RUNRES

Nutrient Cycles – Rural Urban Linkages

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Swiss Agency for Development and Cooperation SDC

Final Progress Report for Phase 1 (2019-2023)

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Executive summary

The main objective of RUNRES Phase 1 was to co-design, test, implement and scale safe, (cost-)efficient, and socially acceptable innovations to valorize urban and rural waste resources to enhance circular economies connected to food and agriculture. RUNRES achieved this by working with several transdisciplinary innovation platforms (TdIP) in four regions: Arba Minch, Ethiopia; Bukavu, Eastern DRC; Kamonyi, Rwanda; and Msunduzi, South Africa.

The different areas where RUNRES was active had different agriculture systems, urban developments, and social contexts. Through a co-design process, different innovations and their application could be co-developed with different stakeholders coming from different sectors: agriculture, waste treatment, sanitation, feed and food sectors, academia, and public authorities. The resulting innovations cover a broad spectrum, from co-composting organic waste, to rearing black-soldier flies. In each region, actors gained ownership of these innovations to further develop a circular economy (see the country summaries below).

The project aimed to achieve the following impacts: 1: Improved environmental (and human) health, and 2: Improved household income and food security. The 15 TdIPs set up during RUNRES Phase 1 could contribute to these goals by reducing the amount of organic and human waste, by producing soil amendment products, animal feed, as well as food for humans. Overall, in the project, we achieved an effective capacity to process organic waste at a level of about 900 tons of waste per month, mostly organic waste. Through the capacity generated in the project, we can recirculate nutrients to cultivate about 1'200 ha of maize, as an example, in ideal conditions for nitrogen application (see Figure 1).

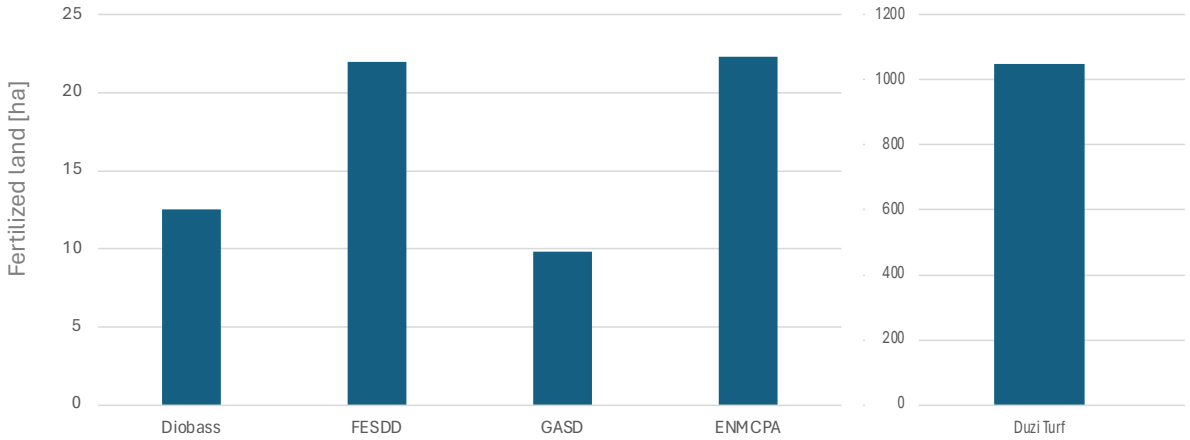

Figure 1: Estimated land (hectares) that can be fertilized with nitrogen from the compost produced in the different RUNRES TdIPs, assuming an application rate of 100 kgN/ha in an hypothetical maize production at ideal conditions. NB: The data for COPED, in Rwanda, was not used due to low reliability.

In each region, actors gained ownership of these innovations to further develop a circular economy. The experience gained from the first phase of the RUNRES project, spanning over four years (2019-2023), goes beyond implementing technical solutions. It has been a

transformation of different sectors that were not in close collaboration before (see Figure 2).

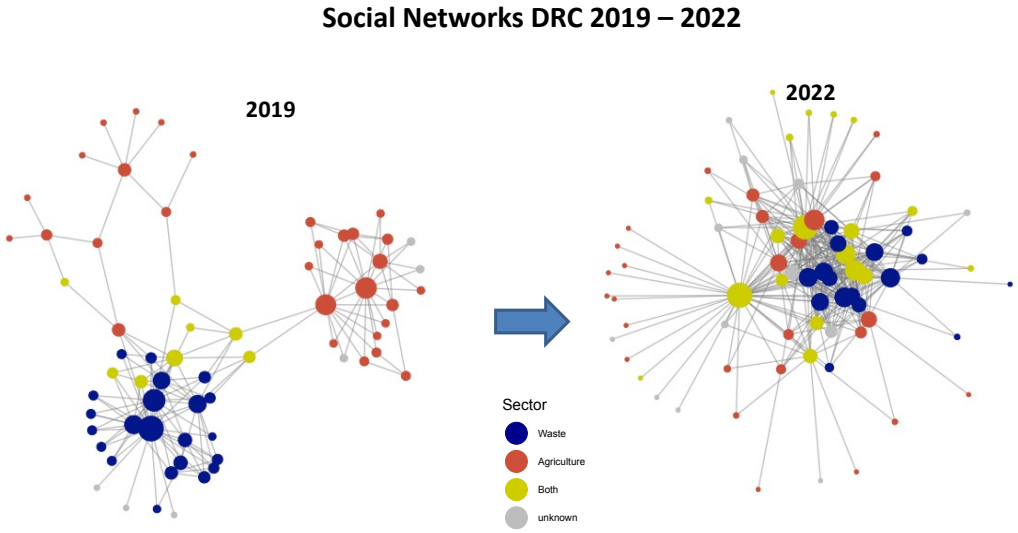

Figure 2: An example of the RUNRES network in the DRC in 2019 and 2022. The nodes represent individuals who are to some degree involved in RUNRES or on RUNRES topics. The networks are contact networks, and the color of the nodes indicate whether the respective individual is part of the agriculture sector, the waste sector, or both sectors.

In Phase 1, we encountered numerous challenges, notably related to organic waste and product quality, and to the market setting. The quality of the organic waste was sometimes low due to insufficient sorting at the source, including inorganic materials like plastics. This required post-collection waste sorting and reduced the profitability of the innovations. We therefore started waste-sorting campaigns, e.g. RANAS. Further campaigns will be expanded in Phase 2 as necessary. Also, our initial evaluation of the markets for the products made from recycled organic waste was incomplete in Phase 1. For instance, we could not correctly estimate the willingness to pay for some of the products, like for compost, where the real willingness to pay was substantially lower than initially estimated. This shortcoming forced us to redesign some of the innovations to make them economically sustainable in Phase 2.

The different innovation settings of the second phase will be deployed over four years. While the initial focus is on *upscaling* the innovations from Phase 1 that have been evaluated as suitable for upscaling ("setting A"), we aim in parallel at *replicating* these innovations in different places with new actors ("setting B"). This will take place through public-private partnerships and through the co-development of business plans with the new actors, to leverage financial resources from existing business development institutions. While some innovations are to be upscaled through the private sector, others will require committed support from the public sector, for instance for organic waste sorting and collection at the household level. Finally, later in time, we aim at *supporting* any actors interested in recovering organic waste through the quality assurance capacity developed within the project ("setting C"). In this way, we will be able to first scale up and then scale out to make a substantial contribution to the sustainability of food systems through a large deployment of circular economy solutions.

Program details

Programme name	RUNRES
Location	Democratic Republic of Congo, Ethiopia, Rwanda, South Africa
Reporting period	01.05.2019 – 30.10.2023
Report compiled by	Leonhard Späth (ETH Zürich) Pius Krütli (ETH Zürich) Sharon Migeri (ETH Zürich) Johan Six (ETH Zürich) Benjamin Wilde (ETH Zürich) Moustapha Byamungu (IITA DRC) Kokou Kintche (IITA DRC) Abayneh Feyso (Arba Minch University) Wondwossen Jerene (Arba Minch University) Kinfe Kassa (Arba Minch University) Behailu Merdekios (Arba Minch University) Celestin Hirwandame (IITA Rwanda) Speciose Kantengwa (IITA Rwanda) Matieyedou Konlambigue (IITA Rwanda) Emmanuel Rukundo (IITZA Rwanda) Samuel Getahum (University of KwaZulu-Natal) Simon Gwara (University of KwaZulu-Natal) William Musazura (University of KwaZulu-Natal) Alfred Odindo (University of KwaZulu-Natal) Ndoda Zondo (University of KwaZulu-Natal)
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1 Brief Description of Program

RUNRES: “The rural-urban nexus: establishing a nutrient loop to improve city region food system resilience” is a science-based development project co-funded by the Swiss Agency for Development and Cooperation (SDC). Its aim is to address two critical development challenges facing rapidly urbanising countries across sub-Saharan Africa: the sustainable and equitable production of food, and the provision of dignified and sustainable basic sanitation. Currently, both the agricultural and sanitation sectors are dominated by linear solutions which heavily depend on resource-intensive inputs. These approaches have led to nutrient imbalances within rural-urban interfaces across the world. In rural areas, long-term nutrient mining has created a downward trend of agricultural productivity, which harms livelihoods and exacerbates food insecurity. Simultaneously, rapidly growing urban areas in lower income countries suffer from an accumulation of organic waste (wasted nutrients) caused by insufficient collection and disposal of green-, food- and human-waste, which harm environmental and human health.

The RUNRES project aims to set a key-step in the transformation towards a circular and more sustainable agriculture and waste management in four Sub-Saharan African countries: DR Congo, Ethiopia, Rwanda, and South Africa. The project is funded by the Swiss Agency for Development and Cooperation (SDC), and entails two main phases: a piloting phase (2019-23) and a scaling-up phase (2023-27). The aim of the first phase was to pilot a set of innovations and evaluate their ability to contribute to a circular economy by linking waste management to agriculture. For this, we took a transdisciplinary approach, where we co-produced the different innovations with different actors: waste collectors, farmers’ cooperatives, collection and treatment companies, regulators and public authorities (municipalities and mayors). This approach made it possible to co-develop innovations that are tailored for the local context, making a concrete step towards a circular economy by connecting waste to agriculture.

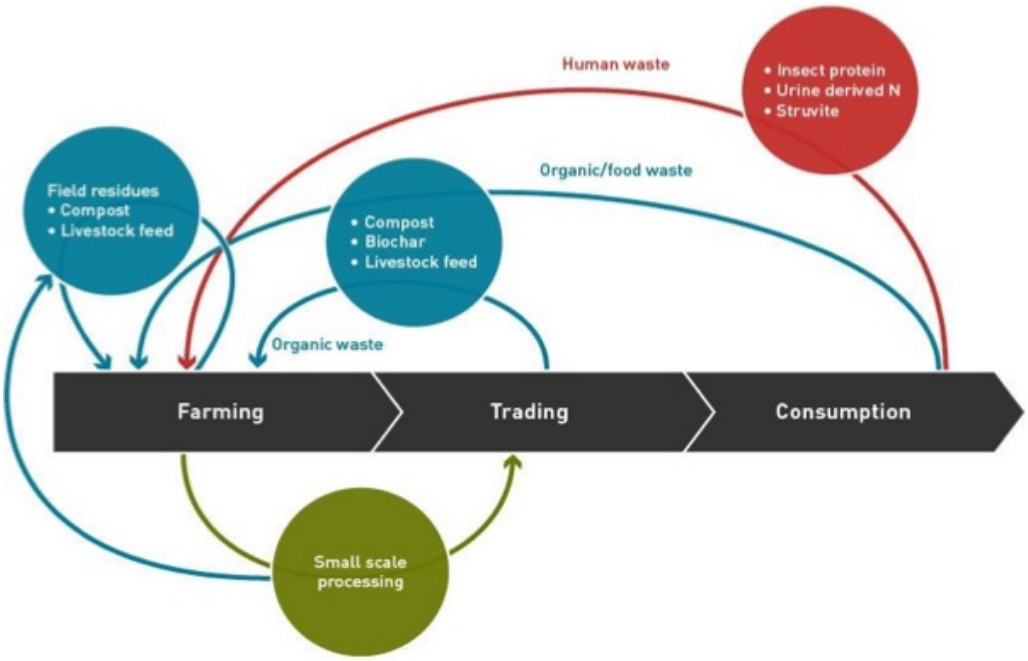

Figure 3: Schematic view of the different types of waste re-circulated back to agricultures as a resource in the RUNRES Project Phase 1.

The different innovations co-developed in phase 1 can be classified in three types: 1. Recycling organic and food waste, 2. Recycling human waste, faeces and urine, and 3. Supporting small scale processing in relation to the flows of recycled waste. For each of these innovations, we ensured that they were technically feasible, regulatory standards were met, and that the output would be a meaningful impact in terms of circular economy. In addition, we also evaluated how the different actors and their respective sectors integrated within the context of the project.

2 Summary of Key Achievements during Phase 1

2.1 DR Congo

During the first phase, RUNRES worked with transdisciplinary innovation platforms (TdIP) in four city regions, including Bukavu, in Eastern DRC. RUNRES was a pioneer of organic waste recycling in Bukavu City region. For four years, waste collectors, waste processors, farmers, and scientists worked in consortia to pilot organic waste recycling. RUNRES officially started in DRC after the first regional workshop held in Rwanda on 13-17 June 2019. The regional workshop aimed at clarifying to the core team the project objectives, training the core team on the TdIP approach, and outlining a road map for the first year. A series of planning meetings at the country level followed up the official partnership between IITA and ETH. The RUNRES kick-off meeting in DRC was organized on 9 September 2019.

The study of the context was one of the preliminary activities implemented at the beginning of the project. The study aimed to understand the local conditions of Bukavu City and its outskirts. A series of studies, including socioeconomic context, policy, and regulatory environment, agricultural production systems, FVC analysis, and the rural-urban waste flows were conducted. As in most other RUNRES countries, we found high levels of acceptance towards the use of organic waste for agricultural production among the respondents, as well as for their related concepts appraisal and support, with slightly lower levels regarding the re-use of human waste. The respondents did not report specific taboos, although dealing with human waste may be seen as belonging to lower social positions, and disgust may play a role in the acceptance of the use of human waste. Finally, the collected qualitative data also showed that many respondents view the lack of acceptance of re-using human waste because of a lack of knowledge; hence, they suggested that demonstrations and education measures can help in increasing acceptance. Regarding the policy and regulatory environment study, we found that there is no explicit law regulating the use of human waste for agricultural production in DRC.

The local core team of RUNRES, with support from ETH team, facilitated the establishment of TdIP in DRC. The TdIP approach offered opportunities to local actors with different domains of activities or expertise, such as entrepreneurs, farmers' organizations, processors, influential stakeholders, and scientists to convene, co-design, and co-test the innovations selected jointly through the context analysis. There was a small business or a social enterprise at the center of each TdIP interested in co-investing to pilot the innovation and bring it to scale with the support of other TdIP members. To support this process, the RUNRES core team facilitated a series of workshops with the stakeholders who were interested in leading or piloting innovations on circular economy. A competitive matching grant scheme, accessible to entrepreneurs who met a set of criteria, including the capacity to mobilize 20 to 30% of the project costs as co-funding, was put in place. A standard template for the innovation plan was developed and made available for interested applicants. In total, seven innovation plans were submitted. The project local team reviewed the seven innovation plans for improvement and initial screening. Based on the

available budget for the implementation of the innovation plans, the RUNRES steering committee selected the top three good innovations: Diobass, FESDD, and GASD.

The Quality Assurance Program (QUAP) was set up at the coordination level to monitor the quality of all products and ensure that they meet the acceptable standards at country levels. This program helped scientists identify challenges and provided adapted support to improve the processes. During the RUNRES Phase I, each compost produced by Diobass, FESD, and GASD had initially several critical quality problems. The first and most serious were the high levels of Chromium (Cr) and Nickel (Ni) identified in the compost. The observed levels of Cr and Ni in the compost being produced by Diobass (+95%Cr, +95%Ni), FESD (+148%Cr, +11%Ni), and GASD (+150%Cr, +58%Ni) presented a serious challenge to the viability of these innovations. Although these limits would be allowable under South African regulations, they violate some European standards and should likely be considered environmentally hazardous. Once present in a substrate, very little can be done to remove heavy metal concentrations in compost. Additional analyses showed that the soil mixed into the compost is the source of the high heavy metal concentrations in the compost. To address these quality issues, the incorporation of soil in the compost production process was reduced. By the end of the project, 990 tons of compost were produced by the different consortia.

During the implementation of project activities in Phase 1, implementing partners at all levels faced several challenges. Of technical nature, sorting waste at source, the quality of the compost, and the non-adoption of the toilets were an issue. Also, several issues on running the project appeared, like managing the TdIPs, and the durability and the sustainability of the toilets that has been set up in the project. Finally, the economics of the TdIPs turned out to be challenging, where profitability could not be achieved on the one hand because the willingness to pay for compost by farmers was very low, and on the other hand because the production and transportation costs were too high. Eventually, a better involvement of the authorities to enforce waste-management regulations and waste sorting improved the situation by the end of Phase 1. Thanks to the numerous innovations tested, Phase 1 allowed us to outline promising potentials for Phase 2. After discussions on the evaluation results by all stakeholders (SDC, ETH, IITA and the consultant team), focus would be more on commercial companies (rather than development NGOs), coffee, fruits and agroforestry seedlings (rather than mature coffee trees) and vegetable production.

The following major lessons learned during Phase 1 of the RUNRES Project in DRC are that 1. The sustainability of the project's achievements depends directly on the end-users' ability to pay for the end products, which was limited in Phase 1; 2. Due to limited institutional framing, the municipality engagement, as well as the “chiefs of avenues”, are one of the key success factors of the RUNRES Project in DRC; 3. The distance and the quality of the roads between the waste collection and waste treatment sites are critical factors to keep costs low, and these factors are hard to improve due to the topology and the density of the area; and finally 4. Business plans require reliable data, and some estimates we made at the beginning of Phase 1 were not correct.

2.2 Ethiopia

In Ethiopia, RUNRES started officially in June 2019 and extensive efforts were made to identify and engage local stakeholders. Accordingly, local stakeholders were identified from different levels (practitioners, government, etc.) and invited to participate in a kick-off-meeting.

A comprehensive context study was conducted to gain a deeper understanding of the local challenges, existing practices, and opportunities related to nutrient mining and waste management. The study provided the information necessary to select locally appropriate circular economy innovations to support a transition towards a circular economy predicated on nutrient recycling innovations for co-testing and piloting with profit making beneficiaries, more specifically: on municipality organic waste recycling in the form compost; small-scale agro-processing of green raw-banana into banana flour and baby food; and human waste recycling (source separated human-urine) and recycling in the form of struvite. The project team and stakeholders prioritized these innovations due to their potential contribution to improving the circularity of nutrients, reducing postharvest loss of banana, and enhancing soil health and fertility to improve crop productivity. After systematic evaluation of the submitted Innovation Plans, three innovations have been selected: 1. Egnan New Mayet on compost production (ENMCPA). For this innovation, solid waste collection women-associations were selected; 2. Anjonus on fruit and vegetable processing; and 3. MASSP on human urine recycling.

Egnan New Mayet focused on organic waste treatment and collection. Before the RUNRES intervention solid waste collection was done by donkey pooled cart. After the RUNRES intervention, women associations are using self-dumping mini trucks, which is safe for waste handling both in term of volume to be transported and health of waste collectors. When we compare composting before and after the RUNRES intervention, we observed significant changes. Initially, waste processors were preparing too small piles and turning piles was done with human labor, and it could not convert enough waste to compost. Egna New Mayet started bulky compost production using windrow composting, while turning is done using compost turner. With a reported compost production of 15.5 tons/month in 2022, the production could increase to 49.1 tons/month in the first half of 2023.

Anjonus focused on banana processing, including enhanced boiling, slicing, drying, milling, and packaging processes, leading to increased efficiency, quality, and environmental sustainability. Before the intervention, work was mainly manual, where boiling was conducted using fire, slicing was done manually, drying with the sun, and milling with a rudimental machine. After the intervention, boiling was carried out with an electrical boiler, the bananas processed through a slicing machine, an electric dryer, and a milling machine. Also, a packaging machine was introduced, allowing adjustments in the amount to be packed, recording packing dates, and inserting barcodes for each packet. Anjonus had difficulties to ramp up production to its designed capacity. In 2022, it produced only 100kg of banana flour per month, about 10% of the capacity. Through a mediation process, the production increased to about 500kg of

banana flour per month, to 50% of its designed capacity.

In Phase 1, the human urine recycling innovation MASSP was selected to source separated human urine, to be recycled in the form of struvite precipitate. To facilitate the installation of this innovation, the Arba Minch Municipality provided a production site for the enterprise, and poor sanitations areas were selected to install and collect source-separated human urine to process into struvite using a struvite reactor. MASSP planned to install 16 struvite reactors, but they were unable to install them because of several factors: 1. A poor design of the reactors, proving insufficient for struvite production; 2. Difficulties in sourcing the reactants to a sufficient high quality; and 3. A general inefficiency due to an over-ambitious plan.

By conducting the Quality Assurance Program (QUAP) and financial viability analysis for all developed products, we screened out innovations that met technical, environmental, and market demand requirements while attracting private sector investments for manufacturing, marketing, and distribution. Samples of compost produced by ENMCPA in Arba Minch, Ethiopia were randomly collected and sent to ETH Zürich Sustainable Agroecosystems' Lab and Cropnuts Laboratory service in Nairobi, Kenya. The results from these analyses revealed that the compost met the regulatory compliance standards set by the Agriculture Ministery of Rwanda (proxied as East African standard). Consequently, ENMCPA was granted permission to sell their compost products. Also, for the small-scale food processing innovation Anjonus, we funded the laboratory costs associated with testing their products. They underwent regular laboratory tests conducted by the Ethiopian Conformity Assessment Enterprise Laboratory. Following a thorough evaluation of the product's elements, they obtained market entrance permission from the Food, Medicine, and Health Care Administration and Control Authority of Ethiopia.

Besides of successful implementation and achievement of the project, we also, encountered some challenges during the project implementation period, namely: 1. A low education level of many stakeholders, especially the waste collection women-associations members, where writing innovation plans, putting innovative ideas on paper become difficult task and their data recording capacity has been low. Our learning element was to simplify our procedures to allow and support marginalized people. 2. The lack of business expertise in the project technical team made it difficult to adequately advise innovation leaders in designing and implementing their innovation plans. The learnings related to this point will be addressed in Phase 2 through the Business Experts. 3. A limited understanding of the TdIP concept made the repartition of the responsibilities difficult, where most of the activities rested on the shoulders of the innovation leader, with limited to no support from other platform members in some cases. We learned from this that the mechanisms for the collaboration within TdIPs should be made more explicit. Finally, 4. the project faced analytical challenges in implementing the QUAP due to the lack of well-organized laboratories in the domestic set-up to conduct quality analysis. As a result, we sent samples to ETH Zurich and Kenya to get the analysis results on the different RUNRES products. In Phase two, a ring trial will help to identify functioning laboratories in Ethiopia to ensure the quality of the products in Phase 2.

2.3 Rwanda

In Rwanda, RUNRES started officially in June 2019. A series of planning meetings followed up the officiation of the partnership with ETH. Rwanda hosted the first regional workshop on 13−17 June 2019, to clarify project objectives to the core team, train the staff on the TdIP approach, and outline a road map for the first year. The kick-off meeting followed this regional workshop, this time at the country level, involving 40 stakeholders. Participants discussed and defined the city region's food and sanitation system, challenges, and possible innovations.

The context studies were one of the preliminary activities implemented at the beginning of the project. At the end of the study, the project team identified organic waste management, Black Soldier Fly larvae production, small-scale processing of cassava peel into animal feed, and human waste recycling as potential innovations for co-piloting with local actors. Due to a lack of clarity on the legal framework, the steering committee put on hold the innovations on human waste during the first review. However, the committee reconsidered its positions later in September 2021, based on additional information provided by the leaders of these innovations, and approved the support by the project for research purposes.

AKANOZE recorded significant growth over the years. In 2022, the company collected 496 tons of peel-waste and processed them into 192 tons of animal feed ingredients, and 156 tons were sold. During the first semester of 2023 (from January to June), AKANOZE sold 53 tons of animal feed ingredient. With a selling price of 250 RWF/Kg, they needed to produce and sell at least 77 tons per year of High-Quality Cassava Peel (HQCP) flour to break even. If the sales move up-ward, the company can secure reasonable margins and use a price strategy to beat the competition. In 2022, the company sold more than 100 tons of products, which supports the scenarios considered in the analysis. The 5-year projection shows an internal rate of return close to 50%, indicating a good return on investment.

Between 2021 and 2022, MAGGOT FARM increased BSF larvae production from 11.7 to 73.7 tons per year and the compost from 25.7 to 144.6 tons per year. The same trend was observed the following year, with a production of 36.2 tons and 69 tons by June 2023 for larvae and compost, respectively. The projected Net Present Value (NPV) of more than RWF 16,000,000 and an internal rate of return of 29% indicate a reasonable return to attract investors, considering the cost of capital in the country.

The amount of organic waste processed by COPED Ltd between 2021 and 2022 has decreased from 1859 tons to 216 tons due to different challenges leading to the suspension of activities. Indeed, since 1 March 2022, COPED suspended the processing of waste collected from households at the Bishenyi site at the request of the Rwanda Environment Management Authority (REMA) for noncompliance. COPED has engaged the regulators to implement the recommendations to resume operations.

CEFAPEK is implementing a human waste recycling innovation, in which red-worms decompose or assimilate fecal matter while the urine is collected and stored. As the innovation is still

under research, the company produced 85 Kg of compost in 2022. Conversely, they collected 620 and 560 liters of urine in 2022 and 2023, respectively.

AFS did not record any (waterborne) human waste treatment, because the facility is still under construction. The delay was due to a lack of expertise from the entrepreneur. Only in the middle of 2023, an expert in waste treatment was identified to support the innovation leader with technology that is directly related to the South African DEWATS.

The project has also encountered the following challenges during its implementation: 1. COVID-19 Outbreak: This prevented the RUNRES team from meeting with stakeholders to facilitate activities and provide technical assistance. Communication was restricted to phone calls and emails. Such a situation delayed the timeframe for developing and evaluating proposals. 2. Even though the project's approach is based on the TdIPs, most of the activities rested on the shoulders of the innovation leader, with limited to no support from the other TdIP-members in some cases. The diverse understanding of the TdIP concept may explain such a situation. 3. Compliance with local regulations: On the one hand, the regulator found that the COPED recycling facility was too close to a swamp, and there were potential risks of polluting the agricultural production, even though local authorities provided the site. For this, COPED relocated the facility to a new site. On the other hand, the regulators found that some values for heavy metals in the produced compost were above national standards. Subsequent analyzes carried out at ETH showed that this was not the case, and that the produced compost complied to the regulatory requirements. 4. The lack of business expertise in the project technical team made it difficult to adequately advise innovation leaders in designing and implementing their innovation plans. Finally, 5. QUAP: The project faced analytical challenges in implementing the QUAP due to the lack of laboratories with expertise in conducting some analyses, leading to delays in concluding on the quality of products as per standards.

These challenges led to the following lessons learned: 1. The piloted innovations addressed real needs on the ground, especially animal feed ingredients, but the current production reached was insignificant compared to existing needs. An appropriate scaling strategy for each innovation should be designed and implemented to duplicate them nationwide. 2. The trajectory of the innovation depends heavily on the quality of the entrepreneur, especially their knowledge and experience of the value chain. Testing the innovation by a company with an existing business unit in the same value chain is likely smoother in the project timeline than a complete new start-up. An existing business can leverage its human and financial resources to support the testing phase of the innovation, which, in general, is yet to generate revenue. 3. The QUAP is the best ally for entrepreneurs testing new products derived from innovation. The design of the innovation plan, especially the timeline, should integrate the period required to complete the QUAP before putting the product into the market. This should be included as a stringent requirement in the agreement with innovation leaders. RUNRES should have also considered reasonable targets for production and sale during the testing and piloting phase. Finally, 4. The engagement of local authorities and national policymakers from the inception is paramount to

ensure their support. Therefore, a facilitator such as RUNRES should work deliberately with innovation leaders to generate evidence through quality data, inform policymakers, and advocate for enabling policies to scale successful innovations.

2.4 South Africa

Four stakeholder meetings were held in South Africa between June 2019 and May 2020, these include the kickoff meeting (KOM), community feedback, validation and innovation selection meetings. The main objective of KOM, which was held in September 2019, was to launch the project in Msunduzi city region and establish a transdisciplinary innovation platform, this was successfully achieved and was supported by the following influential stakeholders, traditional leadership, Vulindlela ward councilor and UKZN's Deputy vice chancellor. A total of forty-six stakeholders attended the KOM. The community feedback meeting, which was held in Vulindlela in November 2019, was aimed at reporting matters that emerged from the KOM to community members.

The stakeholders that were interested in the innovations formed different TdIPs. The planned Innovation Selection Meeting in South Africa coincided with strict lockdown that was instituted by the government to prevent the spread of COVID-19. The lockdown forced the team to use other methods for assisting stakeholders to form TdIPs and this was done through grouping the TdIP members according to their interest and then having a series of online meetings. This was not as effective as a face-to-face meeting would have been, but it resulted in the formation of 4 TdIPs focusing on co-composting (DuziTurf), DEWATS, biochar (RUSUS) and small-scale processing (not funded).

DuziTurf was fully functional by 2021. They sell the compost as a package for lawn or grass planting, which was their already existing business before they started selling compost. They also targeted commercial farmers so that they can sell compost in bulk to cut down transportation and packaging costs. In 2022, DuziTurf saw an increase in the sales because some of the bigger companies like TWK who were selling agricultural inputs were closing down. To ensure the quality of the products, QUAP ensured that the products that were produced were safe. In this effort the RUNRES team worked with the Water and Sanitation Hygiene (WASH) R&D Centre. The products met international and South African regulations for agricultural inputs. In term of financial viability, at the current selling price of ZAR 0,99/kg (0.053 USD), DuziTurf has to sell about 2500 tons/year to break even. Currently, they produce about 10 000 tons of compost per year but in the past, sales have been low and they were selling about 1500 tons per year. DuziTurf reached co-composting capacities absorbing about 500 m^3 per month of dewatered sewage sludge, which was previously not always adequately managed. The 5-year projections shows that this innovation at the scale of DuziTurf can have a 105% internal rate of return (IRR) which indicate a good return on investment.

Through RUNRES Phase 1, following challenges came to light: 1. The land system in KwaZulu Natal is under Ingonyama Trust which is ran by the Zulu Monarchy. In one of the areas where one of the RUNRES innovations was going to be implemented, the stakeholders did not have ownership of the land as it belonged to Ingonyama Trust, and this created problems for the project between 2020 to 2021 because the stakeholders were forced out by traditional

authorities before the biochar innovation could be implemented. This continued to be a struggle until RUNRES engaged with the Department of Agriculture and land belonging to this department was secured. 2. In the case of RURUS, focusing on biochar, the people with whom the project intended to work were people that came from previously disadvantaged groups. However, with the unfolding of the project, the two project initiators adopted a gatekeeping behavior that did not comply with the UKZN rules for procurement. It also became apparent in the RUNRES interactions with stakeholders that female stakeholders were unable to assert themselves because any discussions and decision that were taken in the absence of the two leading males belonging to the community-based cooperatives were not respected nor implemented. Consequently, the voice of the youth was also stifled within the stakeholders as the young people were also female. This, in addition to various forms of intimidation, led to a termination of the collaboration between UKZN and the RUSUS initiators. 3. While DuziTurf managed to produce compost at scale and run a profitable business, the compost was mostly sold to commercial farmers and a little was shared with small scale farmers. This was a challenge as it meant the project failed to reach the intended beneficiaries properly. Finally, 4. In the year 2022, the stakeholders from the Vulindlela community had less interest in the innovations and required that the project could only proceed with a certain percentage of the project funds being given to the community as a form of tenders. This was against the University of KwaZulu Natal procurement policies and therefore the work was stopped. The RUNRES project was advised by UKZN Legal Services to stop all engagements with the stakeholders and the project was moved to a different area because of safety issues.

From the different challenges that emerged during Phase 1, following lessons have been learned: 1. Project implementation is dependent on having willing stakeholders that see value in the project. It is therefore important to target stakeholders with political will especially at the municipality level. If this is not the case, implementation becomes difficult. During Phase 1, some project activities had to be moved to a municipality with more receptive leadership and the project was implemented with the support of the municipal and traditional leadership. 2. The team learned that there is a hidden cost in project implementation that was not properly planned and budgeted for. These costs are associated with compliance to government policy-frameworks which were considered at the beginning of the project, but the team did not anticipate the slow nature of the process. These processes, for instance securing water use licenses, environmental impact assessment, etc. took considerable time and resources, since it required hiring consultants/professional services to lead the applications. Finally, 3. The members of the RUNRES team had only little experience in projects which involved building infrastructure and purchasing large scale equipment/machinery and this caused delays in project implementation. The procurement for goods and services that were required for implementation had to go through a tender process which was lengthy and did not guarantee that the best service provider would be appointed. Aiming to hire people from previously disadvantaged groups, we felt established processes acted against the project, since there are not many previously

disadvantaged entrepreneurs in the sanitation field.

3 ToC and objectives

The main objective of RUNRES were to co-design, test, implement and scale safe, (cost-)efficient, and socially acceptable innovations to valorize urban and rural waste resources and enhance food value chains in order to enhance circular economies and thereby improve the resilience of city region food systems. RUNRES achieved this by working with transdisciplinary innovation platforms (TdIP) in Arba Minch, Ethiopia; Bukavu, Eastern DRC; Kamonyi, Rwanda; and Msunduzi, South Africa.

The development of more resilient food value chains through food value addition, recycling of food processing waste, and the enhancement of markets across the supply chain increased employment opportunities in our selected city region food-systems and aimed to improve food security across the entire nexus. At the same time, improved waste management strategies in these cities reduced public health burden, and environmental and social challenges, caused by inadequate sanitation and waste removal, while simultaneously generating valuable and marketable agricultural inputs.

To identify the specific impacts of Phase 1, we conducted with our project partners a theory of change exercise during a planning workshop in January 2019 in Nairobi in which we identified two impacts that contribute to achieving the overall objective. The two impacts are:

Impact 1: *Improved environmental (and human) health*

Impact 2: *Improved household income and food security*

The impacts are the result of a series of immediate and intermediate outcomes. For each of these outcomes, we have different output elements that had to be fulfilled through the Phase 1 of RUNRES.

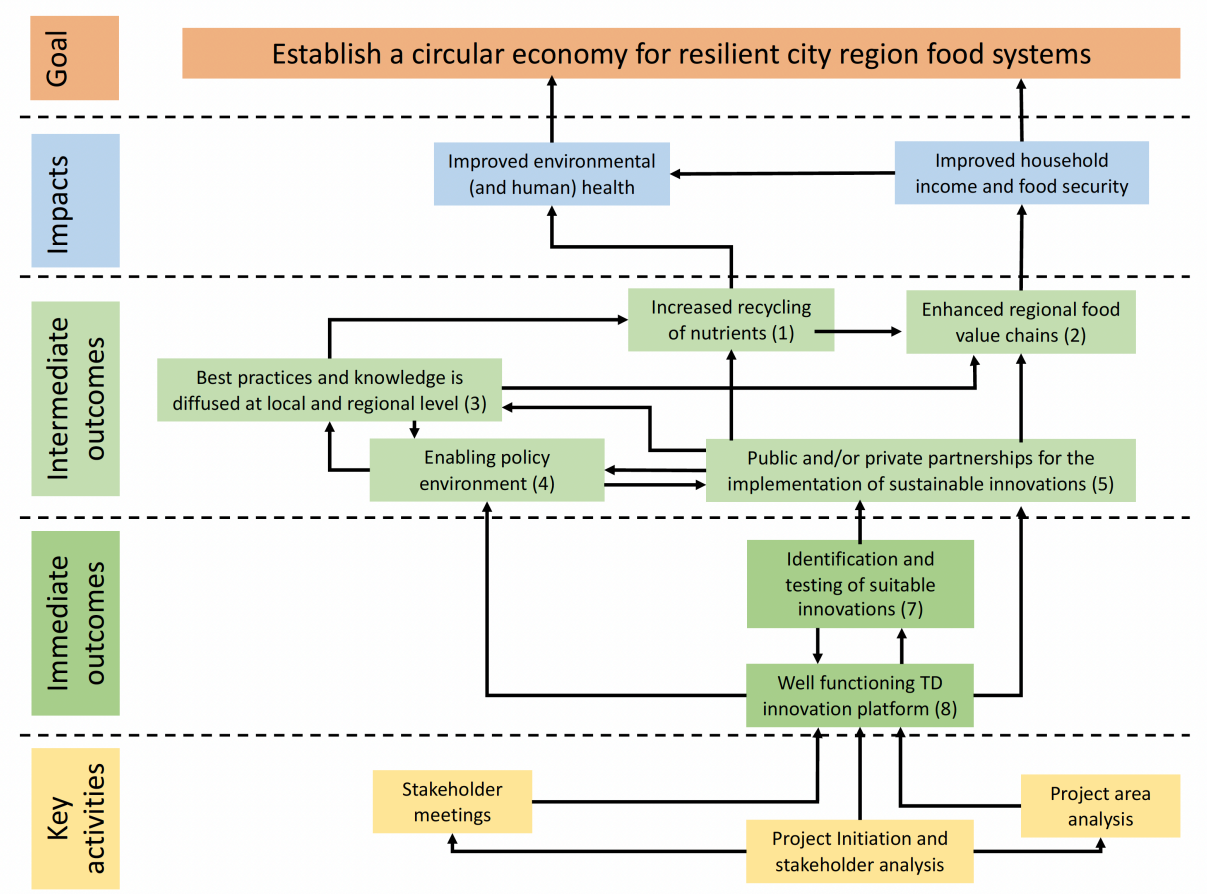

Figure 4: Theory of Change for RUNRES Phase 1 (2019-2023). NB: the output elements are embedded into the different outcomes, either immediate or intermediate.

3.1 Project Impact 1 – Improved environmental (and human) health

Soil health and fertility is in a critical environmental crisis in Africa. Closely related to impact 1 is the issue of soil mining. Across the continent, farmers do not have access to the soil inputs – organic matter and nutrients – needed to maintain and improve soil health and fertility. While access to soil inputs is limited across the entire continent, the situation is particularly acute for women who rely on such inputs to maintain soil fertility in the fields that produce food to sustain their families. Simultaneously, inadequate provision of sanitation in expanding urban regions contributes to public health crises, groundwater contamination and overall environmental degradation. Through the capture, treatment, and recycling of urban and peri-urban waste streams, RUNRES changes this.

Improving access to adequate sanitation is a necessary step to reduce public health problems, which particularly affect women and children in SSA. RUNRES aimed at facilitating the installation of ecological sanitation solutions that were adapted to the needs of men and women of all ages and which are socially acceptable and based on the co-production of knowledge between scientists and end users (or civil society) (e.g. UDDT). In addition, the project aimed at fostering municipal scale nutrient-recycling initiatives such as composting, co-composting,

production of biochar, the use of black soldier fly larvae, struvite precipitation, and the use of nitrified urine fertilizer. While not every innovation showed to be realizable, these innovations achieved through Phase 1 increased access to locally supplied organic matter and soil nutrients needed to reduce the widespread and chronic soil nutrient mining that currently hinders African agricultural productivity.

In addition, RUNRES coordinated and funded training opportunities for local male and female municipal engineers and city planners to ensure that there is adequate, gender specific, on-site knowledge to maintain these ecological sanitation systems. Because of the provision of these systems, we expected a reduction in the pathogen load released to the environment, which should reduce the rates of diseases (especially water-borne diseases such as diarrhea) within the participating communities, especially children and women.

Impact Milestone(s) achieved	**Improved environmental (and human) health**	2023
Status	in progress	

Through the different RUNRES innovations, we could re-circulate nutrients in substantial quantities. The total effective capacity of the innovations treating organic waste is about 15 tons of Nitrogen per month, producing the Nitrogen necessary to fertilize about 1'500 ha of maize at ideal conditions (see Figure 5 and Figure 6).

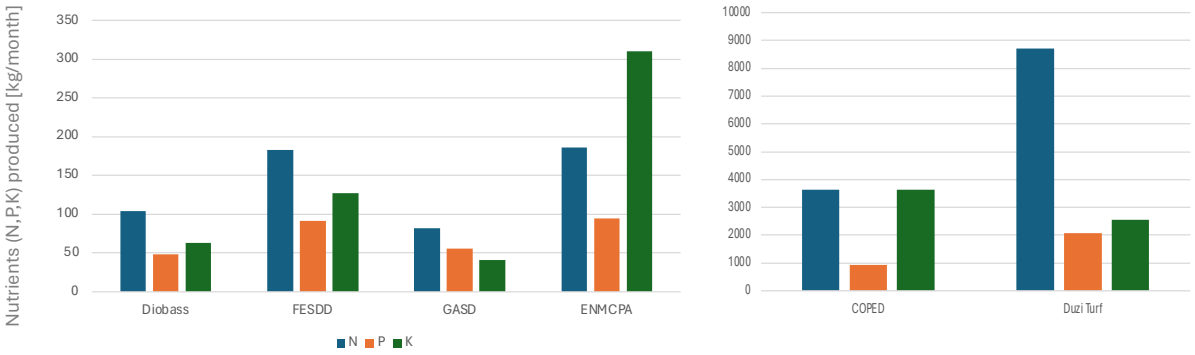

Figure 5: Nutrients (N,P,K) produced per month through the different compost-producing TdIPs in kilograms per month.

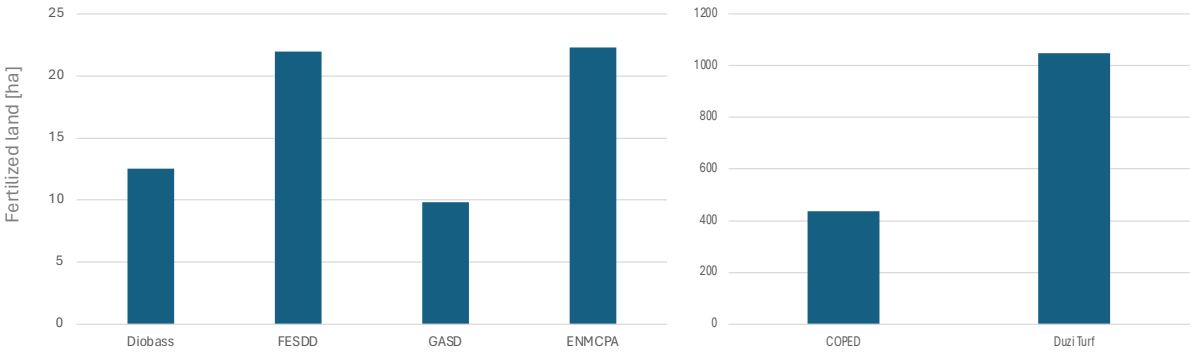

Figure 6: Land (in hectares) that can be fertilized with nitrogen from the compost produced in RUNRES, assuming an application rate of 100 kgN/ha in maize production.

In terms of quality, most of the produced compost fulfilled the safety standards in the different countries (see Figures 7-10). Some exceptions are the levels of Chromium, Aluminum, and Nickel in the DRC (see Figure 7). Nevertheless, additional measures established that this pollution is related to the environment (i.e. the used soil), and not to the waste-treatment process and the compostable raw solid waste.

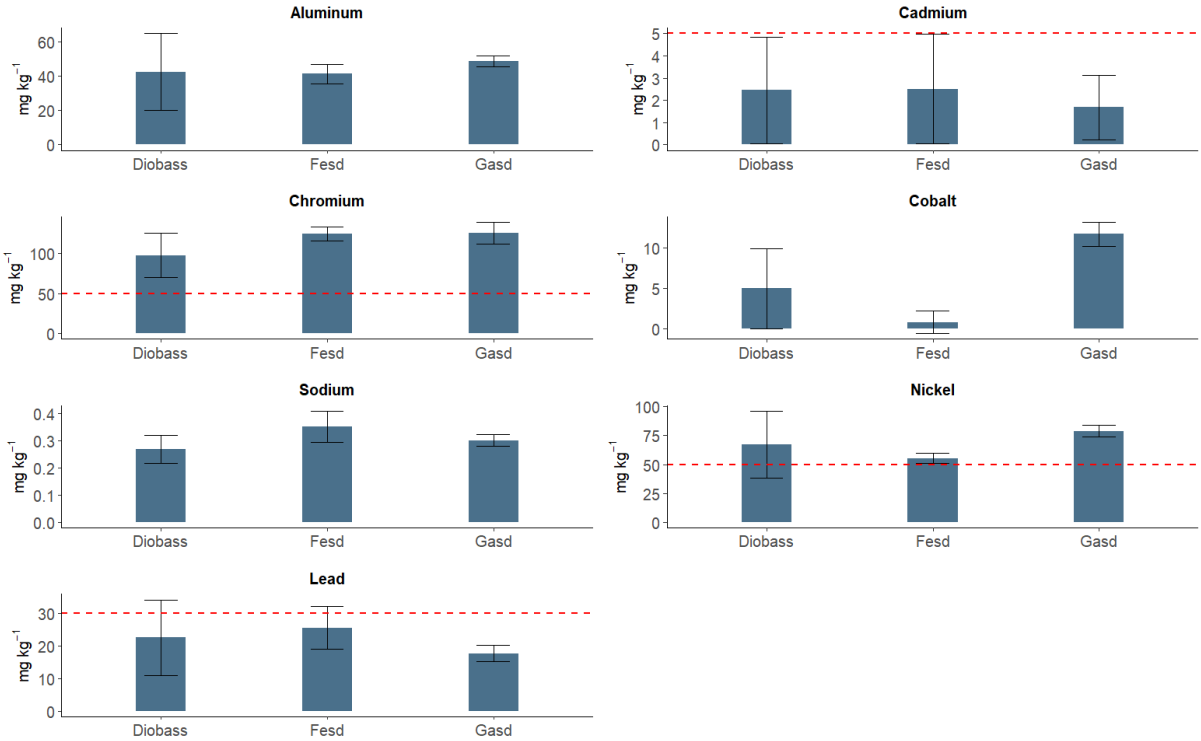

Figure 7: Levels of heavy metals in the compost produced by the different TdIPs in the DRC. In red, the regulatory limit for heavy metals.

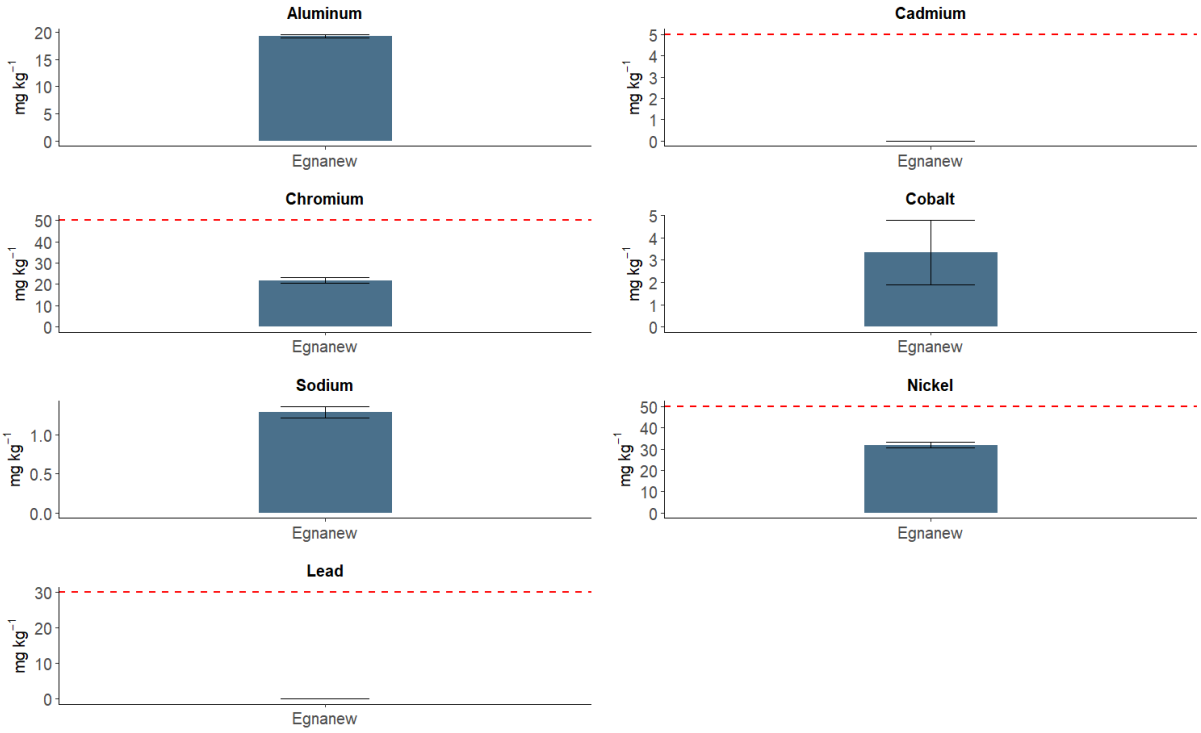

Figure 8: Levels of heavy metals in the compost produced by the different TdIPs in the Ethiopia. In red, the regulatory limit for heavy metals.

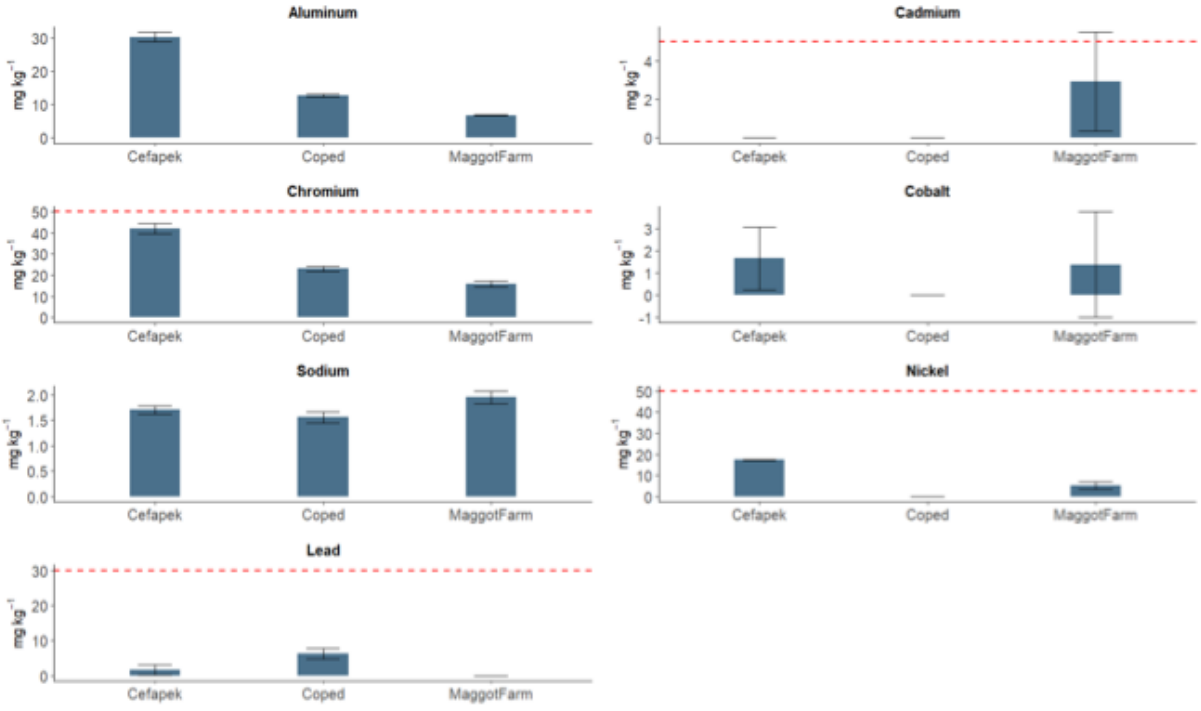

Figure 9: Levels of heavy metals in the compost produced by the different TdIPs in Rwanda. In red, the regulatory limit for heavy metals.

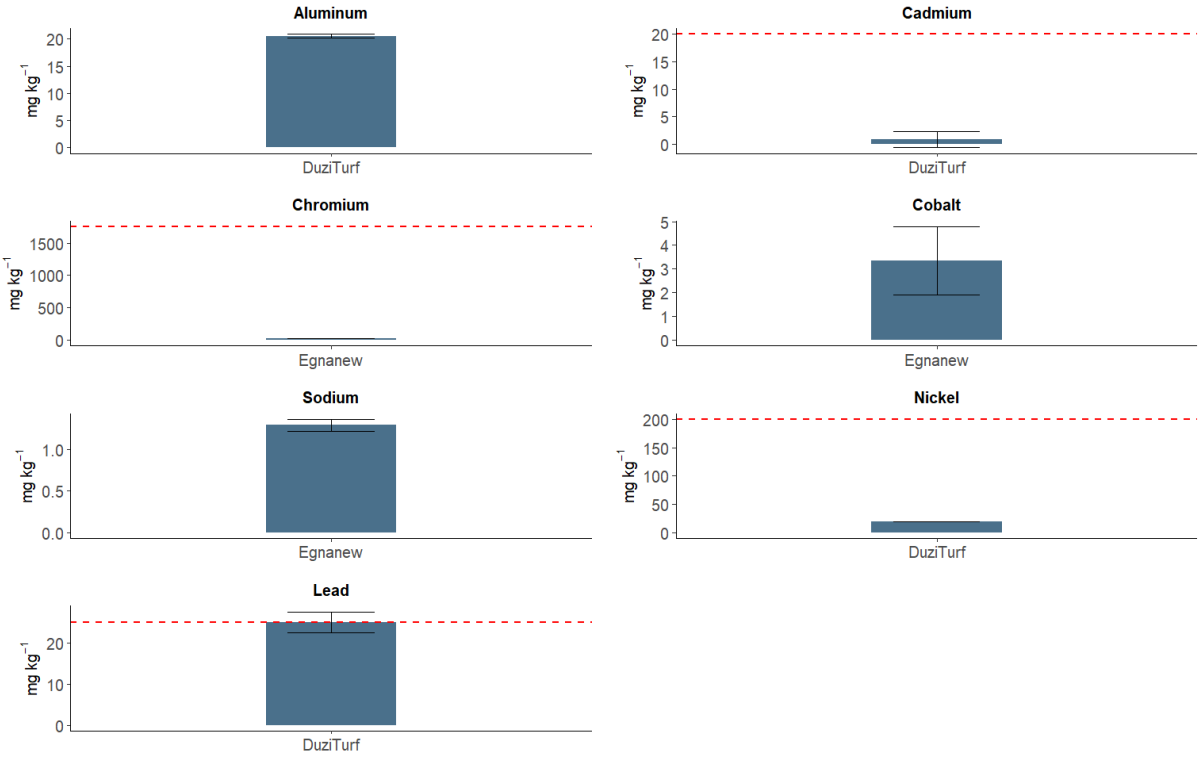

Figure 10: Levels of heavy metals in the compost produced by the different TdIPs in South Africa. In red, the regulatory limit for heavy metals.

3.2 Project Impact 2 – Improved household income and food security

A key component to achieve a well-functioning circular economy is to ensure that our city region food systems have well developed food value-chains and waste value-chains that provide increased income (due to value addition) and high-quality food, and thus generally higher food security to their people.

We expected a substantial impact of the proposed outcomes of RUNRES in a further development that would lead to value creation and jobs, which would increase the household income and access to higher quality food by the direct beneficiaries in our city regions. By bringing public and private stakeholders together we also expected to create new innovative collaborations between agricultural cooperatives and public institutions (e.g. schools and prisons) to produce and process food and recycle waste into marketable products that increase both household incomes and access to healthy food. This could be particularly important to improve the food security of women and (school) children.

Outcome Milestone(s) achieved	**Improved household income and food security**	**2023**

Status	in progress

To evaluate the achievement of Impact 2, we aimed to observe an increase in income in available households. However, most of the innovations could not benefit farmers in a way that could be directly measured. For instance, compost could not be fully distributed, and measuring the effects on crops like coffee manifest themselves only over a longer time than the RUNRES project. The only direct income-related improvement has been for the persons working in the different innovations. However, since we did not capture the information on their situation before the RUNRES project, we could not establish a clear observable change.

We also evaluated the food availability and access to food. We could see some variability in access to food, in time, and between the different countries. This variation showed to be negative (Figure 11) in DRC and Ethiopian regions, and slightly positive in Rwandan and South African regions. However, it is difficult to attribute these results to RUNRES. The first batch of data has been gathered in November 2020, after the start of the COVID19 crisis. The improvement for Rwanda and South Africa could be explained through the loosing of COVID-related restrictions in 2021. The second batch of data, collected in November 2022 showed an improvement in food availability. We could not observe the same trend for DR Congo and Ethiopian regions. In their case, other macro-events could have influenced this negative variation: the geo-political situation in the Kivu region, and the civil war in Ethiopia. While the regions of Bukavu and Arba Minch were not directly affected by the conflict themselves, tensions at national scales may have influenced on the movement of people, investment and the food-system as a whole.

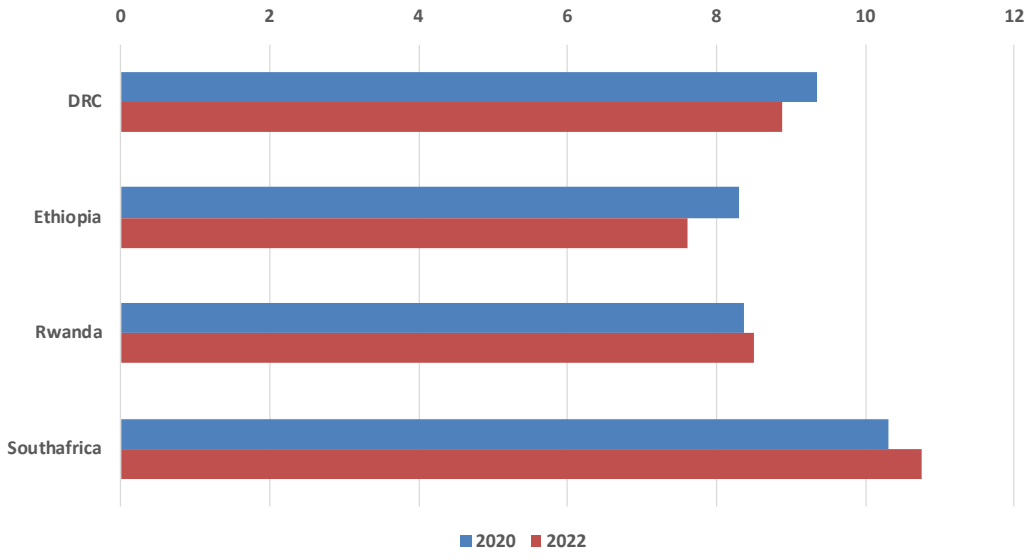

Figure 11: The Household Food Insecurity Access Scale (HFIAS) score on a scale from 0 to 12 for the RUNRES beneficiaries in the four regions where RUNRES was active. We surveyed the respondents in 2020, once the innovations and their scope were clear, and at the end of 2022, towards the end of Phase 1. N_{DRC} = 448, N_{ET} = 336; N_{RW} = 442; N_{SA}

= 320).

4 Results' summary for each Project Outcome

For each element of the ToC, we coupled it with one or more indicators to show how we achieved the different outcomes. In the initial ProDoc, the target values were not defined because where and how we would implement the different innovations was not defined due to the transdisciplinary approach employed in RUNRES. As it became clear though the initial stakeholder-meetings and along the first year in Phase 1, we could define clear targets to be achieved. This process of fixing the targets in the logframe started at the yearly meeting in 2020. By the second half of 2020, we had a set of targets for the different RUNRES innovations in the different countries.

Due to the different types of innovations implemented, we could not have unique metrics that could be valid for all innovations. Hence, we had to detail the metrics for each innovation, and then group the different indicators only when possible, or reasonable, like for organic waste, or compost and co-compost produced.

Once the targets were set, we co-designed a set of monitoring tables that could be tailored to specific needs of each innovation. However, this process took longer than expected, and reliable and systematic data-collection took only place by mid-2021 (Figure 12). From there, we could monitor the different quantities and specificities of the innovations, to see whether we were on track or not. Since the targets have been defined in the logframe as quantities to be processed for the whole duration of the implementation of the innovations, varying from 2.5 to 3 years, we could not keep the numbers in absolute terms. We therefore switched to relative numbers, mostly in form of capacity, i.e. quantity processed/produced/etc. over time.

By the end of Phase 1, as the decision to have a no-cost extension, many innovations stopped to record the data, since the collection was perceived as linked to the funding that they got. For this reason, we only have reliable data for the year 2022. For 2021, the monitoring process was put into place, and for 2023, more and more stakeholder stopped their recording (Figure 12) because they saw this as a contractual obligation set in the MoUs, which covered Phase 1 only until the beginning of 2023.

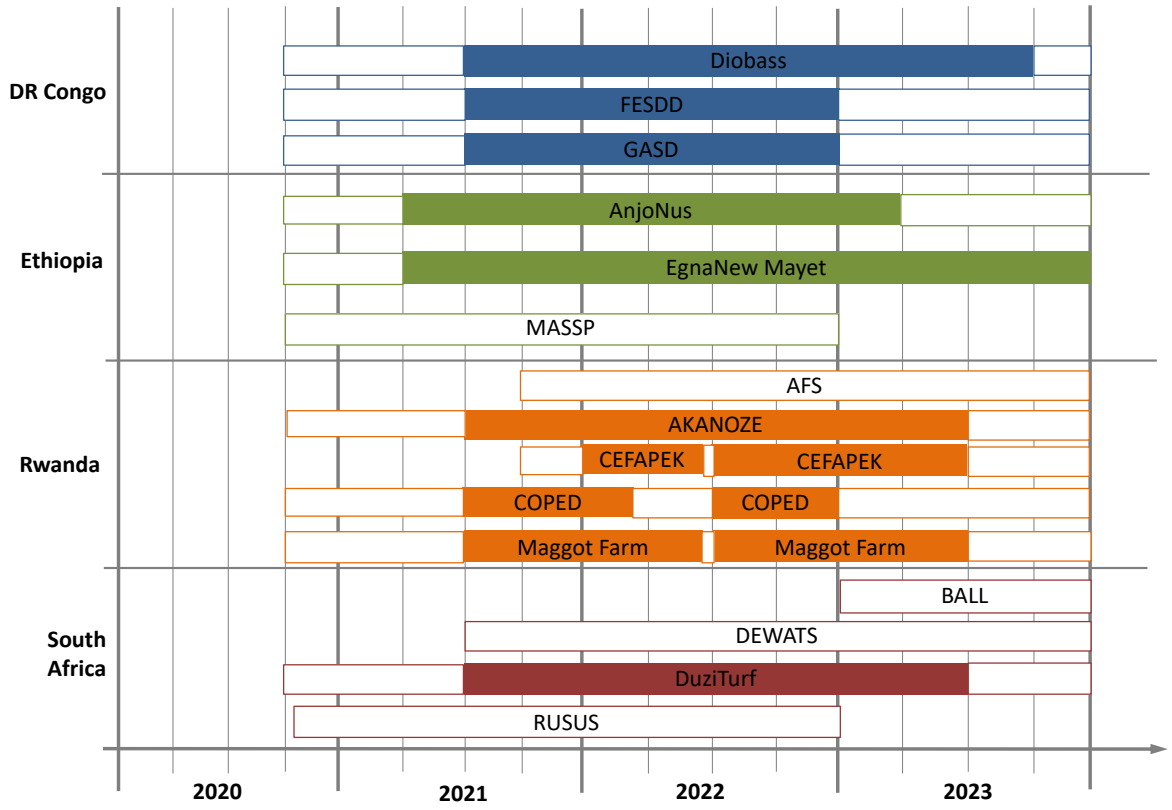

Figure 12: Recording of the monitoring data over time, where the full color bars indicate a reliable collection, and the empty bars indicate no collection. Some innovations never had a reliable monitoring for different reasons: some never came to production, for instance RUSUS (biochar) or MASSP (struvite); some are still being established, for instance AFS (sanitation, water borne) and BALL (agroecology living-lab) and will collect data in Phase 2.

The results of each outcome in the ToC are underpinned by different metrics described in the logframe. However, as a matter of simplicity, we summarized the different outcome achievements through "traffic lights" (see Figure 13). For this, we assigned "green" when the outcome or output has been overall achieved, with consistent results; "orange" when the outcome or output has been only partially achieved, and/or with inconsistent results; and "red when the outcome or output has not been achieved So far, the logical chain from activities to impacts shows to be overall quite good, even though some elements did not work, and some other only partially worked. In the following sections, we will describe each outcome and its underlying output elements we achieved in Phase 1.

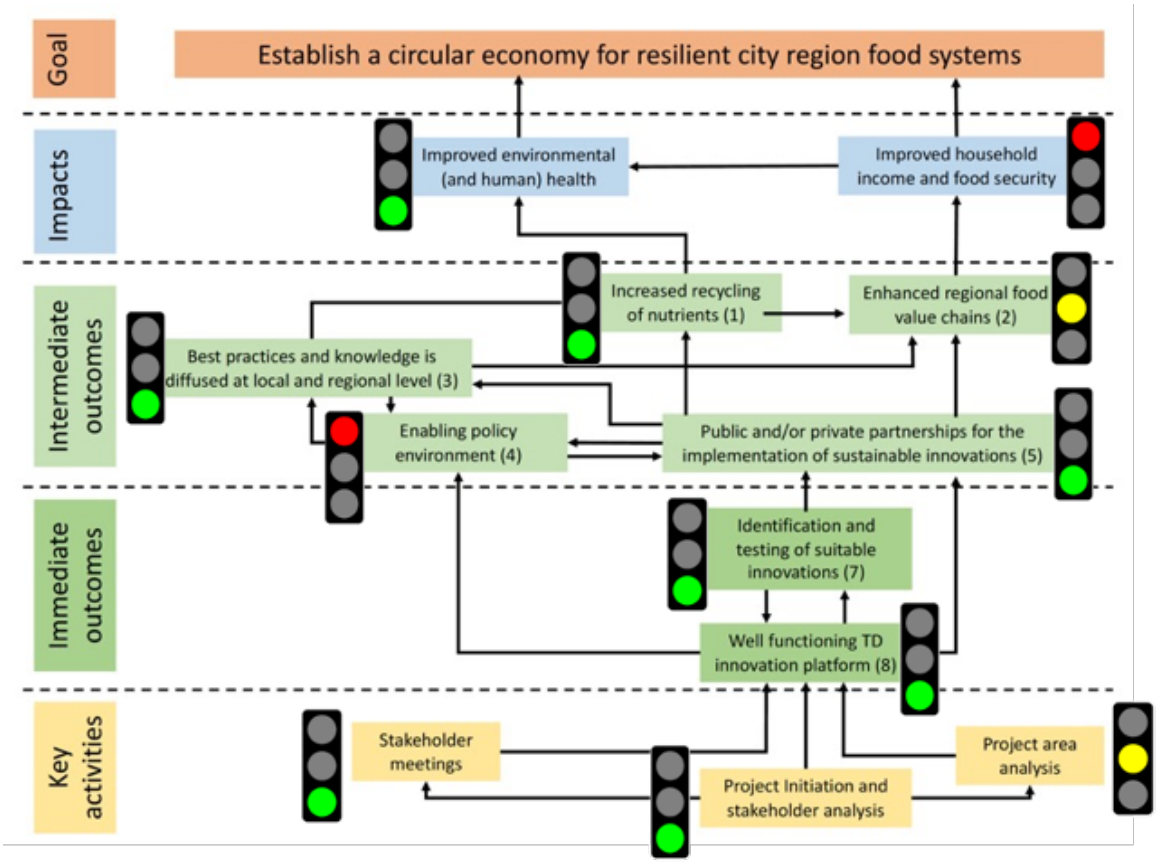

Figure 13: A picture of how far the different outcomes could be achieved in RUNRES Phase 1. In the traffic lights, green means that the outcome has been overall achieved, with consistent results. Orange means that the outcome has been only partially achieved, and/or with inconsistent results. Red means that the outcome has not been achieved.

4.1 Project Outcome 1 – Increase recycling of nutrients

The aim of the Outcome 1 is to achieve an increased volume of waste being hygienically processed and redistributed to support agricultural production. Its main metric is the amount of organic waste being collected, processed and re-distributed to support agricultural production. Here, we disaggregated this "index" into three distinct indicators: collection, processing, and distribution. The results are described through Outputs 1 and 2 below.

Outcome Milestone(s) achieved	Increase recycling of nutrients	2023
Status	finalized	

4.1.1 Output 1.1: Improved collection, transport, and processing of waste streams

Based on the findings collected during the first year, RUNRES supported the installation of innovations in sanitation and waste management that are adapted to the needs. Innovations will capture, transport, and treat urban waste streams and facilitate their return to outlying rural areas to improve regional food production (i.e. facilitate their recycling).

Output	**1.1. (1) Improved collection, transport and processing of waste**	
Activities carried out	Co-design of innovations: - Composting and co-composting - Collecting through Urine-Diverting Dry Toilets (UDDT) and using urine after storage (3 months) - Transforming cassava peels into feed - Rearing Black Soldier Fly larvae - Decentralized water treatment system (DEWATS)	
Progress	The innovations mentioned above are active, except the DEWATS that we planned in South Africa (Umgeni) and Rwanda (AFS). The stored urine mentioned earlier refers to urine collected from UDDTs installed at a market in the DRC at GASD and from CEFAPEK in Rwanda.	
Milestone(s) achieved	Composting and co-composting Collecting and using urine Transforming cassava peels into feed Rearing Black Soldier Fly larvae Decentralized water treatment system (DEWATS)	Since 2021 Since 2022 Since 2021 Since 2020 Planned for 2024
Any action required	- Identifying the different bottlenecks for upscaling (applies to all innovations) - Redesigning the innovations when the bottleneck is not addressable in isolation (for instance the composting-innovations in the DRC)	
Status	In process	

Through the monitoring in Phase 1, we could evaluate the quantities of waste that could be treated by the different innovations. Because of delays in setting up the monitoring scheme, we

only measured the monthly capacity of the different innovations, centered around 2022. The collection capacity achieved by most of the innovations is in the same magnitude as the targets fixed in the first year. Some TdIPs, however, deviate substantially from the initially planned capacity:

- COPED in Rwanda: they had to close for half a year due to environmental pollution around their treatment site. This substantially decreased the quantity they could process in the whole project.
- DuziTurf in South Africa: this innovation increased its output by more than a magnitude. This is mostly due to the role of the landscapers, who initially had no place where to dispose their green waste. Setting up this waste disposal possibility fulfilled a latent need for recycling green waste to make compost and co-compost.

For Output 1.1, we split the output in its three components for more clarity in the waste value-chain: 1.1.1. collection and transport, 1.1.2. processing of waste, and 1.1.3. production of usable products (e.g. compost).

Output 1.1.1: Improved collection, transport and processing of waste
"X amount (e.g. tons or cubic meter) of waste hygienically processed.", here waste collected and transported

[t/month]	Waste type	Targeted capacity (Logframe freeze)	Achieved capacity	Diff. [%]	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	organic w.	147	**73.9**	-50	M	sorting, collection and transportation
Ethiopia	organic w.	107	**29.8**	-62	L	treatment
Rwanda	organic w.	367	**65.8**	**-82**	M	environmental regulations
	cassava p.	49.5	**31,9**	-36	H	sourcing
South Africa	organic w.	64.7	**1070**	**+1550**	H	role of landscapers (increase)
	sewage s.	73.3	**91.7**	+25	H	geo-situation (increase)
Total	organic w.	686	**1240**	+80	L	see above
	cassava p.	49.5	**31,9**	-36	H	see above
	sewage s.	73.3	**91.7**	+25	H	see above

Most TdIPs processed the waste they collected. Nevertheless, some struggled with the quality of the waste collected, where plastics had to be sorted out before composting. This is for instance the case in the DRC, where collectors filled the trucks with non-organic waste if they

were not completely full of organic waste. While this reasoning aimed to increase the efficiency of transport, a bottleneck in the DRC, it cost more time then on the treatment sites to re-sort the waste. At the beginning of Phase 1, COPED in Rwanda and Egnan New Mayet in Ethiopia faced similar issues. These issues have been addressed by clearly separating the two waste streams, organic and non-organic.

Output 1.1.2: Improved collection, transport and processing of waste

"X amount (e.g. tons or cubic meter) of waste hygienically processed.", here waste processed (or treated)

[t/month]	Waste type	Targeted capacity (Logframe freeze)	Achieved capacity	Diff. [%]	% of coll.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	organic w.	82.3	72.7	-12	**98**	M	-
Ethiopia	organic w.	101	22.0	**-88**	**74**	L	treatment, unreliable data
Rwanda	organic w.	243	63.2	**-74**	**96**	M	Regulations
	cassava p.	49.5	31.9	-36	**100**	H	-
South Africa	organic w.	64.2	1070	**+1560**	**100**	H	-
	sewage s.	73.3	75	+2	**82**	H	-
Total	organic w.	491	1230	+150	**99**	L	see above
	cassava p.	49.5	31.9	-36	**100**	H	see above
	sewage s.	73.3	75	+2	**82**	H	see above

The production level of usable products has been roughly in line with the quantity of waste collected during the project. Here, we can observe the same magnitude jumps for the innovations that unlocked nicely during Phase 1, DuziTurf with the landscapers, and those that had troubles producing, for instance COPED due to alleged environmental pollution. In the case of COPED, we had also a very low data reliability, since the RUNRES compost has been mixed with other non-RUNRES compost piles. This confusion made us unable to further use their data. Other innovations, like AKANOZE, could identify clear bottlenecks in their production. For them, it has been drying. While cassava is usually harvested during the rainy season, it is more difficult to dry the cassava peels in the sun, and the possibility of actively drying could substantially increase their production in Phase 2.

Output 1.1.3: Improved production of usable products

"X amount (e.g. tons or cubic meter) of waste hygienically processed.", here production of usable products							
[t/month]	**Product type**	**Targeted capacity (Logframe freeze)**	**Achieved capacity**	**Diff. [%]**	**% of proc.**	**Data reliability (H/M/L)**	**Remarks (bottleneck)**
DR Congo	compost	47.8	51.8	+8	**-39**	M	-
Ethiopia	Compost	96.3	15.5	**-84**	**-30**	L	Unreliable data
Rwanda	compost	232	287	+23	**+354**	L	Confusion between RUNRES and non-RUNRES compost: the data was not accounted for in the total
	cassava p. flour+m.	18.3	16	-13	**-49**	H	drying
	BSFL	10	6.7	-33	**NA**	H	-
South Africa	compost	171	671	**+290**	**-41**	H	-
Total	compost	547	746	+36	**-40**	L	see above
	cassava p. flour+m.	18.3	16	-13	**-49**	H	see above
	BSFL	10	6.7	-33	**NA**	H	see above

4.1.2 Output 1.2: Pathways are established to increase local agricultural production with waste-recycled input products.

The co-developed products from recycled waste will be valuable agricultural inputs for farmers to provide nutrients to their farmland. Specific products and the extent to which such products have been made available in Y4 has been defined together with the stakeholders during Y1.

Output	**1.2. (2) Pathways are established to increase local agricultural production with waste-recycled input products**
Activities carried out	Establishing selling opportunities for following products: - (co)-Compost (DRC, ET, RW, SA) - Cassava peel flour (RW) - Black soldier flies' larvae (RW)

Progress	While most of the production for Phase 1 could be sold, two main issues remain to be solved: the willingness to pay for (co)-compost, which is lower than initially expected, and the existence of a market for the products, where today several innovations rely on a reduced number of buyers for their products.	
Milestone(s) achieved	Selling compost (DRC, ET, RW, SA) Selling cassava peel flour (RW) Selling black soldier flies' larvae (RW)	Since 2021 Since 2021 Since 2021
Any action required	Further development of the market for the different products; increasing the willingness to pay for soil amendment products.	
Status	in progress	

While collection and transformation worked relatively well during Phase 1, the distribution has been a bottleneck. This was caused by a lower willingness to pay than expected for soil amendment products. This is one of the reasons why the compost production in all countries has been difficult to be redistributed; only around 20% could be sold in DRC, Rwanda and South Africa, whereas 40% could be sold in Ethiopia. In addition, it has been difficult to document how much compost has been sold, since many actors, even after many times insisting to keep records, did not keep a clear sales' records, limiting the reliability of the data collected.

In the case of other products, like those related to animal feed, drying and storage has been a bottleneck. For instance, Maggot Farm sold their BSFL fresh. While this worked well in Phase 1, storage may be a problem in Phase 2 when the produced quantity grows and BSFL will take a larger role as an ingredient for producing animal feed according to given formulas.

Output 1.2: Pathways are established to increase local agricultural production with waste recycled input products.
Distribution capacity.

[t/month]	Product type	Targeted capacity (Logframe freeze)	Achieved capacity	Diff. [%]	% of prod.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	51.8	6.92	-87	**-84**	M	willingness to pay
Ethiopia	compost	50	5.8	-88	**-62**	L	willingness to pay, low data reliability
Rwanda	compost	149	63.5	-57	**-78**	L	low data reliability

	cassava p. flour	10	5.33	-47	**-20**	L	low data reliability
	BSFL	10	5.33	-47	**-20**	H	-
South Africa	compost	68.6	120	+75	**-82**	L	low data reliability
Total	compost	319	196	-39	**-81**	L	low data reliability
	cassava p. flour	10	5.33	-47	**-20**	L	low data reliability
	BSFL	10	5.33	-47	**-20**	H	see above

4.2 Programme Outcome 2 – Enhanced regional food value chains

For Outcome 2, we aimed at having more small-scale food processors being established and producing more high-quality food. For this outcome, we only consider food for humans, while feed for animals has been considered through Outcome 1 above.

4.2.1 Output 2.1: Improved availability and quality of locally processed food products.

Through the implementation of innovations during year 2 (Y2) and Y3, local food products have been co-developed that are of high quality and generate increased revenue, which aimed to encourage food processors to increase value addition of these food products. RUNRES particularly encouraged innovations where economic growth could be enhanced by the inclusion and the empowerment of women and youth. The expected number of products and quality level has been defined together with the stakeholders during Y1.

Outcome Milestone(s) achieved	**Enhanced regional food value chains**	
Status	in progress	

Output	**2.1. (3) Improved availability and quality of locally processed food products.**
Activities carried out	Co-developed the production of dried banana-flour. The resulting products is banana flour and baby formula.

Progress	The plant has been constructed but does not function at its full capacity by the end of Phase 1.	
Milestone(s) achieved	Construction and operation of the plant	Since 2021
Any action required	A mediation process between the different members of the TdIP has been started in 2022, with the aim of bringing the plant to its designed capacity.	
Status	in progress	

The only innovation producing food that is active by the end of Phase 1 is Anjonus in Ethiopia, aiming to produce banana flour and baby formulas based on that flour. While the construction of the drying, grinding and packaging plant has been successful, the TdIP has not made it yet to increase the production levels to the designed capacity of the plant. This was mainly due to personal divergences between some members of the TdIP. A mediation process was started by the RUNRES Ethiopian team, with the aim of increasing the production level during the last months of Phase 1 and into Phase 2; this was successful, but results will only be seen in Phase 2.

Another innovation dealing directly with food products is BALL in South Africa. This TdIP is focusing on vegetables, where most elements needed for the production were provided on spot, mainly through composting of organic waste and human waste. This TdIP did not make it to start of production during Phase 1, but will do so during Phase 2. Finally, although minor in its focus on food production targets, the TdIP AFS in Rwanda aims to reuse human waste from a bus stop for producing food in the vicinity of the waste source. The innovation is still under construction and will be active during Phase 2. We therefore do not provide any numbers on these innovations in this report.

Output 2.3: Improved availability and quality of locally processed food products.
"X tons of high-quality processed food products supplied by small scale food processing units."

[t/month]	Product type	Targeted capacity (Logframe freeze)	Achieved capacity	Diff. [%]	Data reliability (H/M/L)	Remarks (bottleneck)
Ethiopia	Banana flour	3.5 t/month	0.1 t/month	-97%	L	

4.3 Programme Outcome 3 – Best practices and knowledge are diffused at local and regional level

The aim of Outcome 3 is having best practices and knowledge to be shared with local and regional stakeholders (beyond our action-research practitioner partners, government institutions, academia, private sector and NGOs, civil society organizations and local community structures).

Outcome Milestone(s) achieved	**Best practices and knowledge are diffused at local and regional level**	
Status	finalized	

For Outcome 3, we operationalized the number of interactions with scaling partners as an indicator. We defined scaling partners as actors that can make upscaling happen, from a technical, financial or policy-related perspective. While we had a least one interaction per TdIP with such actors, the number of interactions turned out to be less than initially planned. This is mainly due to the difficulty to involve such actors in the process. While we had the presence of some influential actors at the kick-off meetings in 2019, and at the stakeholder meetings in 2023 focusing on upscaling, their presence remained scarce along with the project, since the issues raised at the stakeholder meetings were usually of technical or economic nature. Nevertheless, having those key actors at the stakeholder meetings that took place at the beginning and at the end of Phase 1 made it possible to position the RUNRES project in the agenda of those actors.

Output 3.0: Number of interactions with scaling partners

"# of interactions with scaling partners at local and regional level."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	9	9	M	
Ethiopia	compost	6	1	M	
	banana flour	4	1	M	
	struvite	2	0	M	
Rwanda	compost	4	4	M	
	cassava p.	4	6	M	

	flour				
	BSFL	4	5	M	
	sanitation	ND	7	M	
South Africa	compost	10	8	M	
	DEWATS	10	5	M	
	Biochar	10	0	M	Did not work out
Total	compost	29	18	M	
	banana flour	4	1	M	
	cassava p. flour	4	6	M	
	BSFL	4	5	M	

Output	**3.1. (4) Best practices and knowledge are defined and scaling partners are engaged to diffuse them at local and regional level**	
Activities carried out	During the second half of 2020, we set the number of best practices and knowledge that should be reached through Phase 1. For each innovation, we identified the best practices related to the goal that these innovations aimed to achieve. At the end of Phase 1, we verified whether these best practices had been implemented.	
Progress	Best practices for piloting most of the innovations have been internalized.	
Milestone(s) achieved	Definition of the main best practices to be implemented in Phase 1. Verification of the implementation of the set best practices.	2020 2023
Any action required	Not all TdIP implemented the best practices that they aimed to achieve. For some, AFS (sanitation) in Rwanda and BALL (agroecology living lab) in South Africa, the formal practice did not start yet. Others, like MASSP (struvite) in Ethiopia and RUSUS (biochar) in South Africa did not make it to production.	
Status	Finalized, except for two TdIPs (AFS and BALL)	

During Phase 1, innovations developed jointly with stakeholders from different sectors entailed specific best practices that are likely to be of interest to scaling partners in other city region

food system and that have the potential to be used at scale. For each innovation, we defined several best practices that had to be implemented through the project to have different functioning waste recycling chains. These best practices, e.g. safe compost production or effective organic waste collection, have been put into practice in the successful innovations (see Output 3.1 below).

The TdIPs of RUNRES will gradually become hubs that generate and co-produce knowledge that is of use to other stakeholders and other city regions. The number of expected practices and the form (channels, type of content, data, etc.) in which knowledge is diffused has been defined during Y2 and 3 with the stakeholders.

Most TdIPs aimed to implement few core best-practices articulated around transforming waste. While most could be implemented and be internalized by the different actors, some could not be implemented. In particular, co-composting has been deployed to a lesser degree than initially planned. This has been the case due to several factors: 1. the reluctance of users to use UDDT for sitters, like it was the case in the DRC; 2. The difficulty in building up a DEWATS, like for AFS in Rwanda; or 3. A lack of users of toilets, like for CEFAPEK in Rwanda.

Some other practices, like timely drying cassava peels in Rwanda could also not be well implemented, since cassava harvest happens during the rainy season, and thus drying was sometimes inefficient and hence the peels started to rot and were unusable as a feed.

Output 3.1: Number of best practices defined in each city region food system
"# of best practices defined in each city region food system."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	2	1	H	No co-composting
Ethiopia	compost	2	2	H	
	banana flour	1	1	H	
	struvite	1	0	H	Did not work out
Rwanda	compost	3	3	H	
	cassava p. flour	5	4	H	Drying not fully well-practiced
	BSFL	5	5	H	
	sanitation	ND	4	H	Only CEFAPEK, no AFS

South Africa	compost	4	4	H	
	DEWATS	5	2	H	Job creation + functioning IP
	Biochar	3	0	H	Did not work out
Total	compost	11	10	H	
	banana flour	1	1	H	
	cassava p. flour	5	4	H	
	BSFL	5	5	H	

4.4 Programme Outcome 4 – Enabling policy environment

Policy support for implementing and scaling of key innovations of RUNRES was provided by public and/or private sector partners. Public and private sector stakeholders were engaged strategically to explore how RUNRES innovations can be supported by and mainstreamed in their government or business strategies.

Outcome Milestone(s) achieved	Enabling policy environment	
Status	In progress	

Output	**4.1. (5) Supporting activities and policies for key innovations of RUNRES are adopted by public and/or private sector organisations at local and regional levels**	
Activities carried out	Policy-screening in the context studies	
Progress	To be improved	
Milestone(s) achieved	Policy context studies, as a part of the context studies	2019-2020

Any action required	The policy briefs have to be tailored to the policy contexts of the respective countries.
Status	Development of the policy briefs is ongoing and will be finalized in 2024.

An enabling policy environment is key to implement innovations that are identified in the TdIPs. Through the TdIPs, we aimed to form a group of stakeholders or 'community of innovators', who are committed and able to reach out and closely collaborate with government, public or private sector decision-makers. This should have led towards the generation of additional resources (legal support, finance, knowledge, etc.) and be valuable to reach the intended impact at scale. Since RUNRES is set-up in collaboration with municipalities in each city region food system, a direct relationship to the local authorities was established. The project coordinators and project partners steered the development of an enabling policy environment that is of benefit to local needs and gives selected innovations the opportunity to be scaled-up through either public or private sector investment.

Initially, we envisioned the development of a new participatory governance system for each city region food system that engages with policy making processes. As the RUNRES innovations should have matured during Y2 and Y3, the required enabling environment and actions should have been defined together with the relevant stakeholders. However, we could not carry out this development for several reasons. First, the collaboration between science and the practitioners has not worked as well as initially anticipated. Although much has been carried out for the integration between science and practice, some scientists focused more on research than on practical applications, where COVID-19 also played an inhibiting role. On the other hand, some practitioners did not fully internalize the use of science for their daily activities. One example is COPED that had to interrupt their operations due to pollution. In this case, measurements carried out by the authorities led to the shutdown of the composting site. However, a subsequent analysis of the samples showed that there was no reason to shut down the plant. If measurements would have been done earlier in the process, such interruption could probably have been avoided.

Another issue was the field of policy that was new to many of the RURNES team. The nuances around policy, for instance between policy, law, regulations, practices, were not fully known among the RUNRES team members. While we carried out a policy scoping during the context studies, we missed out some existing policies that already regulated the use of waste in some places. For instance, in the case of COPED in Rwanda, the authorities based their decision to suspend the compost production on a set of policies that we did not know about at the beginning of the project.

Over Phase 1, the contact with the policy makers has not been as strong in all countries than initially expected, and as a result, a disconnection between scientific results and policy-making

occurred in some countries. In that sense, a set of policy briefs is unfortunately missing at the end of Phase 1, but meetings and engagements with the public sector was significant. Nevertheless, in South Africa, RUNRES has contributed to the development of the National Faecal Sludge Management (FSM) strategy through the Department of Water and Sanitation. Also, in Ethiopia, the Birbir municipality has shown interest and support in taking up RUNRES innovations, specifically composting, where the goal is to promote sustainable waste management practices, reduce landfill waste, and create a valuable resource that supports agricultural activities.

In the logframe, we defined the indicators for an enabling policy environment as 1. the number of meetings held, 2. the number of policy briefs written, 3. The number of fully engaged public stakeholders, and 4. The amount of co-funding.

For the number of meetings held, it turned out that we carried out more meetings than expected. While some partners initially planned meeting once or twice a year, they ended up meeting monthly.

Output 4.0.1: Number of meetings held
"# of meetings held"

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	40	35	H	For three TdIPs
Ethiopia	compost	3	15	H	
	banana flour	3	15	H	
	struvite	3	15	H	
Rwanda	compost	4	29	H	
	cassava p. flour	4	NM	H	
	BSFL	4	8	H	
	sanitation	ND	0	H	Only internal meetings
South Africa	compost	4	2	H	
	DEWATS	4	5	H	
	Biochar	4	1	H	Did not work out
Total	compost	51	81	H	
	banana flour	3	15	H	

	cassava p. flour	4	NM	H
	BSFL	4	8	H

Regarding the number of policy briefs written, we could not achieve any by the end of Phase 1. Nevertheless, this is being carried out during the first year of Phase 2.

Output 4.0.2: Number of policy briefs written
"# of briefs written to promote policies for the implementation and scaling of key innovations together with public stakeholders."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
Total	compost	10	0	H	
	banana flour	1	0	H	
	cassava p. flour	2	0	H	
	BSFL	2	0	H	

While we were unsuccessful in generating policy briefs, the different TdIPs, with the support of the project coordinators, engaged with key stakeholder from the public sector. Overall, the number of these engagements surpassed what was initially planned at the beginning of Phase 1.

Output 4.0.3: Number of full engaged public sector stakeholders
"# of full engaged public sector stakeholders in TdIPs."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	6	3	H	Essentially the municipality
Ethiopia	compost	1	4	H	Ag. office Arba Minch, Municipality, Environmental protection AM city administration, mayor office

	banana flour	1	2	H	Manufacturing directorate Arba Minch city, Manufacturing directorate Gamo Zone.
	struvite	1	1	H	Arba Minch water supply and sewage management enterprises' office.
Rwanda	compost	3	5	H	District agronomist; sector agronomist; executive secretary of the sector; vice-mayor for economic development; hygiene and sanitation unit of the district; REMA.
	cassava p. flour	2	4	H	District agronomist; sector agronomist; executive secretary of the sector; vice-mayor for economic development
	BSFL	2	5	H	District agronomist; sector agronomist; executive secretary of the sector; vice-mayor for economic development; animal resources officer
	sanitation	ND	6	H	hygiene and sanitation unit of the district
South Africa	compost	3	2	H	Umgeni water; Msunduzi municipality
	DEWATS	3	5	H	Umgeni water, Umgeni municipality, DWS, Julukandoda school, DFFE (Dept. of forestry, fisheries and environment)
	Biochar	2	0	H	Did not work out
Total	compost	13	14	H	
	banana flour	1	2	H	
	cassava p. flour	2	4	H	
	BSFL	2	5	H	

To increase the economic sustainability of the different TdIPs, we required for Phase 1 a co-

funding level of at least 28% from the different stakeholders involved in the TdIPs. Most of the innovations could reach this value through cash and in-kind. The two TdIPs that eventually did not work out had different amounts of funding engaged. RUSUS in South Africa had no RUNRES-funding engaged when the decision was taken to stop the development of the innovation. Until that time, RUSUS only invested in the TdIP in-kind in form of work and land. In the case of MASSP in Ethiopia, they partially used the RUNRES funding only during H2-2020 and H1-2021 before the innovation has been terminated.

Output 4.1: Percentage of total co-funding

"X % of co-investment by national/regional partners in scaling up activities including funding of innovations."

	TdIP	% of co-funding	Remarks (bottleneck)
DR Congo	DIOBASS	30.75%	
	FESDD	30.0%	
	GASD	30.02%	
Ethiopia	EgnaNew Mayet	56.6%	
	Anjonus	47.2%	
	MASSP	0%	Funding from RUNRES partially engaged in H2-2020 and H2-2021
Rwanda	AKANOZE	40.4%	
	COPED	29.6%	
	MAGGOT FARM	43.9%	
	CEFAPEK	64.4%	
	AFS	TBC	AFS received 20,000 USD. We are yet to have a report from AFS.
South Africa	BALL	22%	The co-financing is based only on 2023 as this is a newer innovation.
	DEWATS	40%	
	DUZITURF	86%	

RUSUS	NA	No funding from RUNRES eventually engaged

4.5 Programme Outcome 5 – Public and/or private partnerships are established for the implementation of sustainable innovations

Private partners of the agri-food sector (e.g. waste recycling companies, food processors, traders) and the public sector (e.g. waste management and sanitation government offices, public schools) are involved and fully participate in TdIPs. We aim to increase co-investment by both private and public partners in designing and testing food value chain innovations. Public-private partnerships co-invest to implement sustainable sanitation and waste recycling innovations. This will lead to the establishment and formalization of markets for food products derived from waste-derived fertilizer.

Outcome Milestone(s) achieved	Public and/or private partnerships are established for the implementation of sustainable innovations	
Status	in progress	

4.5.1 Output 5.1: A network among agri-food system actors is established to implement food value chain innovations.

To enable the development of high quality locally processed food products, knowledge is required in terms of legal aspects, market situation, consumer needs, etc. Through the development of a network of private food processors RUNRES aims to foster an environment that stimulates the sharing of information.

This network gradually emerged and grew out of the TdIPs to enable the development and implementation of food value chain innovations. We particularly encouraged the participation and inclusion of women and youth in this network. Based on the stakeholder network mapping conducted in Y1 of the project, specific activities for strengthening the existing networks have been defined accordingly.

Output	**5.1 (6). A network among agri-food system actors is established to implement food value chain innovations.**

Activities carried out	In all RUNRES countries, we carried out stakeholder meetings twice a year.	
Progress	Finalized	
Milestone(s) achieved	Local kick-off meeting Bi-annual stakeholder meetings, at least one day each	Second half of 2019 Since 2020
Any action required	The routine of stakeholder meetings will continue in Phase 2.	
Status	in progress	

Not all the innovations developed in RUNRES deal directly with food processors. For Phase 1, the innovation centered on cassava peels and banana flour received some resonance from other food processors. For the other TdIPs, while they are also indirectly linked to food, direct collaboration with food processors has not been documented, since it was not the main scope of these innovations.

Output 5.1.1: Number of food processors involved in # of meetings to discuss opportunities and challenges to implement and scale-up food value chain innovations.

"# of food processors involved in # of meetings to discuss opportunities and challenges to implement and scale-up food value chain innovations."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	NA	NA	H	
Ethiopia	compost	0	0	H	
	banana flour	1	2	H	Interest to duplicate the innovation to process enset root and stem into flour: 1 from Gamo zone, 1 from Oromia region.
	struvite	NA	NA	H	
Rwanda	compost	NA	NA	H	
	cassava p. flour	3	3	H	Only on cassava

	BSFL	NA	NA	H	
	sanitation	NA	NA	H	
South Africa	compost	NA	NA	H	
	DEWATS	NA	NA	H	
	Biochar	NA	NA	H	
Total	compost	NA	NA	H	
	banana flour	1	2	H	
	cassava p. flour	3	3	H	
	BSFL	NA	NA	H	

In the same way as for the interactions with food processors, only two units related to food value chain innovation have been established: Anjonus for banana flour in Ethiopia, and AKANOZE related to cassava processing in Rwanda.

Output 5.1.2: Numbers of implemented units of food value chain innovations.
"# of implemented units of food value chain innovations."

	Product type	**Targeted number of (Logframe freeze)**	**Nb.**	**Data reliability (H/M/L)**	**Remarks (bottleneck)**
DR Congo	compost	NA	NA	H	
Ethiopia	compost	NA	NA	H	
	banana flour	1	1	H	
	struvite	NA	NA	H	
Rwanda	compost	NA	NA	H	
	cassava p. flour	1	1	H	related to cassava
	BSFL	NA	NA	H	
	sanitation	NA	NA	H	
South Africa	compost	NA	NA	H	
	DEWATS	NA	NA	H	
	Biochar	NA	NA	H	Did not work out

Total	compost	NA	NA	H
	banana flour	1	1	H
	cassava p. flour	1	1	H
	BSFL	NA	NA	H

Beyond the numbers related to the different PPPs established in Phase 1, we could also measure through Social-Network Analysis the evolution of the connections between the different stakeholders in the RUNRES regions. For instance, we could see that the project contributed to connect the agriculture sector and waste sector (see Figure 14 for the example of the DRC)

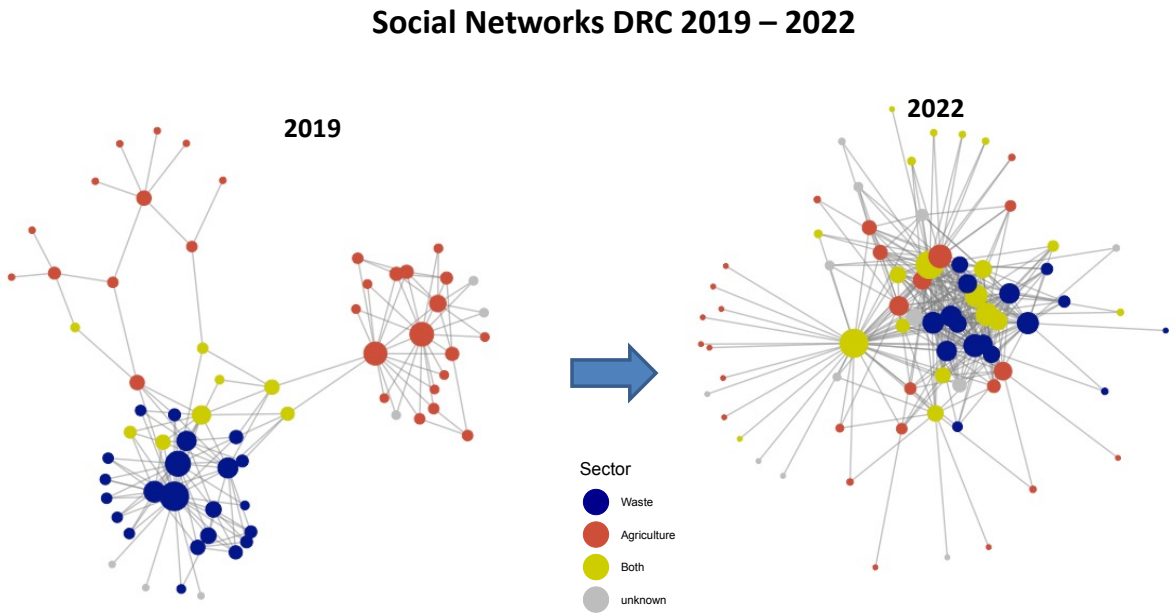

Figure 14: presents the RUNRES network in DRC in 2019 and 2022. The nodes represent individuals which are to some degree involved in RUNRES or RUNRES topics. The networks are contact networks. The color of the nodes indicate whether the respective individual is part of the agriculture sector, the waste sector, or both sectors. The size of the nodes represents the degree centrality. A bigger node means that this individual has more connections in the network. (credit: Rea Pärli).

4.5.2 Output 5.2: Public-private partnerships are formalized to co-invest in designing and testing of sustainable sanitation and waste recycling innovations.

We initially anticipated that the recycling of all waste types would not fully tap into a market that allows the making of profit on all recyclables by private companies. To resolve this challenge, public-private partnerships (PPP) were expected to be needed to foster the recycling of waste at substantial levels. The number of established public-private partnerships depended

on the specific innovations that have been prioritized to resolve the waste problem. Co-investment by public and private partners increased stakeholder buy-in in the project, but also their dependency. This guaranteed that innovations remained demand-driven, and increased the scaling potential of innovations.

Output	**5.2 (7). Public-private partnerships are formalized to co-invest in designing and testing of sustainable sanitation and waste recycling innovations**	
Activities carried out	Formalization of the PPPs though the MoUs in 2020	
Progress	Finalized	
Milestone(s) achieved	Signing of the MoUs Termination of the time-frame of the MoUs	2020 2023
Any action required	Setting new MoUs for Phase 2	
Status	In progress	

During Phase 1, while being mainly of private nature, the different TdIPs have involved the public sector to different degrees. TdIPs working on transforming organic waste, for instance, have been largely dependent on the collaboration with the authorities for making waste sorting carried out properly. Other innovations were less tight to the public sector. Nevertheless, a tie, especially through the municipalities was always there.

For this report, a private partnership is established if a formal relationship exists, and joint activities are being implemented. In the case of the Phase 1 TdIPs, this formalization took place through the MoUs.

Output 5.2.1: Number of public-private partnerships established in each city region food system to implement waste-related innovations. A private partnership is established if a formal relationship exists and joint activities are being implemented.

"# of public-private partnerships established to implement sustainable sanitation, waste recycling, and food value chain innovations."

	Product type	**Targeted number of (Logframe freeze)**	**Nb.**	**Data reliability (H/M/L)**	**Remarks (bottleneck)**

DR Congo	compost	3	3	H	
Ethiopia	compost	2	2	H	Collection and processing
	banana flour	1	1	H	
	struvite	1	0	H	Did not work out
Rwanda	compost	1	1	H	
	cassava p. flour	1	1	H	
	BSFL	2	1	H	Waste-sourcing from COPED did not work
	sanitation	ND	2	H	
South Africa	compost	1	1	H	
	DEWATS	1	1	H	
	Biochar	1	0	H	Did not work out
Total	compost	7	7	H	
	banana flour	1	1	H	
	cassava p. flour	1	1	H	
	BSFL	2	1	H	

4.5.3 Output 5.3: Public-private partnerships are established to promote waste-derived fertilizers and the food products grown with waste-derived fertilizer.

We expected that food produced with waste-derived fertilizers will not be accepted by all communities and therefore the marketing of this food presented extra challenges in some of the city region food systems. Thus public-private partnerships were needed to co-produce the knowledge about these products and thereby enable the consumption of agricultural products that were grown on waste-derived fertilizer. The reluctance versus the consumption of these products was expected to depend on the communities in each city region food system and thus the set targets have been co-defined during Y1 with public and private stakeholders.

Output	**5.3 (8) Programme Public-private partnerships are established to promote waste-derived fertilizers and the food products grown with waste-**

	derived fertilizer.	
Activities carried out	Establishment of the PPPs though the MoUs for the food-centered innovations	
Progress	finalized	
Milestone(s) achieved	Signing of the MoUs Termination of the time-frame of the MoUs	2020 2023
Any action required	Setting new MoUs for Phase 2	
Status	In progress	

During Phase 1, we only had two TdIPs centered around food: Anjonus with the banana flour products, and AKANOZE with the cassava peels. Several other TdIPs were indirectly related to food production, and this aspect did only come into the MoUs in a marginal way.

Output 5.3: Number of public-private partnerships in each city region food system to promote food products grown with waste-derived fertilizer.
"# of public-private partnerships in each city region food system to promote food products grown with waste-derived fertilizer."

	Product type	Targeted number of (Logframe freeze)	Nb.	Data reliability (H/M/L)	Remarks (bottleneck)
DR Congo	compost	3	0	H	Planned for Phase 2
Ethiopia	compost	2	1	H	Collection and composting taken together
	banana flour	1	1	H	
	struvite	1	0	H	Did not work out
Rwanda	compost	1	1	H	
	cassava p. flour	1	1	H	
	BSFL	2	1	H	
	sanitation	ND	1	H	Only for AFS

South Africa	compost	1	1	H	
	DEWATS	1	1	H	
	Biochar	1	0	H	Did not work out
Total	compost	7	3	H	
	banana flour	1	1	H	
	cassava p. flour	1	1	H	
	BSFL	2	1	H	

4.6 Programme Outcome 6 – Identification and testing of suitable innovations

A number of suitable (i.e., societally acceptable and economically viable) innovations have been identified to support the establishment of a circular economy in each city region food system. Cost-benefit analysis, social acceptability study, and resource needs have been provided for each potential innovation.

4.6.1 Output 6.1: Key innovations are selected to be implemented and tested in Y2 and Y3.

To conclude the first year and the identification of suitable innovations, the RUNRES team of each city region conducted a stakeholder workshop to select those innovations which are considered to be most promising in terms of successful implementation and piloting in Y2 and Y3 and that can provide the biggest benefits to both men and women of all ages. In this workshop, stakeholders ensured that the selected innovations would be supported by the local municipality, be rooted in stakeholder co-investment models to ensure their sustainability, and be aligned with existing policies and ongoing activities. The selection of the innovations has been evidence-based following a number of pre-identified criteria (e.g. co-investment through private-public partnerships, technical and financial feasibility, gender and youth specific benefits, etc.).

Output	**6.1. (9) Key innovations are selected to be implemented and tested in Y2 and Y3.**
Activities carried out	Selection and establishment of viable innovations in the four RUNRES regions
Progress	partially finalized

Milestone(s) achieved	DRC: establishment of 3 TdIPs Ethiopia: establishment of 3 TdIPs Rwanda: establishment of 5 TdIPs South Africa: establishment of 3 TdIPs	2020 2020 2020 (2021 for AFS and CEFAPEK) 2020 (2023 for Umgeni-DEWATS and BALL)
Any action required	Renewing the MoU for Phase 2 for the innovations selected for Phase 2. Continuing of the implementation for the innovations that are not finalized yet (AFS, BALL and Umgeni-DEWATS).	
Status	Finalized for 11 innovations, ongoing for 3 others (AFS, CEFAPEK, Umgeni-DEWATS)	

Following the development of the different TdIPs in 2019-2020, MoUs were finalized for 12 innovations in the four RUNRES regions. Two innovations started later, with relatively small budgets in Rwanda: AFS with a DEWATS, and CEFAPEK for a tiger worm UDDT. Some innovations did not come to function: MASSP in Ethiopia, RUSUS in South Africa (biochar), and some are still in the establishment process: AFS in Rwanda, and Umgeni in South Africa.

4.6.2 Output 6,2: The potential of possible innovations is scientifically assessed and outlined for each city region food system.

An iterative process between scientific study and testing of innovations was carried out to identify suitable innovations for generating a circular economy. This means that before any potential innovation was tested, there was a scientific study to evaluate if it has any potential to be a real solution. The scientific analysis for waste-related innovations required for each of them a Cost-Benefit Analysis (CBA), a study on its social acceptability, a study on age and gender related barriers and potential impact, and legal and regulatory analysis to implement it. We carried out the different preliminary studies in the context studies, finalized by 2021.

Innovations on food processing required studies on the level of value addition, market potential, potential for women and youth inclusion, as well as legal and regulatory status. These studies have been coordinated by the project coordinators to ensure similar results are being produced and knowledge is being shared among the four city region food systems. The postdoc in each city region food system has also been responsible to collect data and perform the analysis together with additional support from research assistants and the Coordination Unit.

Output	**6.2. (10) The potential of possible innovations is scientifically assessed and outlined for each city region food system.**	
Activities carried out	Context studies were carried out in the four RUNRES regions. These studies included evaluations of: the agricultural system, the food value chains, the waste stream quantities, the socio-economic context, and the existing policy situation.	
Progress	finalized	
Milestone(s) achieved	Context study report finalized	2021
Any action required	none	
Status	finalized	

4.6.3 Output 6.3: Project area analysis is conducted for each city region food system.

To enable a circular economy, the local context strongly determines which innovations can be successful in effectively addressing nutrient gaps, waste management problems and inefficiencies in food value chains. Hence, in a first step, the existing waste streams and food value chains were mapped in each location. Subsequently, legal frameworks as well as policies of agricultural and sanitation sectors needed to be studied to understand the complexity of the underlying challenges. Furthermore, we commissioned an in-depth gender and youth study to understand the role of gender and age related to the RUNRES project. This study aimed at identifying age and gender related roles, needs, barriers and potential impact at the household and community level related to the potential innovations for waste management and value chain development. The identified gender and age dynamics were considered and addressed during the implementation of innovations.

Output	**6.3. (11) Project area analysis is conducted for each city region food system.**	
Activities carried out	Context studies were carried out in the four RUNRES regions, where we mapped of the different possible waste-streams to be addressed in RUNRES Phase 1.	
Progress	finalized	
Milestone(s) achieved	Context study report finalized	2021

Any action required	none
Status	finalized

4.7 Programme Outcome 7 – Well-functioning transdisciplinary innovation platform

Transdisciplinary innovations platform that includes male and female stakeholders of all ages, are functioning in each city region food system, and were supposed to have a theory of change specific to their city region food system.

4.7.1 Output 7.1: Commitments of stakeholders to co-implement solutions are secured.

The project coordinators in each city region food systems were responsible to secure concrete commitments (i.e. with Terms of References, MoUs) from the co-identified stakeholders to co-design and co-implement potential innovations. This has been heavily based on the information gained from the stakeholder analysis and kick-off meeting, the project area analysis, and the development of a theory of change in the TdIPs. Once innovations were prioritized, specific co-investment agreements and MoUs were established to facilitate focused innovation design and testing with subsets of partners.

Output	**7.1. (12) Commitments of stakeholders to complement solutions are secured.**	
Activities carried out	Co-developed the different innovations in the four RUNRES regions, and formalized the commitment of the different stakeholders though a series of MoUs, one for each TdIP.	
Progress	finalized	
Milestone(s) achieved	MoU signed	2020
Any action required	none	
Status	achieved	

4.7.2 Output 7.2: A theory of change is developed for each city region food system.

After the kick-off meeting was held in each city region food system and a mapping of the stakeholders was done, additional stakeholder meetings were organized by the project coordinators to foster a common understanding of what the project is aiming to achieve and to map the agri-food systems in a participatory way. The stakeholder analysis of the agri-food system was complemented by scientific analysis performed by the RUNRES scientists. This revealed the key opportunities and gender-specific barriers for optimizing agri-food systems, which provided further input for the co-development of the theory of change for the particular city region food system. The theory of change guided RUNRES in identifying what combination of innovations were required, acceptable and supported to overcome the main bottlenecks in the agri-food system. While this exercise was carried out at a project level, we did not carry out this exercise for each TdIP. However, each TdIP had a set of target values to be achieved that fit to the overall ToC of the project. The different data were collected through the monitoring and were used in aggregated form to showcase the achievement of the project in Phase 1.

Output	**7.2. (13) A theory of change is developed for each city region food system.**	
Activities carried out	Not carried out at a TdIP level	
Progress	only partially achieved	
Milestone(s) achieved	A set of metrics for the success of each TdIP has been set	2020
Any action required	none	
Status	partially finalized	

4.7.3 Output 7.3: The stakeholders for a transdisciplinary innovation platform are identified in each city region food system.

Preliminary work on the identification of stakeholders was carried out in the preparatory phase of this project, but the project coordinators performed a thorough stakeholder analysis (including social network analysis) of the stakeholders in each city region food system. This mapping was carried out through the Stakeholder Identification Protocol.

The stakeholder analysis provided information on existing stakeholders, their organizational structures, their current level of interactions and the potential resources (e.g., financial, natural

and human capital) that they could contribute to implement the innovations within RUNRES. The analysis also elucidated the gender and age specific roles stakeholders could play in the innovation and implementation part of RUNRES.

Based on the analysis we designed the different stakeholder meetings, and invited them for a kick-off meeting of the RUNRES project. We put a particular focus on including both male and female stakeholders of different ages in the project kick-off meeting and in creating an enabling environment for active participation by all stakeholders. At this kick-off meeting, the joint problem was identified by applying the Soft System Methodology (step 1: rich picture technique). This kick-off event was also meant to collect the expectations regarding the project of the new stakeholders (e.g. via outcome space technique) and provided project partners and stakeholders with skills, tools and knowledge on how to implement participatory approaches in the subsequent workshops.

In parallel to organizing the kick-off meeting, the project coordinators interacted with the partnering municipalities. The objective of this interaction was to establish a focal person from the municipality who is close to the mayor, and could support the implementation of RUNRES and ensure the participation of the municipality in the TdIPs.

Output	**7.3. (14) The stakeholders for a transdisciplinary innovation platform are identified in each city region food system.**	
Activities carried out	Stakeholder identification protocols were elaborated among the RUNRES team and filled by the project coordinators.	
Progress	finalized	
Milestone(s) achieved	Stakeholder identification protocols filled by the end of 2019 MoU for each TdIP signed	2019 2020 (2021 for AFS and CEFAPEK in Rwanda)
Any action required	none	
Status	finalized	

5 Partners & Stakeholders

The following tables summarizes our relationship with key partners and institutional stakeholders during the reporting period, sorted for each RUNRES region.

Partner / Stakeholder	Engagement update for the DRC
Bukavu municipality	The Bukavu municipality is determined to support the scaling up of the promising innovations implemented in RUNRES Phase 1 by making its technical team available to the project and by directly involving the avenues' and houses' chiefs to support waste management RUNRES activities.
Kabare Kingdom	As result of the knowledge exchange workshop organized at the IITA Kalambo station, the stakeholders committed to supporting IITA in scaling up the achievements of RUNRES Phase 1. This is the case of the King of Kabare territory who promised land which will serve as a composting site for Phase 2.
SNV	SNV, the national extension service is ready to be deployed to promote the RUNRES innovations end products and organize campaigns to raise awareness among Bukavu households on sorting waste at source and subscribing to the waste collection service.
ORHEOL	Orheol is committed to supporting potential RUNRES Phase 2 partners (Diobass and Wa-Kongo) in developing their business plans. The first drafts are almost ready to be submitted to the steering committee for evaluation and validation.
WA-KONGO	One of the potential partners with significant scaling capabilities and high co-funding capacity has been identified, selected and is already engaged in the development of the composting business plan to be implemented in Phase 2 of the RUNRES project (B setting).
OLAM	An agreement has already been signed between IITA (RUNRES-EiA) and OLAM for supporting the implementation of activities on valorization of coffee pulps produced in coffee washing stations to produce the larvae of black soldier flies.

Partner / Stakeholder	Engagement update for Ethiopia
USAID	CATALYZE MS4G program funded 12’472’875 ETB (220’000 USD) to help increase organic fertilizer market-linkage development (July, 2023 to June, 2024). While using this fund, ENMCPA trained 50 Agricultural extension workers, 40 lead/model farmers and conducted 30 farmers field days with 120 average participants to train theoretically and practically how to apply compost on banana, apple, maize and sorghum crops in the Gamo, Konso, Gerdula, and Alle zones.
Arba Minch Municipality Office	Facilitating organic waste collection and composting via deploying two drivers paying a monthly salary for the last two years. Also, they support waste collection Associations via subsidizing fuel and lubricants for waste collecting vehicles.
TechoServe	Collaborating and designing training food fortification and food handling safety measures for Anjonus.
GIZ	Collaboration, supportive action and resource allocation for laboratory equipment purchase for Anjonus.
Gamo Zone Job creation and Enterprise development Department	Regulatory bodies. They are working with both ENMCPA and Anjonus for production site expansion and marketing shops provision.
AMU	Specifically, the College of Natural and computational, Chemistry and Biology laboratories are providing basic laboratory testing service to Anjonus.
Lante Fruit and Vegetable production and marketing cooperatives	Facilitates bulk compost purchase of ENMCPA and serving as banana supplier for Anjonus.

Partner / Stakeholder	Engagement update for Rwanda
SPARK and EQUITY BANK	We had the first meeting to discuss about how RUNRES stakeholders can benefit from financial products at affordable rates. SPARK has a guarantee fund from which RUNRES stakeholders can benefit by accessing loans at cheap rates.
Circular Food Systems for Rwanda Project	We created a partnership to influence circular economy policies and the development of standards for circular economy products.
Global Green Growth Institute (GGGI), Rwanda country program	GGGI is working and investing in waste management. We created a partnership to share knowledge in waste management and recycling.
GIZ	GIZ is working on municipal waste management. We created a partnership around the advocacy for the public and private sector to adopt circular economy practices.
RAB (Rwandan Agricultural Board)	Samples from COPED and CEFAPEK were sent to RAB for testing. The collaboration with RAB also entails the promotion of alternative sources of carbohydrates and proteins for animal feed production. RAB participated in the end-project knowledge-sharing meeting. We are exploring collaboration in the establishment of knowledge centers for BSFL and HQCP innovations.
RSB (Rwandan Standards Board)	Collaboration to analyze the products from various innovations as part of the QUAP: RSB issued the standards for compost and animal feed. RSB tested the samples of COPED compost.
RICA (Rwanda Institute for Conservation Agriculture)	Collaboration to analyze products from various innovations as part of the QUAP: RICA issues the export permits for compost samples that are tested in laboratories outside Rwanda.
ACELI and SNUPP	Contact was made several times, but it was found difficult to engage our stakeholders with them due to both focussing on rather well-established entrepreneurs.

Partner / Stakeholder	Engagement update for South Africa
FID	Submission of a proposal for a project aiming to build the capacity of South African policymakers to design, test, pilot, evaluate, and scale sustainable innovations in water and sanitation, waste management, and agricultural spheres (CAB-CEAT). Reaching the final rounds, final decision due in 2024.
Department of Water and Sanitation (DWS)	The stakeholder has committed to co-financing a scaling type B setting and has put funds aside from a project called *Development of the Guidelines for Financial Mechanism and Economic Models to Facilitate Circular Economy in the Provision of Faecal Sludge Management Services*. This project draws heavily from lessons learned in RUNRES phase I as it seeks to test composting at municipality level. They are also still committed to scaling the DEWATS innovation as type once the concept has been proven by RUNRES.
Umngeni Uthukela Water	The stakeholder is committed to leading a scaling type B composting innovation. The manager for this water board is at advanced stage with the executive committee to secure funds for scaling. This partner has the required land and license requirement for working with sludge/human waste which is often a cause for delays in implementing innovations.
Municipalities: Ethekwini, Harry Gwala, Umngeni, Msunduzi, and Mpofana	These stakeholders have potential sources for green waste, as waste needs will be diverted from their green zones and landfills to the composting facilities. The municipality solid waste managers have been engaged with more meetings to come in the first half of 2024.
KwaZulu Natal Christian Council	The stakeholder has given permission to RUNRES South Africa to use their facility for the knowledge centre for the duration of phase II. The organisation also has a link to farmers through their Church Land Programme and these farmers will constitute the first intake of farmers to be given training at the knowledge centre.
Africa Co-operative Action Trust	The stakeholder has more that 45 years in farmer training and community development. They have agreed in principle to lead the training of farmers at the training centre.
Department of Forestry, Fisheries and Environment (DFFE)	The partner has been engaged through DWS and they will be part of the engagement during phase II as they are an important department for licencing.
Department of Tourism, Economic Development and Environmental Affairs	This stakeholder was an important partner in RUNRES phase I. The department helped the RUNRES team to understand regulations in South Africa. They are fully in support of the RUNRES phase II.

6 Challenges, Solutions & Lessons Learned

The following table summarizes the challenges we have faced during the reporting period and the lessons learned / solutions for each challenge. Here are only the challenges and lessons learned that apply to the project as a whole. Specific challenges and lessons learned to the RUNRES regions are also detailed in the country reports in the Annex.

Challenge	Lessons learned / solutions
Low organic waste quality	The quality of the organic waste was sometimes low. Organic waste had also non-organic material in it, and this required sorting at the waste treatment site. We therefore started waste-sorting campaigns, e.g. RANAS. Further campaigns will be expanded in Phase 2 where needed.
Market analysis	Our evaluation of the markets has been incomplete in Phase 1. For instance, we did not correctly estimate the willingness to pay for some of the products, like for compost, where the real willingness to pay were substantially lower than initially estimated.
Policy setting in mutation	The policy evaluation in the context studies had some limitations, by not considering that policies and their enforcement can vary over time. For instance, this led to the closure of one of the composting sites in Rwanda. For Phase 2, we will better involve policy makers to be up to date with all latest developments in term of policies regulating the food system.
Limited mapping of current and potential innovations	In Phase 1, we did not fully map what new and potential innovations have been ongoing in the different regions. We started with a relatively fixed set of innovations. A more throughout and systematic mapping would have enabled us to rely on a more robust "landscape" of innovations that require support.
Flexibility of interdisciplinary teams	In Phase 1, we relied on the RUNRES core staff to carry out a broad spectrum of activities. While this expanded the scope of capabilities of the core staff, having additional consultants for some specific aspects would have made the Phase 1 process more effective. For Phase 2, we hired consultants with specific skills for issues that cannot be well addressed by the RUNRES core team, like for the business aspects.
Implementation of the different innovations	Many challenges in the implementation of the different TdIPs are known to implementation experts, and having some on board would have been beneficial. This is partly addressed for Phase 2 with the Business Experts.
Monitoring the quality and quantities of the different materials and products	The elaboration of the monitoring tables (ME&L) and the QUAP took more time than expected. Our learning for Phase 2 is that monitoring plan should be a contractual element of the MoUs since the start of the TdIPs.

7 Outlook to RUNRES Phase 2

The main objective of RUNRES during Phase 2 remains to upscale safe, (cost-) efficient, and socially acceptable innovations to valorize urban and rural waste resources and enhance food value chains to enhance circular economies and thereby improve the resilience of city region food systems. RUNRES Phase II will achieve this by working again with transdisciplinary innovation platforms in Arba Minch, Ethiopia; Bukavu, eastern DRC; Kamonyi, Rwanda; and Msunduzi, South Africa.

Following RUNRES Phase I, we could show that some of the innovations are viable, although most of them showed limitations in terms of economic viability. The specific aim of RUNRES phase II is to overcome their limitations in terms of viability through up-scaling. The overall impact for RUNRES phase 2 is:

RUNRES will contribute to improved livelihoods, food security and environmental and human health in city region food systems through the implementation and scaling of innovations for circular food value chains.

The innovations selected for funding during RUNRES Phase II all have a demonstrated capacity to contribute to improved environmental and human health objectives, albeit at different points across the restructured circular food chains. For example, organic waste collected from urban centers of the city regions and transported and processed into compost have the capacity to provide critically needed organic soil inputs for farmers. These innovations simultaneously alleviate environmental and human health challenges in these urban centers, while also improving soil health and fertility in the adjacent agricultural zones.

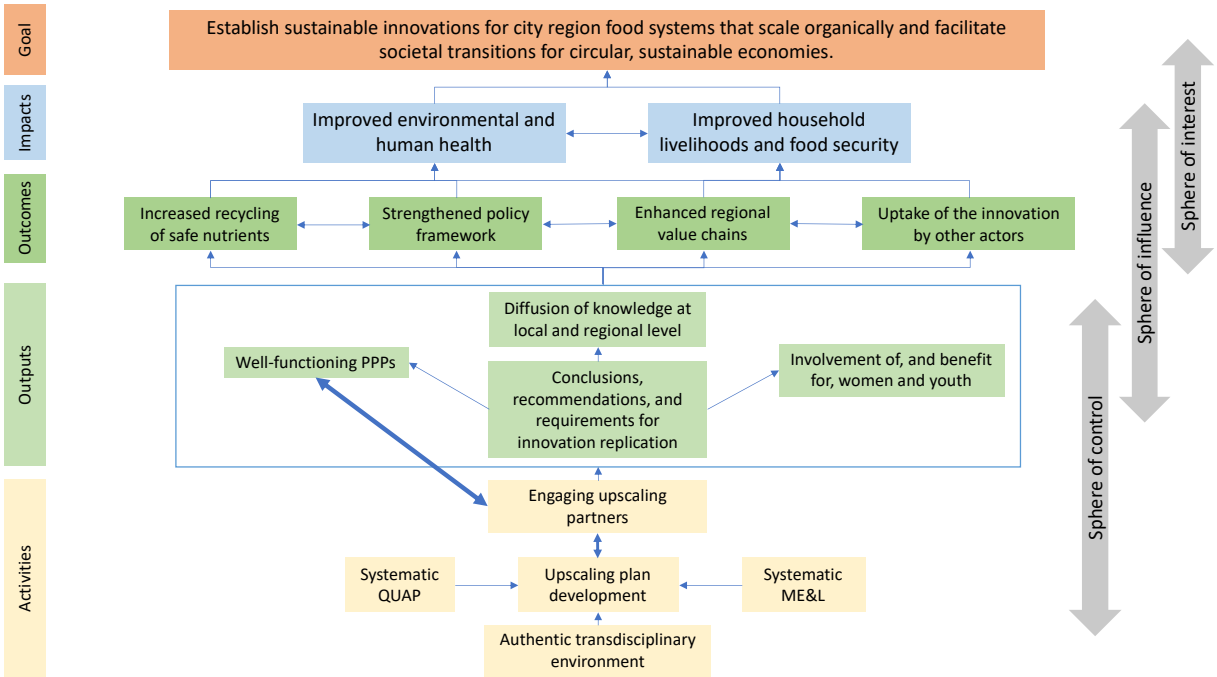

Figure 15: The RUNRES phase II theory of change. Developed collaboratively with the entire RUNRES core team.

The innovations piloted during the first phase of the RUNRES project were selected according to their viability for upscaling. This selection occurred according to the criteria set in the Innovation scalability matrix (ISM) and the Pathway identification questionnaire (PIQ). Through these two tools, the innovations viable for Phase II were selected to be scaled up. Meanwhile, the RUNRES Phase two will have two other settings for up-scaling. The setting for scaling the innovations up will be (see also Figure 16):

Setting A: Upscaling RUNRES Legacy innovations.

This setting will be the next step for existing consortia working on RUNRES innovations for the upscaling. In this setting, the existing consortia will work to have their innovation continue to grow, aiming to reach a larger output with a strongly decreased intensity of financial contribution through RUNRES.

Setting B: Replication with direct RUNRES contribution.

In this setting, some RUNRES innovations will be replicated through other consortia. To support this development, the RUNRES staff and the consortia in setting A will support and/or contribute to the development of these innovations. These innovations will be directly supported through RUNRES financial and technical means. However, the innovations of setting B will have to start at the same level of expertise as the innovation of setting A for Phase 2, since the technologies have already been tested and piloted in Phase 1. Hence, the financial contribution of RUNRES will be significantly lower per unit of output compared to Phase I.

Setting C: Supporting with indirect RUNRES contribution.

This last setting will take place in the form of only indirect support to implement RUNRES innovations by other actors that have their own financial means for implementation. The RUNRES project will not directly financially support these innovations but will indirectly help with the science underlying these innovations and their implementation.

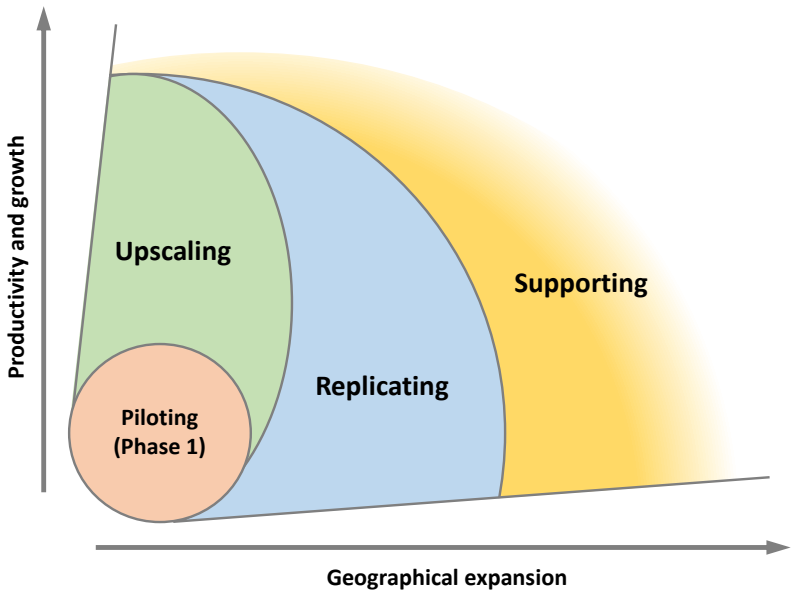

Figure 16: The scaling strategy of RUNRES Phase 2: The A-setting, where the initial innovations from Phase 1 will increase in size (Upscaling); the B-setting, where new innovations will be replicated and funded in other areas (Replicating); and the C-setting, where innovations in other projects with own funding will be supported, but without direct funding from RUNRES (Supporting).

After an intensive bottom-up approach we arrived at crucial decisions about which innovations would be scaled-up in which setting (A-B-C) and hence financial support from SDC:

City Region	Innovation(s)	Scal. Cat.	Main Scaling Partner	Most Likely Scaling Pathway	Remarks
DRC	Compost production	A	Diobass	PPP	Compost activities will be restructured. A new site located closer to the city will be developed. One of the three Phase I innovation leaders will be the leader of this new site.
	Compost production	B	Wakongo	Private	New actor in waste collection and treatment.
Arba Minch	Compost Production + enhanced solid waste management	B	Birbir municipality	PPP	Policy engagement is critical for upscaling of compost production in Ethiopia
	Compost Production + enhanced solid waste management	A	Egnan New Mayet	PPP	This innovation has potential to support strengthened and improved policy frameworks. Engagement and advocacy needs to happen.
	Banana Value Addition	A	Anjo Nus	Private	Leadership challenges still an issue and pose a risk to the project. It is envisioned that this innovation will be phased out within 2 years.

	Compost Production + enhanced solid waste management	C	Gerese and Chencha Municipalities	PPP	Policy engagement is critical for upscaling of compost production in Ethiopia
Kamonyi	Animal feed production	B	Garuka, Lisocom	Private sector	The IITA team in Rwanda is working to create blended finance opportunities for these innovations.
	BSFL and compost production	A	Maggot Farm Ltd.	Private Sector	Maggot Farm will be connected more formally to research groups at UR to develop finished feed products.
	BSFL and compost production	B	Indintabwe Beyond more technologies	Private Sector	New actors in BSF rearing
	Cassava peel processing	A	Akanoze Ltd.	Private Sector	Drying is a key impediment to scaling, not only for AKANOZE, but for numerous other innovations.
	Tiger worm toilets	C	CEFAPEK	PPP	CEFAPEK has piloted a very successful on site, UDDT system. This should be used to support updated sanitation policies in Rwanda.
South Africa	Compost Production + Agroecology living labs (BALL)	B	Lineage Water and Waste Services, KZNCC	PPP	The possible funding channels for DWS needs to be identified.
	DEWATS	C	Dept of Education, Water and Sanitation	PPP	Public funding through Umgeni Water

8 List of Acronyms

AMU	Arba Minch University
BALL	Bishopstowe Agroecology Living Lab
BSF(L)	Black soldier fly larvae
CGIAR	Consultative Group on International Agricultural Research
COPED	Company for Protection of Environment and Development
CU	Coordination Unit
DEWATS	Decentralized Wastewater Treatment Systems
DIOBASS	Démarche pour une Intégration entre Organisations de Base et Autres Sources de Savoirs
DWS	Department of Water and Sanitation
EMNCPA	Egnan New Mayet
FID	Funds for Innovation in Development
GIZ	German Development Cooperation
HEDF	Human excreta derived fertilizer
IITA	International Institute for Tropical Agriculture
KZNCC	Kwazulu-Natal Council of Churches
ME&L	Monitoring, Evaluation and Learning
MoU	Memorandum of Understanding
PI	Principal Investigator
PPP	Public Private Partnership
QUAP	Quality Assurance Program
RAB	Rwandan Agricultural Board
RANAS	Risks, Attitudes, Norms, Abilities, and Self-Regulation
RBET	Reach, Benefit, Empowerment, Transform
RICA	Rwanda Institute for Conservation Agriculture
RSB	Rwanda Standards Board
SC	Steering Committee
SDC	Swiss Development Cooperation
SME	Small and Medium Enterprise

SSA	Sub-Saharan Africa
SSNUP	Smallholder Safety Net Upscaling Program
TdIP	Transdisciplinary Innovation Plan
UDDT	Urine Diversion Dry Toilets
UKZN	University of Kwazulu-Natal
WASH	Water Sanitation and Hygiene Research & Development Center (UKZN)
ZHAW	Zurich University of Applied Sciences

9 List of Annexes

9.1 Business syntheses Phase 1

9.1.1 DR Congo

Country: DRC
Innovation: Compost
Entrepreneur: GASD

Break even analysis for various sale volumes and price

Production volume (MT/yr)	100	500	1,000	2,000	3,000	5,000
Total cost per kg at factory gate (US$/Kg)	0.283	0.199	0.188	0.183	0.181	0.180
Current selling price (US$/Kg)			0.06			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (RWF)	Y1	Y2	Y3	Y4	Y5
Total revenue	5,640.0	5,499.0	7,148.7	10,008.2	14,011.5
Gross profit	-11,052.0	-11,589.4	-17,343.3	-25,995.1	-38,913.3
Net income	(27,502.0)	(28,861.9)	(35,479.4)	(45,038.0)	(58,908.4)

Overall project returns

	Project perspective
Net Present Value (5 year + TV)	-$157,135
Internal Rate of Return (5 year + TV)	N/A

Comments

- The unit requires more than 5,000 MT of annual sales at US$/Kg 0.18 to break-even, while the current projection shows a maximum sale of 300 MT/year at US$/Kg 0.06.
- As a result, the investment is not profitable with the current parameters since the NPV is negative

IITA is a member of the CGIAR System Organization.

www.iita.org | www.cgiar.org

Country: DRC
Innovation: Compost
Entrepreneur: DIOBASS

Break even analysis for various sale volumes and price

Production volume (MT/yr)	100	200	300	400	500	5000
Total cost per kg at factory gate (US$/Kg)	0.160	0.151	0.147	0.146	0.145	0.141
Current selling price (US$/Kg)			0.04			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (US$)	Y1	Y2	Y3	Y4	Y5
Total revenue	3,920	4,025	4,427	4,870	4,870
Gross profit	-9,906	-10,881	-13,650	-16,009	-17,053
Net income	-13,279	-14,400	-17,323	-19,843	-21,057

Overall project returns

	Project perspective
Net Present Value (5 year + TV)	-$69,955
Internal Rate of Return (5 year + TV)	N/A

Comments

- The unit requires more than 5,000 MT of annual sales at US$/Kg 0.141 to break-even, while the current projection shows a maximum sale of 130 MT/year at US$/Kg 0.04.
- As a result, the investment is not profitable with the current parameters since the NPV is negative

Country: DRC
Innovation: Compost
Entrepreneur: FESDD

Break even analysis for various sale volumes and price

Production volume (MT/yr)	100	200	300	400	500	50000
Total cost per kg at factory gate (US$/Kg)	0.157	0.141	0.135	0.132	0.131	0.125
Current selling price (US$/Kg)			0.06			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (US$)	Y1	Y2	Y3	Y4	Y5
Total revenue	6,920.0	11,440.0	14,872.0	20,820.8	29,149.1
Gross profit	-3,237.8	-8,850.7	-14,209.7	-21,929.3	-33,693.5
Net income	-8,583.7	-14,440.1	-20,054.6	-28,042.6	-40,088.6

Overall project returns

	Project perspective
Net Present Value (5 year + TV)	-$86,674
Internal Rate of Return (5 year + TV)	N/A

Comments

- The unit requires more than 5,000 MT of annual sales at US$/Kg 0.125 to break-even, while the current projection shows a maximum sale of 400 MT/year at US$/Kg 0.06.
- As a result, the investment is not profitable with the current parameters since the NPV is negative

9.1.2 *Ethiopia*

Country: Ethiopia
Innovation: Banana
Entrepreneur: Anjonus

Break even analysis for various sale volumes and price

Production volume (MT/yr)	1	2	3	4	5	10
Total cost per kg at factory gate (ETB/Kg)	710	424	328	281	252	195
Current selling price (ETB/Kg)			350			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year	Y1	Y2	Y3	Y4	Y5
Quantity of product sold (Kg)	2,700	3,900	4,563	6,388	8,943
Total revenue (ETB)	945,000	1,365,000	1,597,050	2,235,870	3,130,218
Gross profit (ETB)	573,771	801,969	870,782	1,168,256	1,560,826
Net income (ETB)	-228,876	-24,462	22,617	221,999	487,505

Overall project returns	Project perspective
Net Present Value (5 year + TV)	ETB 589,088
Internal Rate of Return (5 year + TV)	22.9%

Comments

- The unit projects to break even from year 3 with more than 4.5 MT of annual sales, at a selling price of ETB/Kg 350.
- The investment in the BSF unit is profitable since it generates a positive NPV of ETB 589,088 and an IRR of 23%, higher than the cost of capital.

Country: Ethiopia
Innovation: Compost
Entrepreneur: Egna New Mayet

Break even analysis for various sale volumes and price

Production volume (MT/yr)	100	300	500	700	900	1000
Total cost per kg at factory gate (ETB/Kg)	6.8	3.8	3.2	2.9	2.8	2.7
Current selling price (ETB/Kg)	3					

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (ETB)	Y1	Y2	Y3	Y4	Y5
Total revenue	622,129	1,244,258	2,488,517	2,737,369	3,011,105
Gross profit	169,751	294,265	393,781	317,948	216,675
Net income	-411,779	-301,603	-217,142	-308,782	-426,653

Overall project returns	Project perspective
Net Present Value (5 year + TV)	ETB 1,245,100
Internal Rate of Return (5 year + TV)	N/A

9.1.3 *Rwanda*

Country: Rwanda
Innovation: Black Soldier Flyer Larvae
Entrepreneur: Maggot Farms Ltd

Break even analysis for various sale volumes and price

Production volume (MT/yr)	18	20	30	40	50	100
Total cost per kg at factory gate (RWF/Kg)	**1,210**	**1,128**	**883**	**761**	**687**	**541**
Current selling price (RWF/Kg)			**700**			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected pricing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (RWF)	Y1	Y2	Y3	Y4	Y5
Total revenue	18,684,000	37,368,000	63,360,000	63,360,000	63,360,000
Gross profit	10,072,232	19,283,287	33,821,635	32,344,717	30,793,953
Net income	**(9,464,565)**	**(451,174)**	**9,715,739**	**8,529,349**	**7,283,639**

Overall project returns	Project perspective
Net Present Value (5 years + TV)	RWF 16,428,018
Internal Rate of Return (5 years +TV)	28.9%

Comments

- **With more than 60 MT of annual sales, the company demonstrated its ability to break even and generate margins at a selling price of RWF/Kg 700.**
- **The investment in the BSF unit is profitable since it generates a positive NPV of RWF 16,428,018 and an IRR of 29%, higher than the cost of capital (18%)**

Country: Rwanda
Innovation: High Quality Cassava Peels as animal feed ingredient
Entrepreneur: Akanoze

Break even analysis for various sales volumes (minimum cost per kg, with cost of capital)

Sale volume (MT/yr)	50	76	150	200	250	300
Total cost per kg at factory gate (RWF/Kg)	**365**	**249**	**138**	**110**	**93**	**81**
Current selling price (RWF/Kg)			**250**			

Key outputs and scenario analysis (HQCP in Rwanda)

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	Normal
Cost Scenario:	Normal

Financial metrics by year (RWF)	Y1	Y2	Y3	Y4	Y5
Total revenue	13,370,000	31,752,000	51,840,000	58,320,000	65,610,000
Gross profit	12,160,822	28,704,873	46,355,172	51,841,047	57,956,737
Net income	**(5,333,748.5)**	**7,563,331.9**	**19,620,467**	**23,147,602**	**27,099,959**
Net cash flow	(3,080,516)	8,089,169	20,146,304	23,673,440	27,625,796

Overall project returns	Project perspective
Net Present Value (5 year + TV	RWF 41,459,533
Internal Rate of Return (5 year TV)	49.4%

Comments

- **With more than 76 MT of annual sales, the company demonstrated its ability to break even and generate margins at a selling price of RWF/Kg 250.**
- **The investment in the HQCP unit is profitable since it generates a positive NPV of RWF 41,459,533 and an IRR of 49 %, higher than the cost of capital (18%)**

9.1.4 South Africa

Country: South Africa
Innovation: Co-Compost
Entrepreneur: Duzi Turf

Break even analysis for various sale volumes and price

Production volume (MT/yr)	1,000	2,000	2,500	4,000	5,000	6,000
Total cost per kg at factory gate (ZAR/Kg)	**2.34**	**1.21**	**0.99**	**0.65**	**0.54**	**0.46**
Current selling price (Zar/Kg)			**0.9**			

Key outputs and scenario analysis

NORMAL SCENARIO: Key outputs under selected costing and demand scenario

Demand Scenario:	**Normal**
Cost Scenario:	**Normal**

Financial metrics by year (ZAR)	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Total revenue	3,966,637	4,363,301	7,941,208	7,941,208	7,941,208
Gross profit	3,594,690	3,933,702	7,079,196	7,036,095	6,990,840
Net income	**806,019**	**973,254**	**3,288,387**	**3,207,398**	**3,122,359**

Overall project returns

	Project perspective
Net Present Value (5 year + TV)	**ZAR 8,966,585**
Internal Rate of Return (5 year + TV)	**109%**

Comments

- **With more than 4,000 MT of annual sales, the company demonstrated its ability to break even and generate margins at a selling price of Zar/Kg 0.9.**
- **The investment in the co-compost unit is profitable since it generates a positive NPV of ZAR 8,966,585 and an IRR of 109%, largely higher than the cost of capital**

9.2 Phase 1 QUAP report

9.3 End of Phase 1 report AMU Ethiopia

9.4 End of Phase 1 report IITA DR Congo

9.5 End of Phase 1 report IITA Rwanda

9.6 End of Phase 1 report UKZN South Africa