RUNRES
Nutrient Cycles – Rural Urban Linkages

RUNRES – The rural-urban nexus: establishing a nutrient loop to improve city region food system resilience

A cooperation project on nutrient cycling in Arba Minch, Ethiopia; Bukavu, Democratic Republic of Kongo; Kamonyi district, Rwanda; Msunduzi municipality, South Africa, and ETH Zurich supported by the Swiss Agency for Development and Cooperation (SDC)

Pilot phase (2019–2023) of co-designed and tested innovations to valorize urban and rural organic waste resources

FACT SHEETS and POLICY BRIEFS

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Overview

In the four countries, the Democratic Republic of Congo (DRC), Ethiopia (ET), Rwanda (RW) and South Africa (SA), seven co-designed innovations at the rural-urban nexus to valorise organic waste resources in total were successfully tested. These innovations can be potentially implemented elsewhere.

The innovations include: composting (DRC and ET), processing raw banana (ET), rearing black soldier fly larvae (RW), high quality cassava peel flour (RW), co-composting (SA), and effluent and urine valorisation (SA).

DRC

The city of Bukavu, with a population of more than 1.6 million, faces major sanitation challenges, including inadequate waste management infrastructure. Around 900 tonnes of solid household waste, most of which is organic, is generated every day. More than ninety percent of this waste is disposed of on the streets and in the sewers, eventually ending up in Lake Kivu. Composting of organic waste is a promising approach to tackle the sanitation and solid waste problem in Bukavu, while also addressing the declining soil fertility of agricultural land in rural areas.

ET

In Arba Minch, more than fifty percent of the households do not use waste collection services and the vast majority of organic waste is not utilized. Although policies exist that support municipal solid waste management, these are not well aligned with practice (private sector). The two innovations in Arba Minch aimed to close the nutrient cycle by collecting and composting of organic household waste and processing bananas into a nutrient-rich flour.

RW

Rwanda's livestock sector is growing steadily, driven by urbanization and demand for animal protein. At the same time, the already high cost of animal feed continues to rise due to the sharp increase in transport costs in recent years, as the country relies heavily on imports for raw materials. As a response to these challenges the RUNRES project initiated and tested Black Soldier Fly Larvae (BSFL) as an alternative source of protein, and High Quality Cassava Peel (HQCP) flour as a carbohydrate-rich animal feed.

SA

The continued removal of nutrients through the production of food consumed elsewhere is depleting the fertility of agricultural land. At the same time, municipalities are struggling to dispose of sewage sludge from wastewater treatment plants, while many households are not even connected to a sewage system, posing health and environmental risks. RUNRES South Africa has tackled these problems with two innovations: co-composting of green waste and wastewater residues, and the provision of toilet systems in underserved areas that include nutrient recovery (effluent and urine).

Content

This dossier contains the policy briefs and the fact sheets of the RUNRES project and provides a brief overview on the RUNRES project.

Democratic Republic of Congo

Ethiopia

Rwanda

South Africa

Combining nutrient cycles and waste management in Bukavu – Policy Brief

Summary

Bukavu, a city of 1.6 million inhabitants, faces major challenges in sanitation, including inadequate waste management infrastructure that exposes the population to health risks and creates environmental damages. Approximately 900 tonnes of mixed solid household waste are generated daily. Only 7% of the waste is collected, but it is not disposed of properly. The RUNRES project promotes the transformation to a nutrient cycle, concretely the collection and conversion of organic waste into a compost. It turned out that costs for collection, transport and processing are too high to be economically viable.

Sorting waste at source would reduce costs while at the same time reduce unsanitary conditions in urban areas. The RUNRES project explored the RANAS approach to improve source separation. RANAS aims to change behaviour through a tested awareness campaign and the distribution of bins. The RANAS campaign has proved that it significantly improves waste separation at source. Nevertheless, the state's commitment is essential because the costs of collection, transport and composting far exceed the revenues from compost. The municipal administration should implement existing regulations that require households to subscribe to waste collection services. It should also develop and implement waste management concepts that support the separation of waste at source, waste collection and proper landfill with the help of donor organisations.

Recommendations

- **Apply laws on waste management:** The municipal authority should implement Provincial Law No. 001, Articles 13 and 21, which require households to subscribe waste collection services and to sort waste at source. Implementation must be enforced and measures taken against offenders in accordance with Article 42 of this law.
- **Development and implementation of a waste management plan:** The province and decentralized territorial entities should draw up a five-year waste management plan and develop general policies for private initiatives to ensure effective implementation.
- **Promote waste recycling:** The public authorities should promote the transition from the linear model (production-use-waste-dump) to the recycling approach by subsidising innovative business models.
- **Mobilize households for behavioural change:** Raising households' awareness of the importance of separating waste at source and benefits of recycling organic waste for agriculture. Implementing community-based initiatives to promote responsible waste management practices.
- **Establishing a monitoring system:** The authorities should involve local leaders (local chiefs, street chiefs, and leaders of ten households) who will encourage households and monitor improvements, as their commitment and dedication are crucial to mobilizing households.

Introduction

The RUNRES project aims to support the transition to a nutrient cycle. RUNRES promotes the collection of organic waste in the city of Bukavu and to convert it into a nutrient rich compost which will be made available to smallholder farmers in rural areas. In doing so, RUNRES contributes to improving urban waste management, reducing health risks for the city population and reducing environmental impacts. Indirectly, the project also contributes to food security.

However, composting innovations proved to be economically unsustainable in the pilot phase of RUNRES (2019–2023) due to the high costs of collection, transport and processing. For this reason, the RANAS approach was explored at an early stage of the pilot phase to reduce the costs of waste separation. RANAS is a proven intervention strategy that aims to change the behaviour of households in terms of sorting at source.

The problem

The city of Bukavu, with a population of 1.6 million, faces major sanitation challenges, including inadequate waste management infrastructure. Every day, 900 tonnes of solid household waste is generated, 65% of which is organic. Only 7% of the waste is collected, but it is disposed of in unsanitary landfills. The rest is disposed of on the streets and in the sewers, eventually ending up in Lake Kivu and the Ruzizi River. Promoting the recycling of organic household waste to produce compost is a promising way to alleviate this waste problem while putting the concept of the circular economy into practice. However, this faces a variety of challenges: the waste is not sorted at source; impurities in the raw material increase the cost of compost production (additional labour costs) and affect the quality of the product (nutrient content); relevant laws (e.g. that households should subscribe to the waste collection service) are not implemented and enforced; and transport costs (for collection and transport to the composting plant) call into question the economic viability.

The effects of not sorting and collecting household waste at source are:

- **Increased environmental pollution:** If household waste is not properly sorted and collected at source, it is more likely that it will be carelessly disposed of in nature, waterways or streets, rather than recycled, causing environmental pollution.
- **Inefficient resource recovery:** Without sorting, recyclable materials that could be recovered and processed for reuse are mixed with other waste, making them more difficult and costly to extract for recycling.
- **Legal and regulatory consequences:** Non-compliance with existing municipality waste management laws can have legal consequences for households and local authorities, including fines, penalties, and legal actions taken by environmental agencies.

Other challenges of the existing waste management system include: lack of awareness and understanding of the importance of waste sorting at source; inadequate infrastructure for waste collection (e.g. bins) and waste recycling facilities; lack of a waste management plan and coordination of measures implemented by the actors involved; and insufficient involvement of the relevant authorities including local leaders such local chiefs, street chiefs, and leaders of ten households.

Solution and policy implication

The situation can be improved by promoting the composting of organic household waste for agriculture. This includes source segregation, collection, transport to the composting plants and sale of the compost to smallholder farmers in rural areas. A key element in improving the sanitation situation in the city is the RANAS approach. This aims to change the sorting behaviour of households. To achieve this, possible behavioural factors are identified to develop appropriate strategies for behavioural change. The RANAS campaign includes the distribution of waste containers for the sorted waste and raising awareness among beneficiary households about waste separation. Initial test results showed that the RANAS campaign can significantly improve source separation in households. Another important aspect of this innovation is to reduce transport costs by locating the composting plant as close as possible to the source of the waste. Despite these measures, the commitment of the state is needed to make this effective and economically feasible for the innovators.

RUNRES contributes to the solutions by supporting the recycling of organic waste and the production of affordable compost, thus contributing to food security. However, this is not enough. Government's (or donors') support and coordinated policies are needed to achieve a breakthrough in organic waste recycling and nutrient cycles in Bukavu.

Policies and support from the government or donors play a key role in making the nutrient cycle in the city region of Bukavu economically viable and sustainable. This should includes:

- Rules and regulations that encourage the separation of waste at source and the use of compost in agriculture production.
- Provide subsidies, tax breaks or other incentives to encourage businesses and households to participate in waste collection and sorting.
- The municipality should ensure that its obligations to the waste management companies are met by facilitating their task and obliging households to subscribe and set up the necessary waste management infrastructure (processing site) in return for the taxes collected (10% of the revenue from collection and registration fees).
- Train and equip waste collectors with the skills and tools needed to effectively collect and sort waste, while ensuring their safety and well-being. Migrate waste from landfill to composting sites and establish waste sorting calendar.

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Composting in response to sanitation and soil infertility – Fact Sheet

The city of Bukavu, with a population of more than 1.6 million, faces major sanitation challenges, including inadequate waste management infrastructure that exposes the population to health and environmental risks. Almost 900 tonnes of household solid waste are generated each day, of which only 7% (about 60 tonnes) are collected and removed. The rest is disposed of on the streets and in the sewers and eventually ends up in Lake Kivu. Composting is a sustainable method that has the potential to meet the sanitation challenges in urban areas while improving soil fertility in the surrounding rural areas.

In order to solve both problems (unsanitary conditions and soil fertility), the innovation of composting organic household waste was initiated and successfully tested by a consortium led by Diobass in Kabare as part of the RUNRES pilot phase.

Compost production cycle

The composting cycle is a natural process of organic matter decomposition. It begins with the collection of organic waste such as kitchen waste, leaves and garden waste and ends with the use of the product (compost), e.g. in agriculture. The organic waste is piled up on a compost heap, alternating with drier materials such as leaves or twigs. Depending on the type of waste used as raw material, the waste is converted into a nutrient-rich compost within 12 to 16 weeks.

Partners & staff

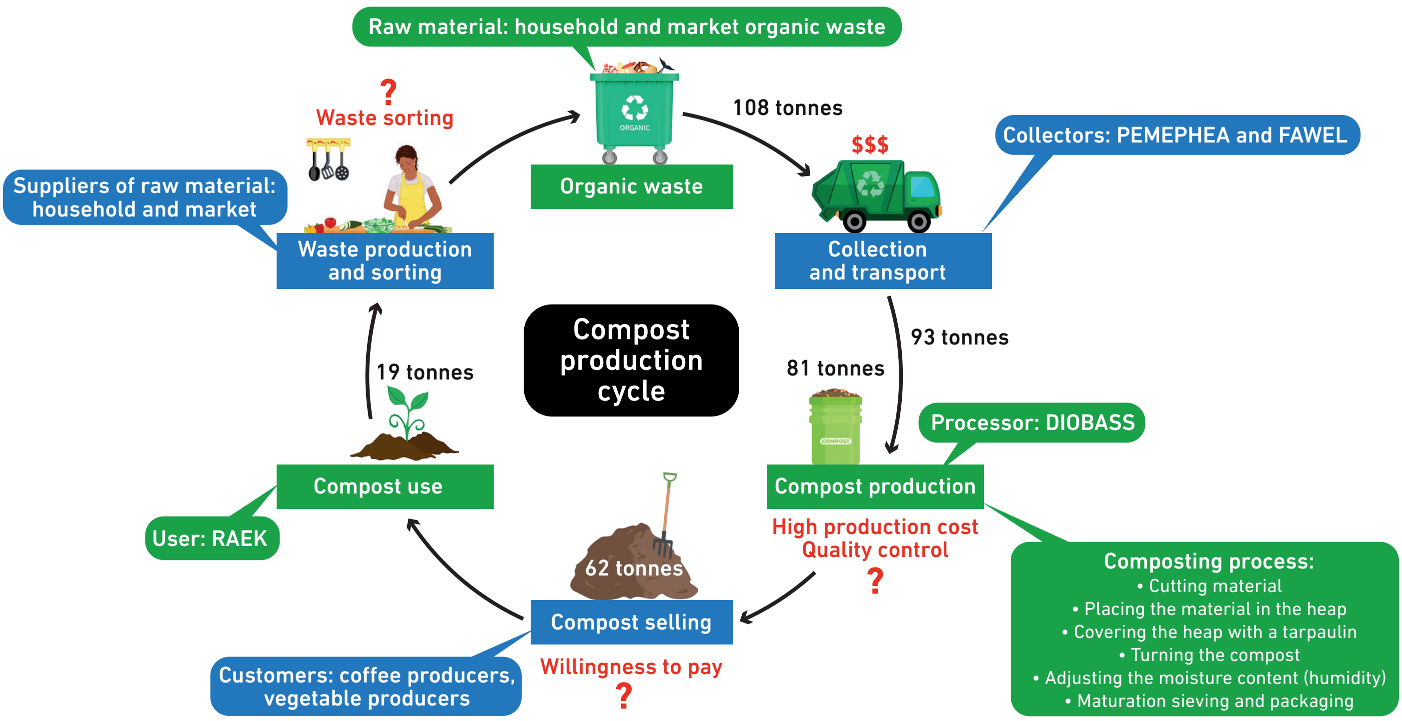
Partners: The innovation was tested by Diobass, in collaboration with waste collectors such as PEMEPHEA (150 households) and FAWEL (150 households), and RAEK, a cooperative of coffee growers in Kabare (100 beneficiaries).

Staff: The consortium employed 15 people, including women aged 20 to 35 years, who focused on public relations, financial administration and site supervision, avoiding physically demanding tasks.

The waste pickers of PEMEPHEA and FAWEL employed 40% young women and 60% young men. When processing waste, 50% of the workers were women and 50% were men. The RAEK cooperative consists of 60% men and 40% women, mainly young people.

Input / output

In addition to the raw material, i.e. organic waste, the input included training on composting organic waste and on the production of coffee seedlings. The output includes the quantities of organic waste collected, waste processed, compost produced, sold and used.



Nutrient and material cycle of the RUNRES pilot phase

Product use and key customer

The end users of the compost produced are the coffee farmers who are members of the RAEK cooperative. The most reliable customers are local vegetable producers. Although the compost is sold at a relatively low price of 30 to 40 US dollars per tonne, small-scale producers are still not willing to pay for it, as they hope to receive it free of charge from development NGOs.

Quality control

It was found that the chromium (Cr) (Cr_{tot} [mg/kg] 97.6 ± 27.8) and nickel (Ni) (Ni_{tot} [mg/kg] 67.0 ± 29.1) levels were both above the regulatory threshold of 50 mg/kg. Further analysis indicated that the soil mixed into the compost was the cause of these elevated heavy metal concentrations. We therefore recommend that the addition of soil to the composting process be stopped in order to avoid possible quality problems.

Waste sorting and transportation costs

In addition to reducing the distance between the source of the waste in the city and the composting plant outside, separating waste at the source also helps to reduce the cost of transporting raw materials by 35%. This significantly reduces the overall cost of compost production.

Investment and profitability

The total project investment is $107,000. The project was anticipated to yield a net profit of $93,000 over its duration.

Item	Amount ($)*
Total investment	107,000
CAPEX	72,000
Working Capital	7,087
NPV (5 years)**	16,428
IRR**	28.9%

** The numbers are based on business data from the pilot phase.*
*** NPV: Net Present Value; IRR: Internal Rate of Return*

Composting operation: labor cost

The total labor cost for composting operations is estimated at $15.2 per tonne for unsorted waste at the source. However, this cost decreases to $9.3 per tonne when waste is sorted at the source.

Composting innovation bottlenecks

The following table illustrates the bottlenecks in composting and innovation-upscaling in the context of Bukavu.

Bottleneck	Measures
Waste sorting at source issue	Sensitization, availability of bins and municipality forcing
High Transportation cost	Bring composting sites closer to the source of waste and waste sorting at source
High cost of production	State subsidy and waste sorting at source
Poor quality of end product (compost)	Add of the nitrogen source materials while avoiding the addition of soil in the process
End users limited willingness to pay for compost	Sensitization and compost price reduction

Start-up requirements

Raw materials: Organic waste such as kitchen and garden waste, agricultural residues, wood chips, paper shreds, and microorganisms are essential ingredients for the composting process. Cow dung and Tithonia leaves must be incorporated to improve the nitrogen content in the compost.

Implementing waste sorting at the source by households, through education programs and the provision of bins for separating organic waste, is crucial.

Facilities and infrastructure: Upstream: for the system to function properly, households must have at least two bins for waste sorting at source. Suitable trucks are essential for transporting the collected organic waste. Downstream: A composting site must be set up and equipped to facilitate the composting process. The site should be located near a water source and close to the source of the raw material.

Process monitoring equipment such as temperature, humidity and aeration monitoring devices is required. Proximity to a laboratory, capable of ensuring quality control of the compost, is necessary.

Complying with regulatory requirements involves environmental regulations, and ensuring health and safety standards. By meeting these requirements, a successful composting business can be established which addresses sanitation issues and promotes soil fertility through sustainable waste management practices.

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Nutrient cycle through composting and banana processing – Policy Brief

Summary

In Ethiopia, there are several policies and legal frameworks that support municipal solid waste management. However, there is a disconnection between waste management policy and practice. This disconnection results in poor waste management, inadequate data recording, and unsustainable business models for organic waste composting.

To address these challenges, the recycling of organic waste through composting, awareness-raising campaigns, context-specific policies, and the establishment of quality testing facilities are proposed. On the other hand, food processing can improve food security, create numerous agricultural jobs, and improve the introduction of new high-quality foods.

The RUNRES project is supporting both nutrient recycling through composting of organic household waste and a small-scale banana processing business in Arba Minch town. However, the latter faces challenges such as delays in market approval and weak entrepreneurial management skills. To unlock the full potential of food processing, policy actions are recommended, including the establishment of dedicated regulatory agencies, the promotion of technology-based solutions, the provision of financial literacy programs, and public-private dialogue and collaboration.

Recommendations

- **Policies for safe and optimized organic waste recycling:** It is recommended formulating and implementing policies for a circular nutrient economy at various administrative levels that promote the separation of waste fractions, subsidise the collection of household waste and support nutrient recovery. This also includes developing facilities to test compost quality and standards, as well as standards and market guidelines for compost. Awareness-raising campaigns should support these activities and can be part of the policies.
- **Promoting public-private partnership:** It is proposed to coordinate public-private efforts to improve the food processing sectors. This requires policy instruments that regulate the quality assessment of products, technology-based solutions for application and approval, the development of financial literacy programmes, and platforms for market linkage.

Introduction

Circular economy represents an alternative to the linear 'produce-consume-dispose' model which has significant environmental impacts. The circular economy model keeps resources in the economy for as long as possible. This can be achieved through better product design, maintaining and extending the lifespan of products, using waste as a resource and cooperating across the value chain. RUNRES promotes the recycling of organic waste by implementing and scaling viable and acceptable innovations such as for composting and food processing. This nutrient cycle improves agricultural production and benefits smallholder farmer, thus contributing to food security, and human and environmental health in city regions.

The problem

70% of the organic solid waste that can be converted to soil amendments is not yet being utilised. Due to poor solid waste management, this waste accumulates in cities, while the excessive nutrient mining reduces productivity in rural areas. On the other hand, Ethiopia is importing increasing amounts of fertilizer to produce enough food for its growing population. This is placing a heavy burden on the economy, as fertilizer has to be heavily subsidized. Small-scale food processing also faces numerous challenges in production and market entry, including access to finance, a lack of infrastructure, weak entrepreneurship and insufficient managerial capacity.

The Ethiopian government has established policies for solid waste management, which includes the national integrated urban sanitation and hygiene strategy, the proclamation on solid waste management, and the proclamation on environmental pollution control. However, there are challenges such as:

- **poor solid waste segregation and management**
- **inadequate waste data recording**
- **lack of sustainable business models and financial support**
- **lack of infrastructure for compost distribution**

Even households that are connected to the waste collection service dispose of their waste illegally to reduce service payment. There are only a few initiatives that implement the 3R (reduce, reuse, recycle), and circular economy models are still in their infancy.

More than 50% of households in Arba Minch do not use public solid waste disposal service. This indicates poor coverage of solid waste disposal services, although there are 19 formally registered micro and small enterprises operating in the waste management sector. This implies improper waste disposal and leads to:

- **environmental pollution**
- **human health risks**
- **infrastructure destruction via flood filling drainage cannels**

Most organic solid waste generated by urban dwellers are moist and biodegradable; it decomposes immediately after disposal. As it decomposes, it releases foul odour and become a breeding ground for pathogens and vectors.

70% of organic waste not yet utilised

> 50% of households in Arba Minch do not use waste collection services

(organic) circular economy in its infancy

lack of appropriate policies to foster composting and food processing

Solution and Policy Implication

To improve this situation, the RUNRES project piloted circular economy in Arba Minch to recycle organic solid waste through composting and banana processing.

The innovations introduced by RUNRES are a strong motivation for people to get involved in waste management and processing. If many people are interested in waste management and making a living out of it, i.e. running a business, policy makers will be forced to improve policies and regulation.

To improve waste management in Arba Minch and elsewhere, the following solutions are recommended:

- **continuous awareness campaign** on waste management and adaptation of existing policies to the local context
- **declaration of rules and regulations** for solid waste disposal, monitoring the progress and taking legal actions
- **definition of business rules**, establishing quality testing facilities, and standardizations of compost as a soil input
- **promotion of public-private collaboration** to ensure that regulatory policies align with the needs of the waste sector

The processing of agricultural products has the potential to add value and contribute to employment and food security. Ethiopian government has identified the food processing industry as one of the vehicles to accelerate economic growth and create jobs.

Realising the full potential of food-processing, requires a coordinated effort from the public and private sectors, as well as from and donors, to channel investment into the establishment of competitive food processing companies.

Based on our circular experience in piloting circular economy projects, we propose the following policies to overcome the challenges and promote the growth of the food-processing sector in Ethiopia.

- **establishing dedicated regulatory authorities** at different levels of government and promote the use of technology-based solutions for the application and approval process
- **developing clear and transparent policies** for conformity assessment, product quality monitoring, and market admission.
- **designing and providing financial literacy programmes and capacity building** for entrepreneurs so that they can use resourses effectively.
- **establishing market linkage platforms** to connect food processing entrepreneurs with domestic and international buyers.
- **promoting dialogue and collaboration** between the private and public sectors, to align regulations with the needs of the food processing sector.

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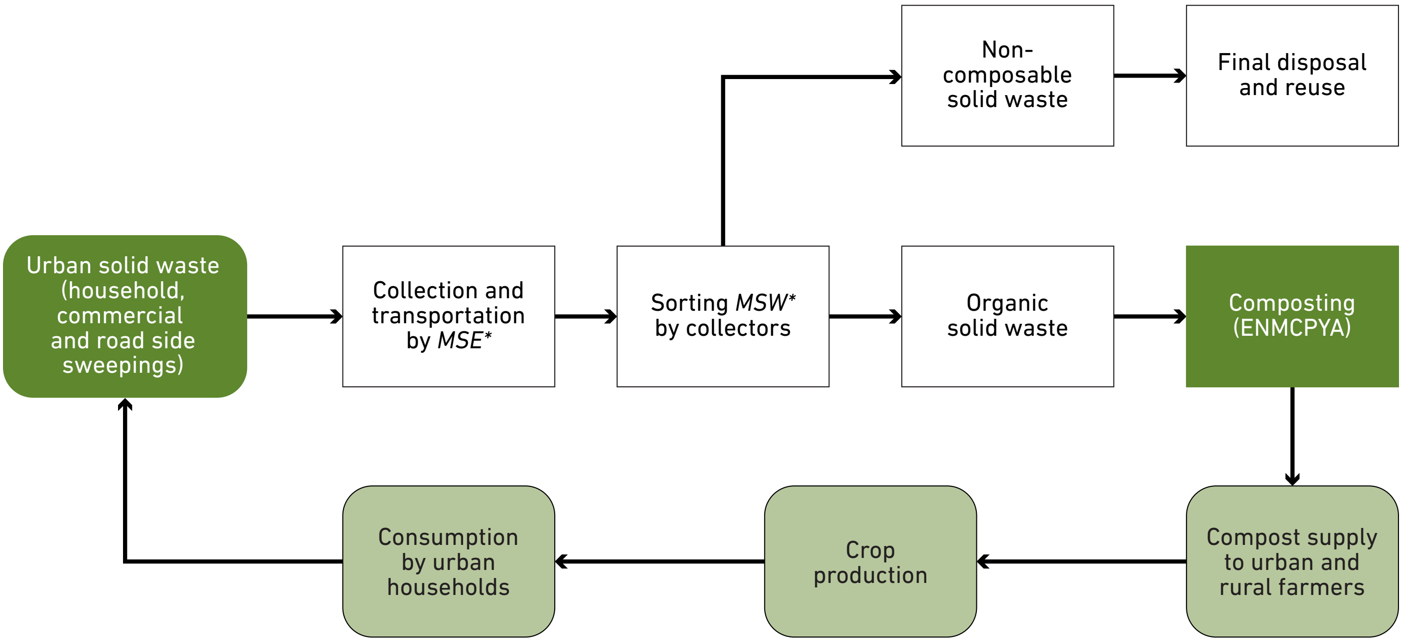
Organic waste recycling in Arba Minch – Fact Sheet

The solid waste generated in Arba Minch and other places in Ethiopia consists of 70% organic material and poses a challenge for the communities. If not properly managed, organic waste leads to greenhouse gas emissions, soil, water and air pollution, and poses health risks to the population. Composting as a waste management and recycling strategy can bring economic benefits, reduce waste volumes and contribute to agricultural production by returning compost to the soil as soil conditioner.

The Eganew Mayet Compost Association (ENMCPA), founded in 2006, produces compost from organic waste, and supplies it to local farmers. With the help of RUNRES, the association has been able to increase the amount of compost produced and improve Arba Minch's waste management and sanitation. Organic waste is composted efficiently and safely and made available as organic fertilizer.

Material flows of nutrient recycling

The solid waste is collected in Arba Minch town and transported to transfer points, where the organic portion is separated for compost production. The inorganic waste is either disposed of or reused if it is plastic or metal. The compost used by farmers serves as organic fertiliser for growing crops that are eventually consumed by residents. Food waste eventually finds its way back to close the nutrient cycle.



* MSE = Micro & small enterprise, MSW = Municipal solid waste

Partners & staff

A total of around 65 people are involved in the waste collection, sorting and composting process.

- 7 composters (6 male and 1 female)
- Permanent job opportunity for 37 waste collectors (29 female & 8 male),
- More than 20 temporary workers involved in composting

Customers / beneficiaries

The direct beneficiaries of the RUNRES project are waste collectors, composters and day laborers which are temporarily employed in composting. Micro and small enterprises (MSE) receive direct support to enhance their waste collection and composting activities. The residents of Arba Minch, the banana and other crop farmers of the Gamo zone are the beneficiaries of this innovation. The availability of high-quality compost improves soil fertility and productivity, benefitting farmers and promoting sustainable agricultural practices in the region.

Quality issues

Quality assessments of the compost have shown that it meets the standards in terms of both nutrients and safety parameter (heavy metals, pathogens). Further information can be provided on request.

Investment and cost

Waste collectors earn their income from residents who pay for the collection service. The solid waste is sorted and the organic part is delivered to composters. The composters sell the compost to farmers to earn their income.

The innovation requires investment in land, buildings, turning machine and working capital.

The investment and operating costs for the composting plant amounted to approximately 240,000 USD.

Item	Amount ($)
Total investment	240,000
CAPEX	77,000

Start-up requirements

Facilities and Infrastructure: Set up a suitable composting area. Depending on the scale of the operation, this may include an outdoor composting area. Covered facilities are required for the storage of the compost. Equipment such as compost turners, spades, sieves and thermometers are required for efficient operation and quality control of the process.

Raw Materials: Ensure a consistent supply of organic waste, including cow dung. This includes establishing partnerships with local solid waste collector associations.

Processing Equipment: Invest in compost turners to process, avoiding the need for slow manual turning.

Regulatory Compliance: The local regulations regarding the quality of compost as an agricultural fertiliser must be understood and complied with.

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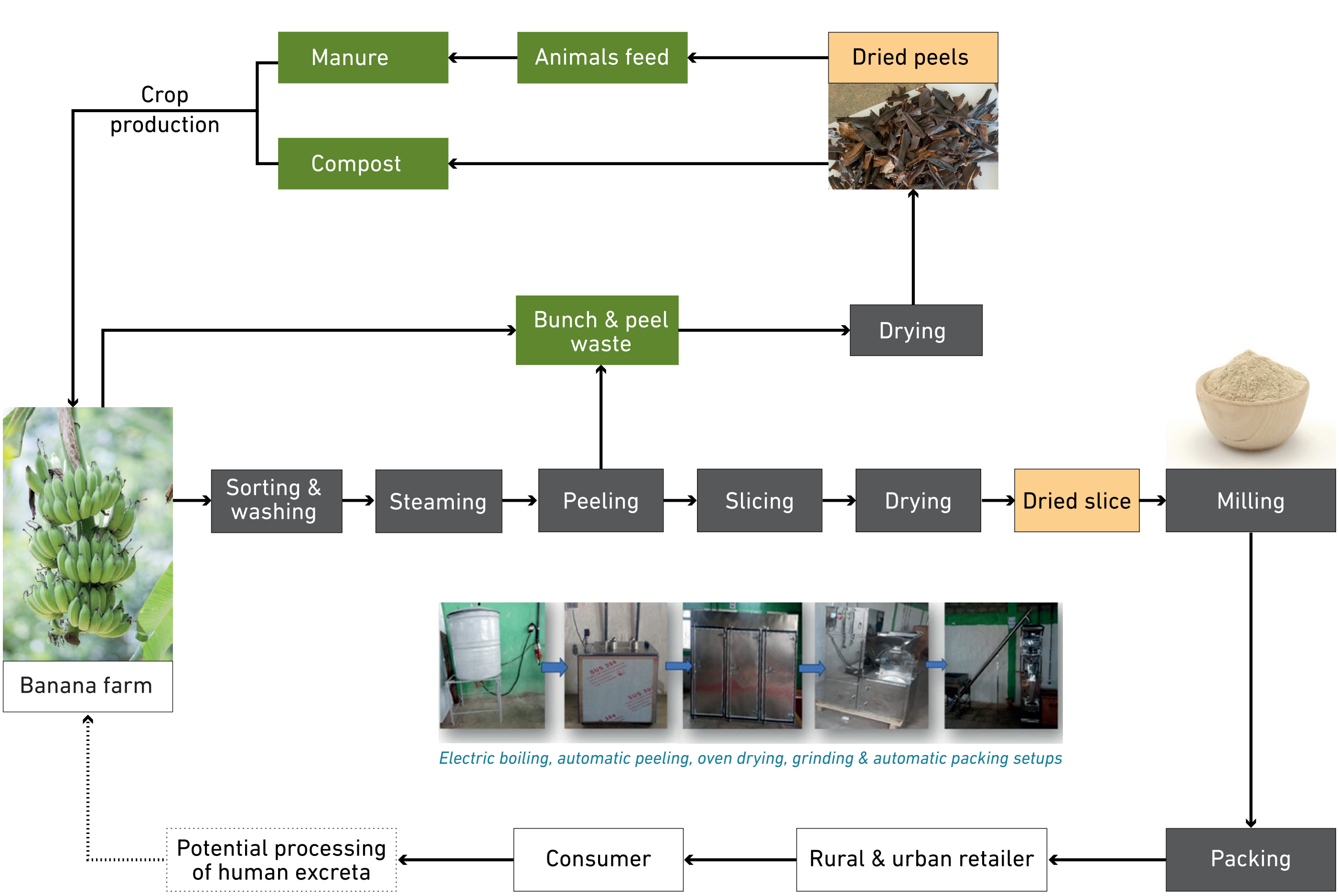
Banana processing by Anjonus, in Arba Minch – Fact Sheet

Post-harvest losses of Ethiopian bananas are estimated at around 25–30%. These losses are due to the perishable nature of bananas, long transport times in overloaded trucks and the traditional kerosene-smoked methods used to ripen them. Processing bananas into flour is a viable solution to this problem.

Anjonus, a fruit and vegetable processing company founded in 2016, has started processing raw bananas into flour in view of the existing post-harvest losses and the absence of banana processing plants in the region, as well as the nutritional advantages of banana flour.

Material flows of banana processing

Raw banana purchased from local farmers are washed, steamed, peeled, sliced and dried in oven. The dried banana milled and packed for the market. The banana peels are composted with other organic waste and reused as agricultural input.



Banana flour processing and waste recycling

Partners & staff

Arba Minch town enterprise development, Gamo zone enterprise development, Lante Tenkir farmers fruit production marketing cooperative, Genta Kanchama farmers fruit production and marketing cooperative and Shewa supermarket are working with Anjonus to deliver raw banana and sell the product, respectively. Anjonus has created casual job opportunity for 10 women in banana processing.

Customers / beneficiaries

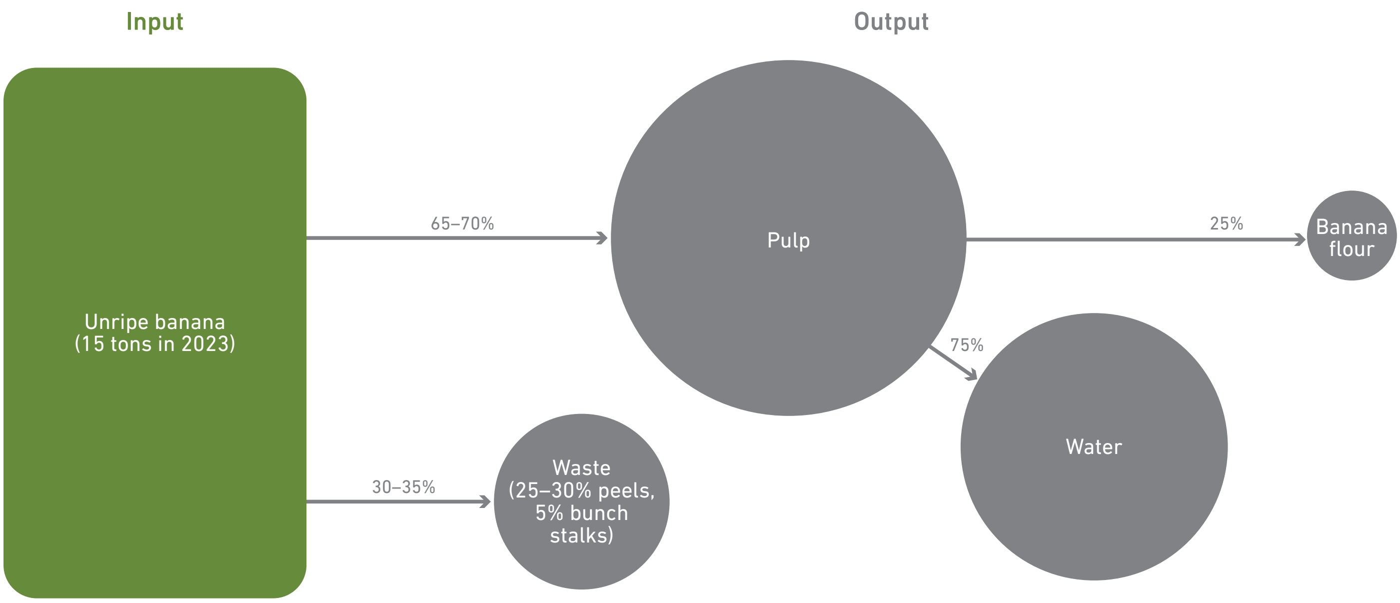
Banana flour customers include people of all ages. It can be feed to kids..

When fortified with additional nutrients, banana flour can help address the problem of malnutrition in refugee camps and nutrition centers in the region.

Quality issues

Anjonus uses unripe banana purchased from local smallholder farmers. The banana flour produced by Anjonus meets the Ethiopian conformity assessment criteria and has been granted a market authorization by the Ethiopian Food, Medicine and Health Care Control Authority. As a result, the product is sold in Arba Minch and Addis Ababa.

Input and output



Contents of unripe banana

Investment and cost

The total investment for this innovation (facility, machinery, equipment and operating costs) amounted to USD 90,000 in the pilot phase. The SDC's contribution enabled Anjonus to switch from manual to mechanical processing of raw bananas into banana flour, which significantly increased production.

Item	Amount ($)
Total investment	95,000
CAPEX	51,000
OPEX	44,000

Start-up requirements

Facilities and Infrastructure: Set up a suitable indoor facility to produce banana flour. Depending on the scale of the operation, this may include a ventilated hall with electricity and water supply.

Raw materials: Ensure a constant supply of raw bananas. This includes building partnerships with local banana farmers.

Processing equipment: Invest in equipment for slicing, drying, oven-drying and pulverising bananas, as well as packaging equipment.

Regulatory compliance: Understand and comply with national regulations concerning quality of banana flour.

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Turning organic waste into animal feed and compost – Policy Brief

Summary

Generally speaking, food is produced in rural areas and consumed in urban areas, resulting in a constant nutrient flow from rural to urban areas. The high demand for and consumption of food in cities leads to the accumulation of organic waste, which causes health risks and environmental impacts. Farmers are confronted with high feed prices and insufficient compost.

RUNRES promotes the recycling of organic waste (e.g. food waste) by converting it into animal feed and compost. This helps to reduce the nutrient mining on agricultural land and health and environmental risk in urban areas.

The innovations High-Quality Cassava Peel (HQCP) and Black Soldier Fly Larvae (BSFL) have been proven to be technically feasible and financially viable – and can now potentially be implemented throughout Rwanda. The HQCP innovation converts cassava peels into animal feed which is used to feed pigs and cattle. The BSFL innovation uses food waste to breed BSFL larvae, which are fed to chickens and other livestock. In addition, the BSFL innovation produces compost that is used by farmers in crop production.

The government and development partners can help to scale up these innovations by developing and implementing policies for the design of effective composting and animal feeding from organic waste. This will promote sustainable agricultural and feedstock production, thus contribute to improved food security, human and environmental health – and fewer feed imports.

Recommendations

- **Development of effective policies:** The government should develop and implement policies that sets a regulatory framework and standards that must include waste separation for integrated organic waste recycling into agricultural inputs.
- **Facilitate the access to finance:** It is proposed that the government develops and implements guidelines that provide access to affordable financial products with a focus on young people and women working in the biowaste recycling sector.
- **Strengthen institutions and focus on political commitment:** Functions for solid waste disposal and recycling should be combined within municipal organizations so that there is a clear sense of accountability.
- **Develop and implement better financial mechanism:** We propose that (a) the government set affordable household fees for the collection of organic waste, and (b) pay for the safe disposal of the organic waste.
- **Education and communication:** Awareness and education campaigns should be implemented to promote the benefits of circular bioeconomy practices and support community participation.

Introduction

This policy brief is based on the results of the RUNRES pilot phase implemented from 2019 to 2023 in Kamonyi District, Rwanda. The RUNRES project aims to set a key step in the conversion towards a nutrient cycle. RUNRES promotes organic waste recycling by implementing and scaling viable and acceptable innovations to convert organic waste into compost and animal feed. This input for agricultural and animal production will benefit smallholders, thereby contributing to food security, and human and environmental health in city region food systems.

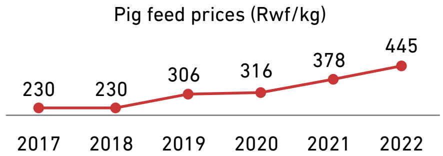
The RUNRES project is scaling up organic recycling innovations such the High-Quality Cassava Peel (HQCP) and Black Soldier Fly Larvae (BSFL), both of which have proven to be economically viable. HQCP innovation converts cassava peels into animal feed that is used to feed pigs and cattle. BSFL innovation uses the food waste to feed BSFL into maggots that are fed to chickens and other livestock. BSFL innovation produces a compost that is used by farmers in the crop production.

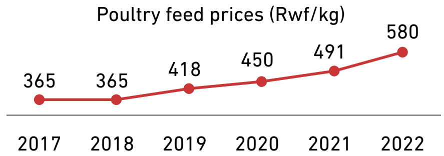
The problem

Like many countries in sub-Saharan Africa, Rwanda has seen a significant population increase of around 30% in the last decade. This growth is associated with a high consumption of natural resources and results in large quantities of organic waste (e.g. food waste) being disposed of in cities. At the same time, Rwanda is facing increased demand for agricultural inputs (e.g. compost) in rural areas and affordable animal feed to support the development of the livestock sub-sector driven by rapid urbanization. Maize and soybean are food sources for humans and animals. However, their production is insufficient to meet the demand for food and feed, which has led to fierce competition between the food and feed industries. This situation has been exacerbated by Rwandan policy, which is pushing for a complete ban on grazing. Pasture land for cattle has shrunk due to changing agriculture and other human activities.

In addition, animal feed prices have increased significantly in recent years. For example, the price of pig feed has doubled in five years, from 230 Rwf/kg in 2017 to 455 Rwf/kg in 2022.

Domestic animals' growth	2012	2022
Cows	349,205	1,424,180
Pigs	42,627	786,191
Chicken	239,368	2,583,333





Data source: National Institute of Statistics of Rwanda (NISR, 2021)

The accumulation of organic waste in urban areas and soil depletion in rural areas have far-reaching environmental, economic, and societal impacts. It results in:

- **agricultural input losses** → The amount of organic waste that is not recycled contributes to the loss of raw materials (nutrients). These are needed to produce agricultural inputs to increase the productivity crops and livestock.
- **environmental degradation and human health risks** → The accumulation of untreated organic waste in urban areas leads to air and water pollution, soil contamination, and greenhouse gas emissions.
- **economic losses** → The improper disposal of organic waste in urban areas results in economic burdens for municipalities, including increased waste management costs and productivity losses in agriculture due to soil / water contamination.

Furthermore, inadequate waste management infrastructure, limited financial resources and limited public knowledge of waste management (i.e. the principles of waste generation, separation, collection, treatment, disposal and recycling) hinder effective waste management in urban areas.

Solution and policy implication

This situation can be improved requiring a comprehensive approach that includes:

- **large-scale implementation of proven innovations for organic waste recycling such as High-Quality Cassava Peel (HQCP) and Black Soldier Fly Larvae (BSFL);**
- **adequate technologies and well-informed waste management strategies;**
- **policy interventions and community education and engagement.**

RUNRES contributes to these solutions by recycling food waste (and other organic waste) and producing affordable animal feed and compost, thus contributing to food security. However, this is not enough. Coordinated policies are needed to help HQCP and BSFL, as well as further innovations in the field of nutrient cycles to achieve a national breakthrough.

Policies play a key role in shaping the framework within which an integrated waste management system operates:

- Regulatory framework: Based on existing policies in agriculture, environment, waste management and human health, an integrated policy sets out the regulatory framework and standards that apply to integrated waste management practices. Policies set the minimum standards for good waste management practices, which must include the separation of organic and inorganic waste, the recycling of organic waste into agricultural inputs, and the safe disposal of inorganic waste in a manner that protects public health and the environment.
- Extended Producer Responsibility (EPR) scheme: The EPR scheme is a policy mechanism that incentivizes producers and manufacturers to design products that are easily recyclable and less harmful to the environment and shifts financial burden to waste producers.
- Economic instruments: The government uses economic instruments such as landfill taxes and pay-as-you-throw (PAYT) waste fees to create incentives for waste reduction and recycling.

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High Quality Cassava Peels (HQCP) as Animal Feed – Fact Sheet

In Rwanda, cassava peels are usually thrown away, which contributes to the accumulation of waste and leads to health and environmental problems. At the same time, the country faces an increased demand for affordable animal feed to support the growth in livestock sub-sector driven by rapid urbanization. RUNRES supported AKANOZE Nyamiyaga, to pilot an innovation that valorizes the cassava peels into carbohydrates-based ingredient (High-Quality Cassava peel – HQCP) for animal feed formulation. The usual major carbohydrates source in the animal feed formulation is maize which makes up around 60% of the feed. However, the local maize supply is not even sufficient for human consumption, which is why feed manufacturers are forced to import maize for feed production, making the feed more expensive. The HQCP innovation provides a good alternative source of carbohydrates ingredient in the formulation of animal feed while helping to reduce environmental pollution.

Innovation technical description

The production of the HQCP is a low-tech innovation with a simple grater or hammer mill, press, and dryer that can be found locally. The whole setup can be installed in a small shelter with a ground outside that serves to dry the cassava mash, off-loading the raw materials and loading the final product. Based on the installed processing capacity, the innovation requires a few permanent employees and casual laborers. The cost-effective innovation process helps remove water and hydrogen cyanide (HCN) that is toxic and can cause health problems even death to human and animals. The HCN in AKANOZE's HQCP is 3.6 mg/kg which is sgnificantly below the HCN in HQCP reference value of 5.4 ± 2.7 mg/kg.

HQCP flour processing flow

AKANOZE collects cassava peels from its cassava roots processing unit and from cassava farmers. The peels are transported to the processing site, where the remnants of soil get removed. The cassava peels are then conveyed into the gread-er to be turned into a coarse mash. Then the mash is fed into the press to remove water and cyanides. After the press, the wet mash (30–40% of initial weight of peels) can be fed to animals or dried in the sun. The dried mash is passed through a milling machine to be ground into a fine flour that can be mixed with other ingredients to produce animal feed.

Partners & staff

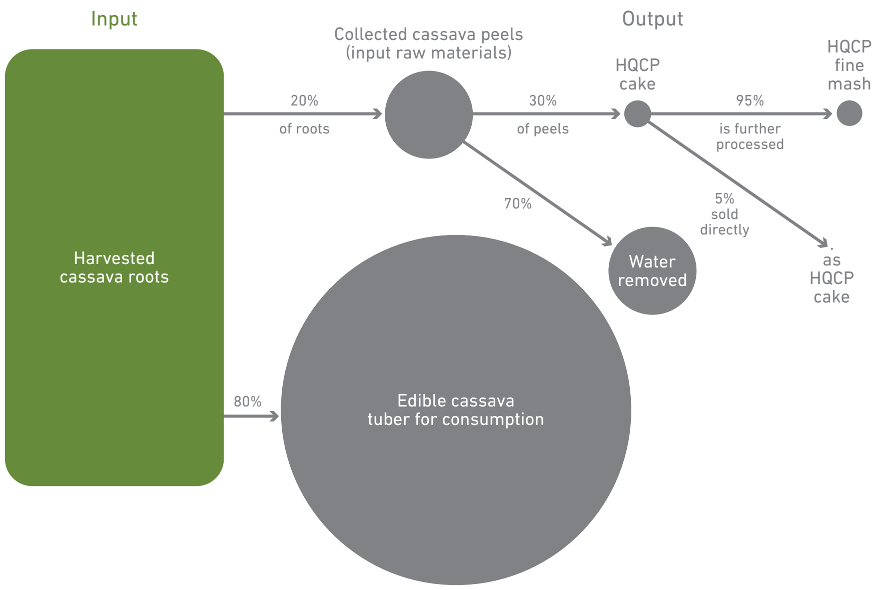
Partners: Akanoze worked with the suppliers of the raw materials (cassava peels) and buyers of final products, i.e. livestock farmers. The business benefited from the technical support from IITA, ETH, Rwanda Standard Board (RSB) and Rwanda Agriculture, and Animal Resources Board (RAB).

Staff: The processing unit is operated by 5 permanent staff (3 men and 2 women) among which 4 are youth and the innovation uses an average of 12 casual laborers monthly, mostly female.

Products and key nutrients

Cassava peels are processed into a wet coarse mash with a low content of cyanides and water. The cassava mash can be ground and dried to produce HQCP flour.

- Coarse mash has a lower energy content and higher fiber content.
- Dry HQCP flour is higher in energy content and lower in fiber content.
- Cyanides (HCN) must be below 10 ppm (parts per million).
- Aflatoxins must be below 20ppb (parts per billion).
- Protein content is below 5%.
- Water content must be below 42% for wet cake and 12% for HQCP flour to be packaged.



Material flow diagram of HQCP production

Ingredients of HQCP

Most of the ingredients in Akanoze HQCP flour are within the reference values, but some are slightly outside the reference range.

Quality Parameter	HQCPF	Reference value*
Dry Matter (%)	89.4	87.5 ± 11.6
Ash (%)	5.75	5.5 ± 4.3
Ether Extract (%)	0	1.8 ± 3.3
Crude Protein (%)	5.42	5.3 ± 2.5
Fat (%)	0.5	1.2 ± 0.5
Fiber (%)	6.97	14.3 ± 9.9
HCN (mg/kg)	3.6	5.4 ± 2.7
Aflatoxin HQCP (ppb)	2.4 ± 0.72	21.0 ± 1.7

** Reference values taken from Amole, Anandan & Okike (2019)*

Customers (farmers)

Animal feed ingredients from cassava peels can replace maize that is more expensive. Cassava peels are more suitable in Rwanda and other places in Africa that suffer from shortage of affordable high-quality animal feed.

HQCP flour is fed to all types of livestock (pigs, cattle, poultry, fish, etc.). An alternative to flour is wet cake of cassava peels which is fed to pigs and cattle. Sheep and goat farmers can also use the wet cake to feed their animals.

481 farmers close to the processing unit supplied the cassava peels.

126 farmers bought cassava mash.

43 farmers bought HQCP flour.

Start-up requirements

- Identify reliable sources of cassava peels at local and district level to avoid high transport costs.
- Identify livestock farmers and raise awareness about the advantage of animal feed production from cassava peelings.
- Proceed to determine the processing capacity and identify the equipment setups.
- Develop and strengthen relationships with sources of cassava peels (cassava farmer organizations and individual farmers) and livestock farmers.
- Owning a cassava root processing unit that can supply 30% of the volume of cassava peels required would be an advantage.

Investment cost and profitability

The HQCP business unit produces and sells the wet cake to pig and cattle farmers and the fine flour to a larger group of livestock farmers (pigs, cattle, poultry, fish, etc.). The unit generates more than 90% of the revenue from the sale of the HQCP flour. It needs to produce and sell at least 50 tonnes per year to be profitable.

This innovation is most suitable for existing cassava processors located in high-production areas so they can secure the raw material. It requires investment in land, buildings, machinery, and working capital. The table provides a summary of the minimum investment required and its profitability.

Item	Amount ($)*
Total investment	101,000
CAPEX	48,710
Working Capital	1,234
NPV (5 years)**	41,459
IRR**	49.4%

** The numbers are based on business data from the pilot phase.*
*** NPV: Net Present Value; IRR: Internal Rate of Return*

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Black Soldier Fly Larvae (BSFL) – Fact Sheet

The Rwandan livestock sector is growing steadily, driven by urbanization and the demand for animal protein. At the same time, the cost of animal feed, already high, continues to increase due to the spike in transportation costs recorded in recent years, as the country relies heavily on imports for raw materials. The RUNRES Project supported Maggot Farm Ltd (MF) to pilot an innovation that valorizes organic waste into Black Soldier Fly Larvae (BSFL) and frass. The BSFL constitute a good alternative source of protein for the production of animal feed, while the frass is an organic fertilizer for soil amendment.

Technical description of innovation

The technical process of utilizing black soldier flies involves introducing their larvae onto organic waste, such as food residues. The larvae consume the waste material, breaking it down. As they feed, they rapidly grow and accumulate nutrients from the waste. Once fully grown, the larvae are harvested and can be used as animal feed, and the frass generated by the larvae serves as organic fertilizer.

BSFL production cycle

The black soldier fly (Hermetia illucens) follows a rapid production cycle, beginning with the laying of eggs in decaying organic matter. Upon hatching, the larvae consume the waste material. As they mature, the larvae enter the prepupal stage, seeking a dry and sheltered area for pupation. Inside their pupal casing, metamorphosis occurs, culminating in the emergence of adult flies. These adults then mate and repeat the cycle, with the entire process typically taking around 14 days to complete under ideal conditions.

Partners & staff

Partners: Maggot Farm Ltd worked with suppliers of food waste (food processors, hotels) and livestock farmers as clients. The business benefited from the technical support from IITA, ETH, and Rwanda Agriculture Board (RAB).

Staff: The company employs 12 individuals including 4 men and 8 women, and 8 youth, a promising trend of youth engagement and inclusion.

Products and key nutrients

The BSFL and organic fertilizer produced by Maggot Farm are subject to quality control. The BSFL provides an affordable and rich animal feed that can be estimated to be 60% protein-rich compared to fish meal containing 48% in terms of protein content.

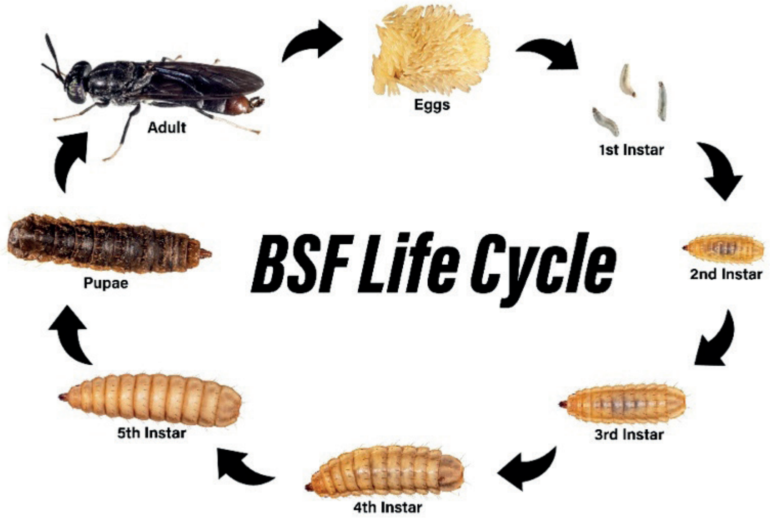
Both the larve and the frass (compost) fulfil the safety and quality standards.

Nutrients' values of BSFL

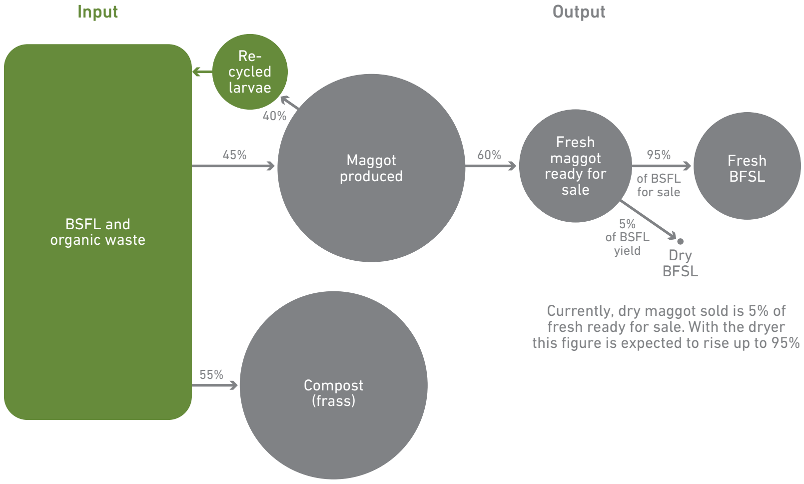
The main nutrient values of Maggot are well above the reference values.

Quality Parameter	MF BSFL by Maggot	BSFL Reference Values*
Crude Protein (%)	50.0	33–41
Fat (%)	22.9	1.2 (0.5)
Ca (%)	4.2	0.2–0.4
Mg (%)	1.5	0.1–0.2
P (%)	0.8	0.1–0.5
K (%)	1.1	0.2–0.4
Na (%)	0.1	0.08–0.3

** BSFL reference values taken from Shumo, et al., 2019*



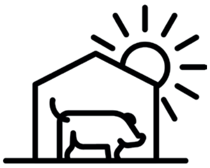
The complete life cycle of a black soldier fly (Terrell, C. and Ingwell, L., 2022)



Material flow diagram of organic waste input and product output of BSFL and frass

Customers

Livestock farmers



Animal feed ingredients from BSFL can replace soybean that is more expensive. BSFL is processed into protein-rich animal feed suitable for poultry, pigs, and other livestock. Livestock farmers seeking sustainable and cost-effective feed alternatives could be primary customers.

Crop farmers

The waste products generated from BSFL rearing, such as frass can be utilized as organic fertilizer. Local farmers are potential customers for these byproducts.

Suppliers of raw material

Food processors and hotels are key suppliers of raw materials. Companies focused on waste management and recycling may see value in partnering with BSFL innovators to divert organic waste streams away from landfills and toward insect-based conversion processes.

Start-up requirements

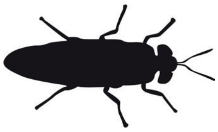
Facilities and Infrastructure

Establish a suitable facility for rearing the larvae. This may include indoor or outdoor space, depending on the scale of the operation. Adequate ventilation, temperature control, and waste management systems are essential.

Raw Materials

Secure a consistent supply of organic waste materials, such as food residues and brewery waste to feed the larvae. This involves establishing partnerships with local businesses or waste management facilities.

Black Soldier Fly Colonies



Acquire black soldier fly eggs to start your colony.

Processing Equipment

Invest in equipment for processing the larvae into animal feed, such as drying facilities, grinding machines, and packaging materials.

Regulatory Compliance

Understand and comply with local regulations concerning animal feed production, and food safety standards.

Investment cost and profitability

On average, a typical business of this size generates 80% and 20% of its revenue from the sale of BSFL and compost, respectively. BFSL is sold mainly through business-to-business arrangements, while the compost is sold to individual farmers. Further processing of the BSFL into powder will increase its usage by animal feed manufacturers. The unit needs to produce and sell at least 50 tonnes per year to be profitable. The innovation requires investment in land, buildings or sheds and working capital. If the funds are available, investment in drying and grinding machinery can be made to produce flour that can be mixed with other ingredients.

Item	Amount ($)*
Total investment	107,000
CAPEX	72,000
Working Capital	7,087
NPV (5 years)**	16,428
IRR**	28.9%

** The numbers are based on business data from the pilot phase.*
*** NPV: Net Present Value; IRR: Internal Rate of Return*

References and further information

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Nutrient recovery from sewage sludge and municipal green waste – Policy Brief

Summary

This project was established in response to challenges of nutrient mining, waste accumulation in landfills, and stockpiling in wastewater treatment plants with implications for socio-economic wellbeing, environmental health and food and nutrition security. The main objective of the RUNRES project is to close the nutrient cycle by channelling organic waste from places where it accumulates, such as urban dumps, back to the places of their origin, i.e. agricultural land and rural areas. The first phase of the RUNRES project in South Africa focused on testing various circular bioeconomy innovations, including the co-composting of organic waste diverted from the municipal landfill and sewage sludge from a municipal wastewater treatment plant. The compost produced is currently sold to commercial farmers, gardeners, landscapers, and homeowners. Lessons from the first phase indicate that decision-makers should promote waste segregation, cross-sectoral thinking, innovative incentive mechanisms, business development services, technical support, and financial intermediation to encourage inclusivity. The second phase of the project will focus on expanding the co-composting innovations in other municipalities.

Recommendations

- **Waste separation:** supporting innovative waste separation efforts through integrated waste management plans to ensure that uncontaminated organic waste increases the resilience of composting innovations.
- **Resource mobilization:** increasing public sector support for co-composting businesses by promoting incentives for infrastructure investment such as weighbridges, long-term leases, and shared municipal facilities to attract private sector finance.
- **Business development services:** promoting the inclusive participation of small businesses such as community-based organizations and start-ups from historically disadvantaged groups by helping them to develop bankable business plans and providing marketing support.
- **Financial intermediation:** leveraging existing policies such Broad Based Black Economic Empowerment (BBBEE) through innovative and targeted concession credit facilities and revolving funds to promote co-financing and inclusive participation of community-based organisations and disadvantaged persons in circular economy.
- **Incentive mechanisms:** promoting circular economy business models by supporting opportunities for trading in carbon credits, clean development mechanisms, biodiversity footprints, corporate social investment etc..
- **Cross-sector collaboration:** improving collaboration between the departments such Water and Sanitation (DWS), Forestry Fisheries and Environment (DFFE), and Agriculture Land Reform and Rural development (DALRRD) at the national and municipal levels to develop a financing structure that is critical for blending..

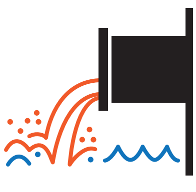
Introduction

The constitution and legislation of South Africa stipulate that provision of sanitation and waste management services fall within the scope of the public sector and are implemented by the local municipalities. However, current economic approaches follow a linear model from the production and consumption of goods to the disposal of leftovers, which leads to resource depletion, environmental impacts and health risks. RUNRES pursues a circular economy approach that aims to close the nutrient cycle by returning nutrients from places of accumulation (cities) to places of mining (agricultural land). In the first phase, RUNRES implemented a co-composting (organic waste diverted from municipal landfills and sewage sludge) pilot project in the Msunduzi municipality. The co-composting project was implemented in collaboration with a private company, a public utility that operates a wastewater treatment plant, and a municipal waste management unit with financial and technical support of RUNRES. It was shown that such an approach is successful and can be applied elsewhere. Consequently, the focus in the second phase is on expanding this waste management and composting innovation to other communities.

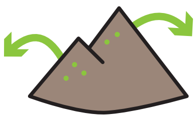
The problem

Urbanization is responsible for 75% of global resource consumption and over 50% of waste generation, but it also contributes to the exploitation of nutrients and organic matter from agricultural land, which has a negative effect on food production. Urbanization is also responsible for the extraction of freshwater from the surrounding area, while wastewater is discharged into the environment. Urban metabolism thus further contributes to environmental pollution, reduced public health, and food insecurity.

- **Many wastewater treatment facilities are not operating efficiently** because the infrastructure is outdated or more wastewater is being produced than the plants can handle



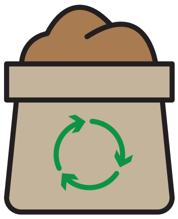
- **In the surrounding crop land, the loss and exploitation of nutrients occurs** when food is produced and exported to urban areas where the food is consumed.



All of this is leading to a decline in food productivity, a loss of biodiversity and a dwindling interest in agriculture among young farmers, which in turn affects food security.

- Commercial farmers who can afford to use mineral fertilizers often see a **loss of agronomic efficiency and have to apply more and more** to meet the needs of the crops, driving food prices up to levels unaffordable to many.

Even in cases where farmers can afford chemical fertilizers, such external inputs provide macronutrients that are important for improving crop yields. However, the essential micronutrients are often not returned to the soil, leading to the production and consumption of nutrition-poor crops, a phenomenon known to as hidden hunger.



- Due to the recent global shock in international trade, caused by SARS-CoV-2, **prices of chemical fertilizers have risen** and many farmers in South Africa have resorted to locally available inputs such as compost.

Solution and policy implication

Although rural areas have traditionally practiced closed-loop systems, economic opportunities have shifted to cities due to population growth and urbanisation, promoting the decoupling of agricultural production and food consumption. In this context, implementing a circular economy offers economic opportunities but is not without challenges. Tackling these challenges is crucial to ensure social benefits such as public health, as well as economic, and environmental sustainability. To address some of these challenges, the RUNRES project piloted the innovation of windrow co-composting, which diverts organic waste from the landfill and mixes it with sewage sludge from the wastewater treatment facility. Windrow composting helps to convert waste into an agricultural input that meets regulatory requirements for sale to farmers. The project works closely with stakeholders from the waste management, water and sanitation, and agriculture sector, including the private sector, to promote synergies and partnerships in the search for solutions. Lessons learned in implementing innovations show that critical investments in inclusive, bankable and sustainable business models and innovative partnership processes in the various sectors are needed. Better waste management through source separation of organic waste, as well as for biosolids from the wastewater treatment plant, could increase the resilience of the co-composting innovation.

Although there are policies such as the Fertilizers, Farm Feeds, Seed and Remedies Act 36 and the National Faecal Sludge Management Strategy, their alignment and coordination with each other is difficult because they are sometimes contradictory. We therefore propose the following:

- **Enhancing collaboration between multiple public sectors** such as DFFE, DWS, and DALRRD: to create synergies to leverage blended finance for improved service delivery, policy alignment, and access of compost to vulnerable groups.
- **Maintain an inclusive circular economy transition:** by promoting innovative inclusive policies such as revolving funds and concessionary credit schemes for historically disadvantaged entrepreneurs.
- **Enforce cost recovery objectives:** to allow waste managers to benefit from landfill space savings and reduced transportation costs by diverting waste into various value offerings such as composting.
- **Promoting full-cost accounting in the public sector:** through innovative mechanisms for internalizing externalities such as health care and clean-ups in the evaluation of business models.
- **Promoting community involvement and awareness:** through education programs that emphasize the importance of e.g. resource recovery and reuse.

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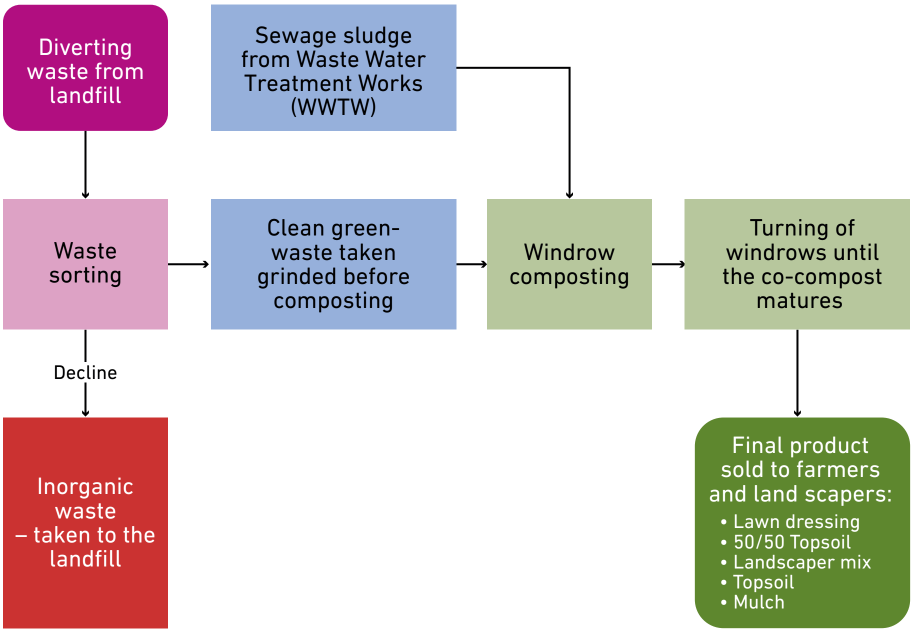
Reframing human excreta management for nutrient recycling – Fact Sheet

South African municipalities face several cross-sectoral challenges in the areas of waste management, sanitation and agriculture. Continued nutrient mining from growing food that is consumed elsewhere and in ever-greater quantities is depleting the fertility of agricultural land. At the same time, municipalities are struggling to dispose of sewage sludge from wastewater treatment plants. Rapid urbanization and changes in diet are leading to the generation of large quantities of food waste and organic waste (including in sewage sludge), which shortens the lifespan of landfills and causes high carbon emissions. To address these challenges, RUNRES carried out a pilot project to co-compost organic green waste and wastewater residues. This contributes to waste management, wastewater disposal and agriculture by making compost available again as a soil improver for agricultural land.

Technical description of innovation

The co-composting innovation, located in Msunduzi Municipality of KwaZulu Natal Province in South Africa, was operated by the private company Duzi Turf. Co-composting is the controlled aerobic degradation of organics, using more than one feedstock which supply a predetermined mix of carbon and nitrogen required for microbial activity. The innovation uses sewage sludge from the Darvil Wastewater Treatment Plant owned by a public utility. The organic waste is received from private landscaping companies that were previously dumping at a nearby landfill operated by Msunduzi Municipality Waste Management Unit. The innovation uses the windrow composting method where the organic waste is piled into windrows and sewage sludge is added to inoculate microorganisms and to regulate moisture for aerobic degradation. The windrows are turned using a mechanized compost turner based on temperature readings to provide oxygen and ensure that all parts of the pile are subjected to the same heat treatment. The process takes approximately 3–6 months depending on the turning frequency in the production process. The result at the end is a certified co-compost product with the following benefits:

- It improves the soil condition by adding organic matter which restores the soil's mineral elements (Iron, Manganese, Zinc, etc.) depleted over the years.
- It provides the necessary nutrients to the plants (Nitrogen, Phosphorus, Potassium, etc.) over a longer period of time than chemical fertilizers.
- It improves the soil health by improving the soil physical, biological and chemical properties.



Material flow at the co-composting facility

Compost production

Partners & staff

The innovation has four innovation partners:

- Duzi Turf (Private sector)
- Umngeni-uThukela Water (Public sector)
- Sobantu Community Cooperatives
- University of KwaZulu Natal/RUNRES South Africa.

The project managed to create 12 employment opportunities (7 seasonal and 5 permanent) for local community members.

The work on site which is physical and manual only attracted male applicants and therefore 100% of the staff is male.

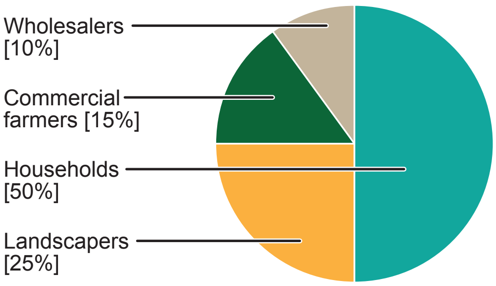
Sources of feed stock

100% of the green waste is supplied by private landscaping companies. These companies collect green waste from providing a service of maintaining gardens, parks, golf course, estates, etc. The municipality at the initial stages attempted to supply green waste but it had too many contaminants (plastics, bottles, concrete, etc.).

100% of the sewage sludge is supplied by uMngeni Uthukela Water which is the main water board in the province of KwaZulu Natal.

Customers

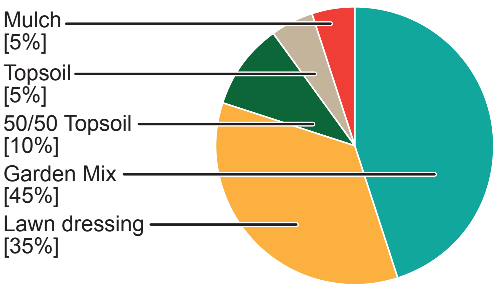
The products are sold to various clients depending on their needs. Clients are wholesalers, commercial farmers, households and landscapers.



- Estimate of green waste delivered to by private landscaping companies per year to Duzi Turf: 25,000 tonnes.
- Estimate of sewage sludge used per year: 2.5 million liters (~2,500 tonnes)
- Co-compost produced per year: 10,000 tonnes

Sales

The co-composting innovation is producing five products and manages to sell about 6,719 tonnes of the combined product per year.



Composting operation: labor cost

The overall labor cost for composting operations is currently at 6.3 USD per tonnene from receiving feedstock all the way to bagging a final product which is ready for market.

Quality results

The co-composting product was tested for agronomic parameters, potential toxic elements and pathogens.

The co-compost is registered with the Department of Agriculture as category B fertilizer. The Lab results show that the product complies with the South African regulatory requirement and is safe to use as an agricultural input.

Start-up requirements

Land requirement: The co-composting process requires a large piece of land, with the current facility occupying about 5 ha of land for storage of raw materials, equipment and finished compost. Additional land may be required for a suitable complementary mix of businesses such as for the on-site production of turf grass and flowers. The site should ideally be located near a landfill and a sewerage plant to keep transport costs low.

Site establishment: Depending on the licence requirements, the site must have a paved surface and a .and a system for management of rainwater and leachate. The planning of the facility may require professional architectural and engineering services. If established at an existing wastewater treatment facility, existing infrastructure and licensing will determine the site establishment costs.

Raw materials: A constant supply of clean organic waste material is required, such as garden and food waste as well as sewage sludge, which is not contaminated with inorganic components.

Equipment: Investment in specialized equipment such as grinder/thrasher/chipper, mixer, payloader, tractor, turner, trommel/sieve, bagger and other equipment is required.

Regulatory compliance: It is important to scope and understand the local regulations concerning the use of human excreta in compost. In South Africa, all organic material is allowed for composting as long as the end product meets the requirements of the Farm Feeds and Fertilizers Act 36 of 1947 for compost registration.

Investments

The innovation requires investment in land, construction of the facility including a shed, offices, and equipment, and working capital for operating the business. Future investment in a weighbridge and pelleting equipment may improve the business performance. It is estimated that if the business sells all the compost it can produce, the internal rate of return (IRR) over five years will be 105%.

Item	Amount ($)*
CAPEX	317,338
OPEX	869,252
NPV (5 years)**	606,034
IRR**	110%

** The numbers are based on business data from the pilot phase.*
*** NPV: Net Present Value; IRR: Internal Rate of Return*

References and further information

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DEWATS: Effluent and urine the liquid gold of agriculture – Fact Sheet

Of the 16.7 million households in South Africa, 61% use toilets that are connected to a sewer system. All other households use various forms of on-site sanitation such as septic tanks, pit latrines, ecological sanitation systems, and a small part of the population (1.5%) still defecate in the open. This poses risks to the environment and human health. In addition, there is the challenge of nutrient mining: nutrients absorbed by crops remain where food is consumed and are thus lost to the agricultural land, as both food waste and human excreta ultimately end up in landfill.

The decentralized wastewater treatment system (DEWATS) that is being built by RUNRES in South Africa, aims to address sanitation challenges in currently underserved communities while promoting efficient resource recovery for reuse in the agricultural sector. The beneficiaries of the project are 900 primary school pupils at Julukandoda Primary School, who before the RUNRES intervention only had dilapidated, ventilated pit latrines.

Technical description of innovation

DEWATS is a technical approach to decentralized wastewater treatment in developing communities. The passive design uses physical and biological mechanisms such as sedimentation, floatation, aerobic and anaerobic conditions to treat various types of wastewater.

The gravitational flow in the DEWATS allows for operation without pump stations, making it more cost-effective. After the primary (settler) and secondary treatment (anaerobic baffled reactor and anaerobic filter), the nutrient-rich effluent can be used to grow plants such as ornamentals and trees. The heavy fecal sludge settles at the bottom of the chambers during the process of gravitational flow. The chambers can be desludged every two years.

The high concentrations of pathogens in the effluent restricts agricultural use in accordance with the safety guidelines of the World Health Organization, unless the wastewater is treated to reduce E. coli to <1000 MPN (most probable number)/100ml.

The toilet pedestals that are installed at the school are urine diversion toilets (UDTs). The pedestals allow for urine to be channeled to the storage tank while fecal sludge is channeled to the DEWATS system. The urine is supposed to be stored in the storage tank until it is safe to use in agriculture as per the WHO guidelines.

The construction works for this innovation is complete and it is waiting for the engineer's certification before the learners can use the toilets. The contractor will conduct a six-month monitoring phase to correct any defects that could arise from using the system.

Input / output

The expected annual amount of treated wastewater is about 250,000 litres, while the amount of collected urine is about 21,000 litres per year. During the process of gravitational flow fecal sludge settles at the bottom of the chambers and can be removed every two years.

Partners & staff

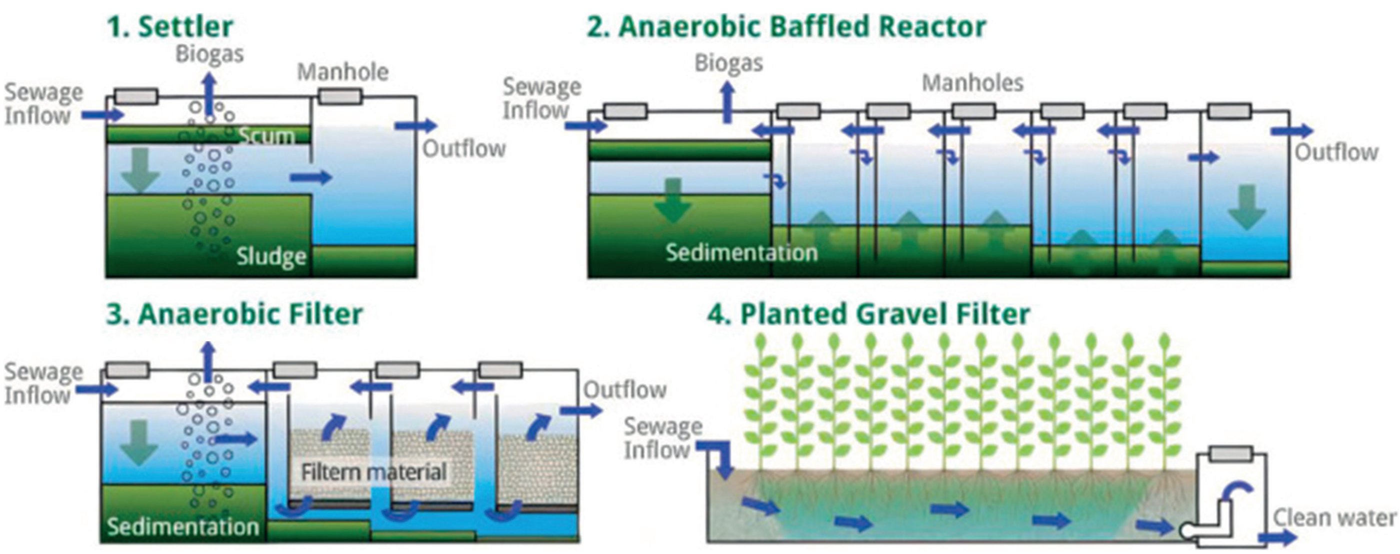
The innovation has four innovation partners: Umngeni-uThukela Water, Department of Education, Dulela Community Cooperatives and University of KwaZulu Natal/ RUNRES South Africa. The project will create 13 job opportunities (10 in agriculture and 2 in cleaning and 1 in operation maintenance), most of them for women and of age over 24 years.

Sources of feed stock

The learners are the source of feedstock as the production of effluent and urine is dependent on the learners' toilet usage. The effluent will be produced from the flushed human waste that will undergo treatment in the DEWATS. The urine will be separated by UDTs and stored in storage tanks. The effluent and the stored urine will be used for agricultural purposes.

Potential turnover for nursery plants

In order to generate income for the operation and maintenance, as well as for the local cooperative that will be involved in the agriculture in the school, the project will grow tree seedlings in a nursery and cut flowers for sale. These



are grown with the wastewater from the DEWATS and the urine from the urine separation tanks. The following table shows the expected annual sales of tree seedlings and flowers from the nursery.

Nursery plants	Quantity produced per year	Annual Revenue
Rose geranium seedlings	640	USD 7,623
Indigenous trees	2,700	USD 11,557
Chrysanthemum cut flower	60,352	USD 14,337
Total		USD 33,517

Investments

This innovation will require the availability of land on which-the DEWATS structure can be built. The amount of investment depends on the desired size, which will be determined by the volume of waste generated daily and requiring treatment daily. This technology requires investment in professional service providers such as geotechnical specialists, surveyors, civil engineers and environmental specialists to ensure that the technology is structurally sound and will not have a negative impact on the environment.

The internal rate of return (IRR) of this innovation over a project period of four years is –14%, which means that it cannot operate profitably. However, in many countries, this innovation is being promoted by governmental agencies to provide underserved communities with a sanitation solution. The innovation has non-monetisable economic, as well as environmental and social co-benefits.

Item	Amount ($)*
Investment costs	109,220
Operational costs/per year	9,892
NPV (5 years)**	16,428
IRR**	-14%

** The numbers are estimates, as the facility is not yet in operation*
*** NPV: Net Present Value; IRR: Internal Rate of Return*

Customers/beneficiaries

Some 900 students will benefit from this innovation by having access to safe sanitation facilities. Ten cooperative members will benefit from the seedlings, which they will sell to potential customers such as government (reforestation programs), wholesale nurseries and households.

Start-up requirements

Infrastructure: Land is needed to build the system, and in the case of Julukandoda Primary School, additional land was needed for the two ablution blocks (boys and girls). The infrastructure should preferably be located behind the facility (school, hospital, residential area, etc.) so that it does not interfere with daily activities in the surrounding area. It should also be far away so as not to pose any potential risks to children.

Site establishment: To establish such an innovation, which deals with wastewater and human waste, it is necessary to consult the relevant state regulatory autority to obtain the required license or permission permit. In South Africa the relevant authority is the Department of Forestry, Fisheries and Environment (DFFE). An exemption was granted for this DEWATS innovation by the provincial arm of the DFFE after the site evaluation showed that no wetlands were affected, there was no risk of groundwater pollution and the distance of the system to the households was acceptable. During construction of the project, geotechnical and civil engineers were on site to ensure that the installation was constructed properly and in accordance with national building regulations.

Raw materials: Once the DEWATS system is in place, a constant water supply for toilet flushing must be ensured. The toilet system installed at the school uses only four liters of water for flushing.

Equipment: The important additional equipment for the DEWATS is designed to remove for sludge and blockages from pipes.

Quality assessment

At one of the DEWATS facilities in the eThekwini municipality, constructed by Breman Overseas Research and Development (BORDA), data was collected to verify the suitability of the effluent for agriculture. The researchers used the Decision Support System (DDS) to test the suitability of effluent from an anerobic filter (AF). The results showed that the AF effluent can be used for agriculture without any negative effects on soil properties, crop production, irrigation equipment and the environment in terms of heavy metal accumulation. The literature recommends that the effluent should not be used for vegetable crops for health reasons, especially those that are eaten raw. The main constituents the researchers focused on were biological components, nutrients, and major constituents.

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The RUNRES project – a short overview

RUNRES is a project that addresses the nutrient gradient between urban and rural areas. Broadly speaking, nutrient mining occurs in agricultural areas due to increased food production, while nutrients are accumulated in urban areas where food is consumed.

The main objective of RUNRES is to co-design, test, implement and scale safe, (cost-)efficient, and socially acceptable innovations to valorise urban and rural waste resources and improve the circular economy related to food and agriculture. RUNRES achieved this by working with several transdisciplinary innovation platforms (TdIP) in Arba Minch, Ethiopia; Bukavu, eastern DR Congo; Kamonyi, Rwanda; and Msunduzi, South Africa. The project aimed to improve environmental and human health, household income and food security.

RUNRES is an eight-years project that has two phases: piloting and scaling. Through a co-design process in phase 1 (2019–2023), various innovations and their application were developed together with different stakeholders from different sectors: agriculture, waste treatment, sanitation, feed and food sector, academia, and public authorities. These innovations cover a broad spectrum, from composting organic waste, to rearing black-soldier flies. In each region, the stakeholders took ownership of these innovations to further develop a circular economy. A total of 15 innovations were set up, half of which proved to be scalable for phase 2 (2024–2027).

There were numerous challenges in phase 1, particularly in relation to the product quality and the market environment. The quality of the organic waste was often low due to insufficient sorting at source, i.e. organic material was mixed with plastic components. This required sorting of the waste after collection and undermined the profitability of the innovations. In addition, the market analysis for the products made from recycled organic waste was too optimistic and partially incomplete. For example, the willingness to pay for some of the products, such as compost, could not be correctly estimated and was often much lower than anticipated. This difficulty meant that some of the innovations had to be redesigned to make them profitable in phase 2.

While some of the projects have the potential to be economically viable, other innovations require further support from the public sector or donors. One example of such support is the sorting and collection of organic waste at the household level. The latter is usually a service provided by the public sector. In the longer term, however, the polluters should contribute to these waste management costs (polluter-pays principle).

The project is co-financed by the Swiss Agency for Development and Cooperation (SDC). The partners in the four countries and ETH Zurich are contributing in-kind resources (mainly labor) and, to a lesser extent, direct cost contributions. The private sector (innovators) is contributing in-kind resources (e.g. land, know-how) and direct investments.

For further information, please access our webpage: https://runres.ethz.ch/