Transformations'.*
[34] *Ibid.*

complete absence of oxygen, yielding carbon-rich biochar, liquid bio-oil, and combustible gases. Conversely, gasification exposes biomass to even higher temperatures with a strictly controlled, limited supply of oxygen or steam, primarily converting the carbon-rich feedstock into a versatile synthetic gas known as syngas. While both advanced thermochemical treatments offer substantial energy recovery potential, they require low-moisture feedstocks to operate efficiently, limiting their direct applicability to untreated, wet municipal biowaste.

**Advantages**

- High energy recovery potential
- Generation of valuable agricultural soil amendments (biochar)

**Challenges**

- Substantial capital costs
- Strict low-moisture feedstock requirements, often necessitating energy-intensive pre-drying

**Success story**: Decentralised biochar production initiatives utilising agricultural crop residues in Kenya.[35]

## 5.6 Composting

Composting constitutes the fifth tier of the Food Recovery Hierarchy. After all prior efforts to recover edible food have been exhausted, the remaining inedible fractions can be converted into compost to nourish agricultural soils.

This aerobic biological decomposition converts organic waste, including food scraps and yard trimmings, into a stable, dark brown product known as humus. The application of mature compost significantly improves soil physical properties, serving as a valuable soil amendment that enhances water retention, promotes crop yields, and assists in the remediation of degraded or contaminated lands.

The composting process is facilitated by combining organic materials in appropriate ratios and adding bulking agents, such as wood chips, to accelerate biological breakdown. The finished material is then allowed to fully stabilise through a curing phase. The efficiency of this aerobic decomposition relies heavily on maintaining optimal environmental conditions for microbial activity. Key factors affecting the process include the carbon-to-nitrogen ratio, oxygen availability, moisture content, particle size, and temperature. Achieving the appropriate thermophilic temperatures is particularly critical, as high heat is required to destroy pathogens and weed seeds that natural decomposition might otherwise leave intact.

Several common composting methodologies can be implemented based on the scale of operation and available resources:

**Windrow composting**: This method involves forming organic waste into long, narrow piles that are periodically turned to ensure aeration. It is

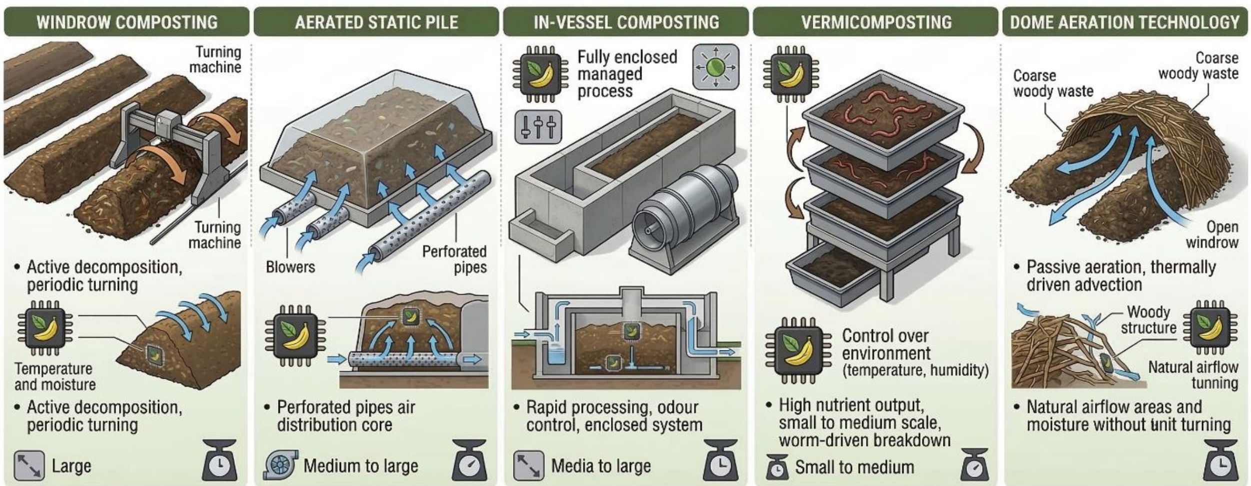



*Figure 9 - Comparison of composting technologies (created with Google Gemini)*

[35] Namaswa et al., *'Availability and Spatial Distribution of Crop and Forest Biomass Residues for Biochar Production in Kenya'*.

advantageous for processing large volumes of waste but requires significant land area and heavy machinery.

**Aerated static pile composting**: In this system, organic waste is mixed in a large pile equipped with a network of perforated pipes connected to blowers that supply oxygen, eliminating the need for physical turning. This approach allows for faster processing times and better odour control, although it involves higher initial equipment costs.

**Dome Aeration Technology**: Tested extensively in South Africa for sub-tropical climates, this non-reactor open windrow process achieves passive aeration through thermally driven advection. It utilises structural materials such as woody waste to create a framework that allows air to circulate, eliminating the need for periodic turning. Its primary advantages are low operational costs and minimal energy input, though it requires specific waste mixing ratios to ensure optimal moisture and structural integrity.

**In-vessel composting**: Organic materials are fed into a drum, silo, or concrete-lined trench where environmental conditions are strictly controlled. This method requires significantly less space and accelerates the composting process, but it is the most capital-intensive option.

**Vermicomposting**: This technique employs specific earthworm species to break down organic matter. It produces highly nutritious compost and operates at cooler temperatures, making it ideal for small-scale or indoor applications, but it is highly sensitive to temperature fluctuations and cannot process certain materials, such as meat or dairy.

Operating a commercial composting facility involves a standard sequence of processing steps. Initially, waste reception and sorting ensure the removal of non-biodegradable contaminants. The organic material is then reduced in size by shredding or grinding to increase the surface area for microbial action. Subsequently, the material is mixed and formed into piles to begin the active composting phase. After the initial rapid decomposition, the compost enters a curing and maturation stage to stabilise. Finally, the mature compost is screened, refined, and packaged or stored for distribution.

Effective management of these facilities requires strict adherence to operational considerations. Odour control is paramount to prevent nuisance to surrounding communities, while proper leachate management is essential to protect local water resources from contamination. Continuous process monitoring of temperature and moisture, coupled with rigorous quality control measures and regular compost testing, guarantees a safe, high-quality final product.

**Advantages**

- Considerably reduces methane emissions by diverting organic waste from landfills
- Eliminates or reduces the reliance on chemical fertilisers
- Provides cost-effective solutions for soil remediation, wetlands restoration, and carbon sequestration
- Creates dignified livelihoods through the formalisation of waste pickers
- Enhances community ownership and environmental awareness.

**Challenges**

- Requires consistent monitoring to prevent odours, pests, and leachate runoff
- Necessitates a significant land area for large-scale operations
- Depends heavily on strict source segregation to prevent contamination
- Relies vastly on continuous community engagement and initial provision of sorting infrastructure
- Vulnerable to land-use changes in rapidly urbanising areas

**Success stories**: While large-scale, centralised composting plants have historically faced challenges in the region due to feedstock contamination, several decentralised and community-led initiatives demonstrate the technology's viability when coupled with robust source segregation.

A contemporary success story within Uganda is the organic waste management facility established at

The Kollekt Village.[36] Supported by the Global Alliance for Incinerator Alternatives (GAIA) and the Climate and Clean Air Coalition (CCAC), this facility operates a structured three-chamber composting system that processes up to 3 tonnes of organic waste. A critical factor in its success is the integration of a dedicated Material Recovery Facility (MRF) and a plastic waste recovery programme. By formally involving waste pickers in the preliminary sorting and storage of materials, the project ensures that only clean, high-quality organic fractions enter the composting chambers. This model not only diverts substantial waste from landfills but also serves as a training hub for hands-on learning in sustainable waste management.

Research in Sub-Saharan Africa highlights a pilot biowaste source-segregation system in Tiassalé (Côte d'Ivoire) as a benchmark for high-quality output.[37] This initiative focused on assessing the efficacy of household-level sorting in conjunction with a decentralised composting plant. By providing residents with the necessary infrastructure and conducting intensive awareness campaigns, the project achieved a remarkably low impurity rate of just 1% in the collected biowaste. Consequently, laboratory analysis confirmed that the resulting compost contained negligible heavy metal contamination, meeting international safety standards. This project demonstrates that when municipal authorities engage citizens effectively, the primary barrier to successful composting, feedstock quality, is systematically removed.

## 5.7 Black Soldier Fly (BSF) farming:

Black Soldier Fly (BSF) bioconversion represents an innovative and highly efficient strategy for the valorisation of organic waste. This process utilises the larvae of the non-pest fly, *Hermetia illucens*, which voraciously consume a diverse range of organic substrates, including food scraps, market waste, and agricultural residues. Unlike traditional composting, which relies on microbial degradation over several weeks, BSF larvae can reduce the mass of organic waste by up to 80% in approximately 14 days.

The biological efficiency of the system is rooted in the BSF life cycle, which spans approximately 45 days. The process begins with the hatching of eggs into newborn larvae, which immediately commence feeding. As they progress through five larval stages (instars), they accumulate significant concentrations of protein and lipids. Upon reaching the prepupal stage, the insects naturally cease

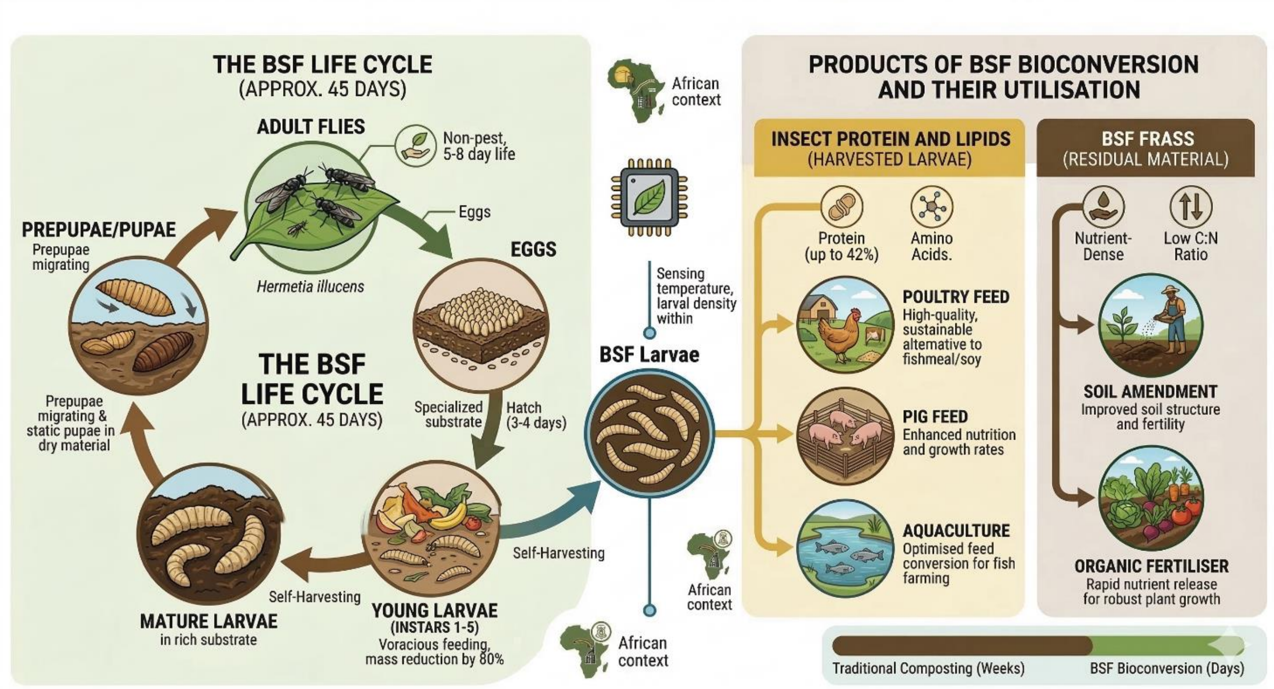



*Figure 10 - Black Soldier Fly (BSF) bioconversion lifecycle and byproducts (created with Google Gemini)*

[36] *Climate and Clean Air Secretariat (CCAC), Eleven African Countries Are Advancing Organic Waste Management and Protecting Waste Pickers.*
[37] *Dongo et al., 'Implementing Biowaste Source Segregation for Sustainable Decentralized Composting Schemes in Tiassalé, Southern Côte d'Ivoire'.*

feeding and migrate away from the waste substrate to pupate; this "self-harvesting" behaviour is a critical operational advantage for large-scale production. The adult flies, which do not possess functional mouthparts and therefore do not transmit diseases, live for only a few days to mate and oviposit, completing the cycle.

The process yields two primary high-value by-products:

- **Insect Protein and Lipids**: The harvested larvae and prepupae are exceptionally rich in protein (up to 42%) and essential amino acids, making them a sustainable alternative to fishmeal and soybean meal in animal feed for poultry, pigs, and aquaculture.
- **BSF Frass**: The residual material, consisting of larval excrement and partially digested organic matter, serves as a nutrient-dense organic fertiliser. BSF frass typically has a lower carbon-to-nitrogen (C:N) ratio than conventional compost, facilitating faster nutrient release and improving soil structure.

Currently, the primary commercial actor in Uganda is Marula Proteen, situated at the KCCA Wankoko recycling facility.[38] This operation processes approximately 8 tonnes of organic waste daily, much of which is sourced through KCCA collection networks. Although additional BSF enterprises have been identified in the Mukono and Wakiso districts, many remain in the preparatory phase while addressing quality-control concerns related to feedstock consistency. However, there is significant momentum in the sector to meet the surging demand for insect-based animal feed.

**Advantages**

- Rapid waste reduction compared to conventional composting
- Significantly lower greenhouse gas emissions, particularly methane
- Production of high-value protein that enhances local food security
- Suppression of harmful pathogens, such as E. coli and Salmonella, within the substrate.

**Challenges**:

- Requires precise environmental control of temperature and humidity for optimal larval growth
- Necessitates high-quality, non-contaminated organic feedstock to ensure the safety of the animal feed
- Initial capital investment for climate-controlled rearing facilities can be substantial

**Success stories**: The Marula Proteen facility in Kampala serves as a successful proof of concept for integrating BSF farming into municipal waste management systems. Furthermore, The Bug Picture has successfully deployed modular, off-grid BSF rearing units in Kenya and Rwanda, demonstrating a scalable model for smallholder farmers to convert market waste into affordable livestock feed.[39]

## 5.8 Incineration and landfilling

Technologies focused on disposal, such as incineration and sanitary landfilling, represent technically feasible options for managing municipal solid waste. However, these methods should generally be avoided for organic waste management unless implemented as part of a remediation strategy for existing uncontrolled dumpsites. In many developing regions, the majority of waste is currently disposed of in open dumps, which leads to severe environmental degradation, including soil and groundwater contamination via leachate, and significant public health risks from disease vectors and toxic air pollutants. While these technologies can sanitise the immediate environment and reduce waste volume, they represent a linear end-of-pipe approach that fails to recover the inherent nutrient value of the organic fraction.

### Sanitary Landfilling and Gas Recovery

Sanitary landfills are engineered facilities designed to isolate waste from the environment through liners and covers. When organic waste is landfilled, it undergoes anaerobic decomposition, producing landfill gas, a mixture primarily of methane and carbon dioxide. While electricity generation from

[38] *Otage, 'Black Soldier Flies Are My Cash Cow'.*
[39] *Stanford, Potential of the Professionalisation of an Insect Association in Kenya.*

this gas is technically feasible, it is inefficient for organic-rich waste streams, which could be more effectively managed through composting or anaerobic digestion. Furthermore, the high moisture content of food waste in tropical climates complicates landfill operations by increasing leachate production, requiring expensive treatment systems to prevent water pollution.

**Advantages**

- Effectively contains waste and mitigates the immediate risks of open dumping
- Provides a controlled environment for methane capture and energy recovery

**Challenges**:

- High capital and operational costs
- Requires permanent land allocation
- Provides no nutrient recovery for agricultural soils

**Success story**: The eThekwini Municipality in Durban, South Africa, operates the Bisasar Road and Mariannhill landfill-gas-to-electricity projects.[40,41] These sites capture methane to generate up to 7.5 MW of electricity, significantly reducing greenhouse gas emissions compared to open dumping, though they are increasingly viewed as transitional solutions as the municipality shifts toward waste diversion.

### Incineration

Incineration involves the controlled combustion of waste at high temperatures to reduce its volume and generate energy. However, this technology is particularly ill-suited for the organic waste typically found in East Africa, which is characterised by extremely high moisture content. Burning wet organic matter requires significant energy input, often necessitating additional fuel, making the process economically and environmentally unsustainable.

**Advantages**

- Rapidly reduces waste volume by up to 90%
- Eliminates pathogens and hazardous biological components

**Challenges**

- Extremely sensitive to high waste moisture
- Releases harmful air emissions if not equipped with expensive scrubbing technology
- Produces toxic bottom and fly ash

**Case Study**: The Reppie Waste-to-Energy plant in Addis Ababa, Ethiopia, was Africa's first major incineration facility.[42] Designed to process 1,400 tonnes of waste daily, the plant has faced significant operational challenges due to the low calorific value and high moisture content of the incoming mixed organic waste, which often prevents it from reaching its full energy-generation potential.

## 5.9 Selecting appropriate treatment methods for different scales

Selecting the most appropriate organic waste treatment method requires a comprehensive evaluation of the local context and the specific scale of waste generation. The decision-making process depends on a multitude of critical factors, primarily the physical characteristics and daily quantities of the waste stream. Furthermore, infrastructural planning must account for land availability, local climate conditions, the technical skills of the available workforce, capital and operational expenditure, and the proximity to viable markets for end products such as compost, biogas, or insect protein.

The municipality's scale heavily influences the technological approach. For **small towns** with populations under 50,000, **low-technology, decentralised solutions** such as open windrow composting are well-suited due to manageable waste volumes and greater land availability.

**Medium-sized cities** housing between 50,000 and 500,000 residents, such as Mbarara in the south-western region, often require a transitional approach. These urban areas benefit from a **combination of decentralised community initiatives and centralised facilities**, potentially

[40] *Couth et al., 'Delivery and Viability of Landfill Gas CDM Projects in Africa—a South African Experience'.*
[41] *Couth and Trois, 'Sustainable Waste Management in Africa through CDM Projects'.*
[42] *Burnley, 'Energy from Waste in the Global South and Its Role in Achieving Net Zero'.*

incorporating aerated static piles or mid-scale anaerobic digestion to handle more concentrated commercial waste streams.

Conversely, **large urban centres** with populations exceeding 500,000, such as Kampala, generate substantial volumes of waste that justify **high-capacity, centralised hybrid systems**. These systems frequently combine multiple technologies, such as large-scale anaerobic digestion and black soldier fly bioconversion, to process diverse waste fractions and maximise resource recovery.

Regardless of the municipal scale, the deployment of these technologies requires structured, evidence-based planning. Advanced modelling and assessment of various waste management scenarios enable local authorities to evaluate the long-term sustainability and economic viability of different strategies. Furthermore, a phased implementation approach is essential. Commencing with rigorous pilot testing allows municipalities to validate the efficacy of a chosen technology against local waste characteristics before committing significant capital to full-scale, permanent infrastructure.

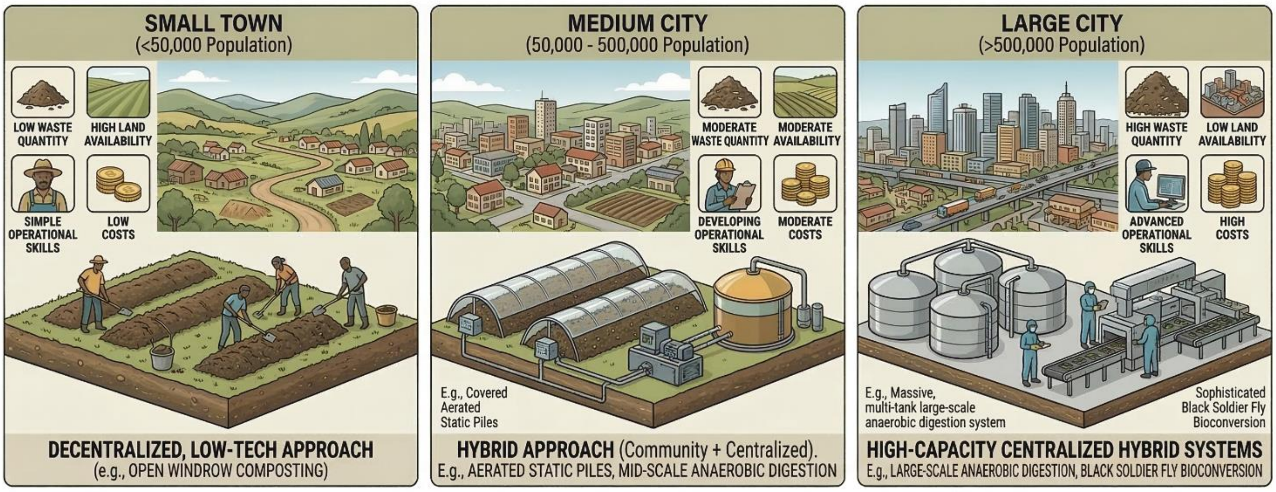



*Figure 11 - Organic waste management approaches based on urban size (created with Google Gemini)*

# 6. Community Engagement and Education

## 6.1 Raising awareness about organic waste sorting

The success of municipal organic waste management systems is intrinsically linked to the active and informed participation of the community. Consequently, raising public awareness is a foundational element of any waste diversion strategy. Effective communication campaigns must clearly articulate both the environmental and economic benefits of source separation, demonstrating how individual actions contribute to broader public health and resource recovery goals. Central to this messaging is the provision of precise, accessible instructions regarding proper sorting techniques. Citizens require clear guidance on categorising materials, specifically distinguishing between acceptable biodegradable inputs and prohibited contaminants.

To maximise community uptake, awareness initiatives must employ a diverse set of methods tailored to distinct audience segments, including residential households, commercial businesses, and educational institutions. Grassroots approaches, such as door-to-door educational campaigns, school programmes, and interactive community workshops, facilitate direct engagement and allow for immediate clarification of sorting protocols. Simultaneously, broader outreach can be achieved through mass media channels, including local radio and television broadcasts, social media outreach, and the strategic distribution of printed flyers and posters at community fairs.

Crucially, cultivating long-term behavioural change necessitates a sustained commitment rather than isolated, short-term interventions. Ongoing awareness efforts are essential to reinforce proper sorting habits and prevent the gradual increase in contamination rates in organic bins. Furthermore, governing bodies must implement structured frameworks to monitor and evaluate the effectiveness of these communication campaigns. By routinely assessing community feedback and analysing the purity levels of collected waste, authorities can refine their educational materials and ensure that public engagement strategies remain highly effective and contextually relevant.

## 6.2 Training programs for households and businesses

Following initial awareness campaigns, the implementation of targeted training programmes is critical to operationalising organic waste sorting across different community sectors. These educational initiatives must be meticulously adapted to


*Figure 12 - Awareness raising process for organic waste sorting (created with Google Gemini)*

address the specific logistical realities of varied environments, including residential households, high-volume restaurants, open-air markets, and corporate offices. The curriculum for these sessions should comprehensively cover proper waste segregation techniques, practical methods for establishing segregation infrastructure in homes or commercial spaces, and effective strategies for troubleshooting common issues, such as odour management and pest control. By explicitly detailing the environmental and economic benefits of participation, trainers can foster sustained intrinsic motivation among participants.

To accommodate diverse learning preferences and operational constraints, municipalities should deploy a combination of training formats. While printed guides and online video tutorials provide accessible reference materials, in-person workshops and on-site demonstrations remain invaluable. Incorporating hands-on, practical components into these sessions significantly enhances knowledge retention and enables individuals to practice segregation protocols under supervision.

Furthermore, the scope of these training programmes must extend beyond the general public to include municipal staff and frontline waste collectors, ensuring standardisation and quality control across the entire waste management value chain. To embed these practices within the local culture, establishing organic waste *champions* within neighbourhoods and business networks has proven highly effective. These designated individuals serve as peer educators and primary points of contact for localised troubleshooting. Finally, the provision of ongoing support and scheduled follow-up assessments after the initial training phase is essential to address emerging challenges, correct persistent sorting errors, and ensure the long-term viability of the organic waste recovery system.

## 6.3 Incentives for proper waste sorting

Developing robust incentive structures is fundamental to driving participation in organic waste segregation, particularly within developing contexts where municipal enforcement resources may be limited. To ensure long-term viability in regions such as East Africa, these mechanisms must be economically realistic and culturally appropriate. Providing free or heavily subsidised segregation bins to households removes the initial financial barrier to entry, which is a critical step in resource-constrained communities. Beyond essential infrastructure, municipalities can deploy financial incentives, such as reduced waste-collection tariffs for households and formal tax rebates for commercial enterprises that consistently achieve high diversion rates.

In informal or low-income settlements where fee-based collection systems are less prevalent, non-monetary rewards often prove highly effective. These include the direct distribution of mature agricultural compost back to the community or the establishment of public recognition programmes. Fostering community-level competitions between neighbourhoods or local markets can promote participation by leveraging local social dynamics to encourage collective responsibility.

While volume-based pricing models successfully drive waste reduction in highly industrialised nations, their immediate application in developing cities risks exacerbating illegal dumping if formal collection coverage is incomplete. Consequently, a phased implementation strategy is vital. Initial phases should focus exclusively on positive reinforcement coupled with ongoing education, strictly tying rewards to measurable outcomes such as low contamination rates. Only after widespread infrastructural access and public awareness are firmly established should authorities introduce punitive measures, such as fines for persistent non-compliance. Case studies from similar Sub-Saharan municipalities demonstrate that continuous monitoring and the flexible adjustment of these incentive programmes ensure they remain aligned with municipal capacities and shifting community needs.

# 7. Troubleshooting and best practices

## 7.1 Common challenges in organic waste sorting

The transition from conventional mixed waste disposal to comprehensive source separation encounters several **systemic** and **behavioural hurdles**.

A primary obstacle is the pervasive lack of awareness regarding proper segregation techniques, which inevitably leads to high contamination rates. When organic waste is mixed with non-biodegradable materials such as plastics, glass, or hazardous household items, the efficiency of downstream processing technologies is severely compromised. Furthermore, residents and commercial entities accustomed to single-bin systems often resist change. Deeply ingrained cultural barriers or misconceptions about handling food waste can also lead to highly inconsistent participation across demographics.

Beyond behavioural factors, practical constraints pose substantial difficulties for waste generators. In densely populated urban areas or informal settlements, limited physical space within households and commercial kitchens restricts the deployment of multiple waste receptacles. This spatial limitation is compounded by environmental factors specific to tropical climates. The storage of putrescible organic matter rapidly generates unpleasant odours and attracts disease vectors, such as rodents and flies. These nuisance factors actively deter consistent public participation when municipal collection frequencies are insufficient to manage the rapid decomposition rates inherent in hot environments.

Finally, structural vulnerabilities at the governance level can undermine the entire recovery strategy. A widespread lack of clear incentive structures or robust enforcement mechanisms significantly diminishes public compliance over time. Even when community participation is high, inadequate downstream infrastructure for processing the sorted organics creates operational bottlenecks. If collection logistics are poorly coordinated or regional processing facilities lack adequate capacity, the separated waste is frequently recombined at the final disposal site, a systemic failure that completely erodes public trust in the sorting programme.

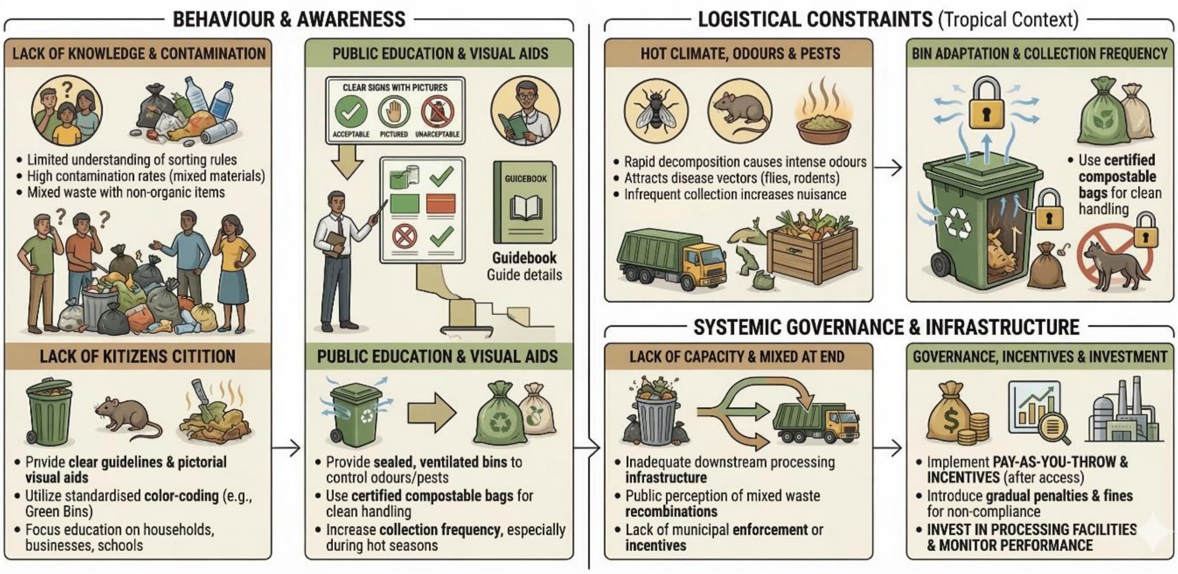



*Figure 13 - Common organic waste sorting challenges and solutions (created with Google Gemini)*

## 7.2 Solutions to frequently encountered problems

To overcome the behavioural and logistical challenges associated with source separation, municipalities must implement comprehensive public education and awareness campaigns. The provision of clear guidelines and intuitive visual aids is critical for standardising proper sorting practices across diverse demographics. Furthermore, the distribution of free or heavily subsidised kitchen caddies and compostable bags directly equips residents with the necessary tools to participate effectively, removing the initial barriers to entry.

In tropical climates, mitigating the nuisance of decaying organic matter requires specific logistical adaptations. Utilising sealed yet adequately ventilated bins is an effective strategy to control unpleasant odours and restrict access to disease vectors. Alongside appropriate storage infrastructure, increasing the collection frequency of the organic fraction, particularly during hot seasons, prevents the accumulation of putrescible waste and encourages consistent household participation.

The introduction of phased economic instruments and structural policies can further stimulate public compliance. While advanced systems like pay-as-you-throw require robust administrative capacity, their gradual implementation, eventually coupled with enforced penalties for severe contamination, serves to incentivise waste reduction and meticulous sorting. However, the deployment of such systems and new collection rules should ideally commence as pilot programmes within select neighbourhoods. This phased approach allows authorities to identify operational bottlenecks and refine their strategies before committing to full-scale municipal implementation.

Finally, sustaining long-term engagement relies on transparency and community integration. Partnering with local community organisations facilitates grassroots promotion and continuous monitoring of sorting efforts. Concurrently, governing bodies must proactively invest in high-capacity processing facilities to reliably handle the anticipated increase in segregated organic volumes. Providing regular, data-driven feedback to residents regarding the positive environmental and economic impacts of their collective efforts reinforces the value of the programme and solidifies public trust in the waste management system.

## 7.3 Lessons learned from other countries

To effectively overcome the logistical and behavioural hurdles detailed in the preceding sections, municipal authorities must analyse successful frameworks established beyond their immediate borders. By examining diverse international approaches to organic waste diversion, urban planners can identify scalable models, adapt proven infrastructural solutions, and anticipate policy bottlenecks. The following case studies illustrate practical applications of source segregation and resource recovery across varying African contexts, offering critical insights for implementation within Uganda.

### City of Cape Town, South Africa

Since mid-2023, the City of Cape Town has started an aggressive organic food waste diversion pilot through its Urban Waste Management Directorate, supported by the Afrifoodlinks initiative.[43] This programme specifically targets major Public Transport Interchanges and two distinct residential areas, Langa and Khayelitsha. By supplying vendors and approximately 2,000 households with dedicated collection buckets, the municipality successfully diverted over 550,000 kilograms of organic material from landfills in under two years.[44] The collected waste is subsequently processed at the Bellville Compost Plant, creating a closed-loop circular economy. A critical driver of this success was the integration of Expanded Public Works Programme teams, which provided reliable weekly collection while simultaneously generating local employment.

**Lessons learned**: targeted pilots enable municipalities to refine logistics and understand participation barriers before committing to full-

[43] *Afrifoodlinks, Cape Town Pilot Project Infographic.*
[44] *Saufft, 'Composting Success with Langa Pilot Project'.*


*Figure 14 - Langa organic waste diversion and composting plant (fairfood.org.za - City of Cape Town)*

scale expansion. Furthermore, leveraging existing public infrastructure and providing free segregation bins drastically reduced contamination rates.

**Potential for adoption in Uganda**: the Cape Town model presents a highly adaptable blueprint for Ugandan municipalities. Urban centres can initiate diversion efforts by targeting high-density commercial hubs and municipal markets, utilising local labour programmes to manage collection logistics. By combining these targeted collections with the promotion of home composting and the establishment of centralised processing facilities, Ugandan cities can maximise diversion rates and stimulate local job creation. Moreover, the continuous assessment of pilot outcomes ensures programmatic flexibility, allowing local governments to adjust strategies based on empirical data to ensure long-term viability.

### Tiassalé, Côte d’Ivoire

The municipality of Tiassalé in southern Côte d’Ivoire offers a compelling model for overcoming the historical failures of centralised waste processing in low-income urban areas. Previous regional initiatives frequently collapsed due to the high contamination levels in mixed waste streams, rendering the resulting compost unusable. To address this, the Tiassalé project implemented a strict biowaste source-segregation system directly linked to a decentralised composting plant.[45,46] Households were equipped with dedicated biowaste collection bins and received extensive training on distinguishing food scraps and yard waste from non-biodegradable materials. The outcomes of this structured intervention were highly significant. The source-segregated biowaste exhibited an impurity rate of merely 1%, yielding agricultural-grade compost with negligible heavy metal concentrations. Furthermore, community acceptance was exceptionally high, with 75% of households adopting the system and a significant portion expressing willingness to pay to continue the service.

**Lessons learned**: the project highlighted that combining affordable, dedicated infrastructure with continuous behavioural education is critical to achieving pure waste streams. It also demonstrated that residents are willing to provide financial support for waste management when it is framed as a community investment.

**Potential for adoption in Uganda**: the replication potential for Ugandan cities is substantial, particularly in areas where centralised collection is logistically prohibitive. By establishing small-scale, neighbourhood-level composting units and engaging local leaders early to prevent 'not in my backyard' conflicts, Ugandan municipalities can foster community ownership while producing safe organic fertilisers. To ensure sustainability, this decentralised physical infrastructure must be supported by municipal policies that standardise compost-quality guidelines and enforce household-segregation mandates.

[45] Yeo et al., *‘Material Flows and Greenhouse Gas Emissions Reduction Potential of Decentralized Composting in Sub-Saharan Africa’.*

[46] Dongo et al., *‘Implementing Biowaste Source Segregation for Sustainable Decentralized Composting Schemes in Tiassalé, Southern Côte d’Ivoire’.*

*Figure 15 - Left: Composting pilots in Tiassalé, Cote d'Ivoire (Yeo et al., 2020); Right: Food waste collection before composting in Dschang, Cameroon (CEFREPADE)*

### Dschang, Cameroon

The city of Dschang in Cameroon, a university town with a population of approximately 100,000, presents a nuanced case study regarding the intersection of formal and informal waste management.[47] Although biodegradable material accounts for half of total municipal waste, local policy frameworks often misalign with sustainable practices, as national agricultural subsidies heavily favour imported mineral fertilisers over locally produced compost. Consequently, the municipal waste agency struggles to incentivise formal segregation. A significant infrastructure gap exists, with the majority of households lacking appropriate multi-compartment bins and instead relying on generic plastic bags. This gap forces centralised composting facilities to manually sort mixed waste, resulting in high labour costs, low-quality compost, and frequent community odour complaints due to poor facility siting. Conversely, the informal sector demonstrates remarkable efficiency. Over 80% of households independently segregate organic waste to feed domestic livestock, while numerous restaurants bypass the municipality entirely, providing their food waste to informal pickers for monetary compensation.

**Lessons learned**: the primary lesson from Dschang is that ignoring existing informal practices and material barriers guarantees systemic failure. Without dedicated bins, household segregation is practically impossible. Furthermore, municipal strategies must actively align with broader national policies to create viable markets for recovered resources.

**Potential for adoption in Uganda**: the Dschang experience underscores the need to design hybrid systems. Ugandan municipalities can bypass the failures of purely centralised models by formally integrating existing waste-picker networks and acknowledging traditional animal-feeding practices. Providing low-cost bins to residents and strategically locating processing sites away from dense settlements will minimise conflict and harness the existing informal economy to achieve high diversion rates.

[47] *Compostage à Dschang, Cameroun | CEFREPADE.*

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