Knowledge Product

Case Study on the Business Model

Kaloola-BORDA Partnership

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Table of Contents

List of Figures

List of Tables

1 Background and Problem Analysis

With the Global Goals target year of 2030 fast approaching, enterprises, the government and various development agencies across the globe are accelerating their efforts to achieve the 17 Sustainable Development Goals (SDGs). In South Africa, this is no exception, with issues surrounding water, sanitation, land and climate change[1].

Figure 1. The state of community ablution blocks in eThekwini Municipality

Figure 2. The state of shared chemical toilets in informal settlements

In South Africa, the number of people using on-site sanitation or non-sewered sanitation (NSS) systems is 7 million, although little to no attention is given to the operations and management of these systems (Kelly, 2023). These systems can be found in rural, peri-urban and urban areas (in informal settlements that are found just outside of urban areas, or located as small pockets within urban areas). According to the latest housing data supplied by the Department of Human Settlements, there are 4 297 informal settlements across the country — which are home to more than two million households — most of which are concentrated in the major metropolitan areas of Johannesburg (210), Cape Town (464) and eThekwini (530) (Comins, 2023). These households still rely on shared public toilets (**Figure 1**)[2], shared chemical toilets (**Figure 2**)[3], buckets, and pit latrines, which are sometimes neither safe (human health, physical safety and environmentally), climate resilient, dignified or practical. eThekwini Metropolitan Municipality encompasses a large rural periphery with informal settlements and challenging topography. Approximately 73% of households had access to a basic level of sanitation in 2020. However, new approaches are required to overcome the challenges of maintaining existing infrastructure and expanding sanitation to less accessible areas (Carbonell *et al.*, 2023). An example of shared public toilets in the municipality is community ablution blocks (CABs) which suffer from: not being open 24/7, facilities that are leaking and not working, vandalism, unsafe and unlit toilets at night and you are sharing this intimate space with many others.

Innovative technologies, such as NSS systems, can provide solutions to these challenges as they are localised systems that can withstand terrain and climate issues. The sanitation economy is a large and growing market, with several opportunities for investment in South Africa, across the residential, commercial, and public sectors. The circular sanitation economy is an approach that views human waste as a valuable resource, rather than a waste product. This approach can help to alleviate pressure on water resources, create new jobs, and reduce environmental pollution (Zvimba and Musvoto, 2018; Delgado *et al.*, 2021; Musvoto and Mgwenya, 2022).

[1] **Reference**: United Nations Sustainable Development Goals - https://sdgs.un.org/goals

[2] **Reference**: GroundUp News Article (April 2023) - https://groundup.org.za/article/living-conditions-at-amaoti-transit-camp-are-inhumane-and-getting-worse-say-residents/

[3] **Reference**: IOL News Article (2024) - https://iol.co.za/dailynews/news/2023-10-06-cautious-nod-given-to-ethekwinis-new-sanitation-proposals/

2 Solution

Loowatt Ltd, a UK-based company, is a leader in sustainable and scalable sanitation and is set to expand in Africa and beyond (**Figure 3**). In South Africa, Loowatt's commercialisation partner is Kaloola.

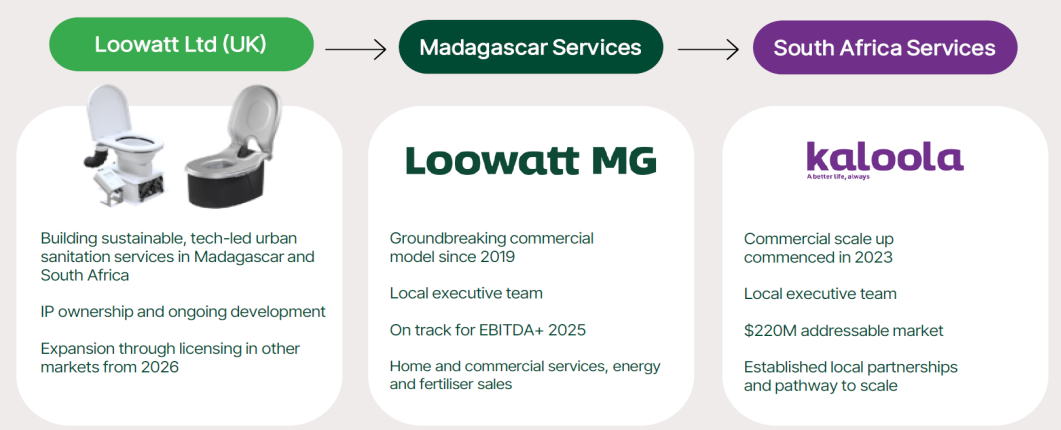

Figure 3. Infographic of Lowatt's global and African footprint in the sanitation market

Kaloola uses the patented **Loowatt System**™ (referred to as 'toilet' in the remainder of this report), a waterless flush toilet which hermetically seals waste (faecal sludge[4]) in a lining material (a polymer film) and transfers it to a container below the floor (**Figure 4**), locking away germs and odour and providing a clean bowl for every use. The toilet uses no water or chemicals, and even compared to low-flush toilets, the toilet can save South African homes more than 3 600 L of water every year (Loowatt, 2025).

Figure 4. The Loowatt System™ showing the flushing

In addition to the household level toilets, Kaloola has a commercial entity in the form of the Waterless Toilet Trailer (**Figure 5**), which specifically targets customers doing special events (*e.g.* weddings and music festivals), construction sites, corporate events and remote working areas (*e.g.* mining sites). Waste is collected in a durable, sealed liner below the toilet. This prevents exposure to odours or contamination, ensuring a clean and comfortable experience for users. The flush is activated with a soft-touch button, reducing contact points and enhancing hygiene. Once flushed, the liner neatly seals the waste, locking in unpleasant odours. An integrated ventilation system ensures air is continuously circulated, removing odours and keeping the space fresh for every user. Solar-powered LED lights are included for nighttime use, making Kaloola trailers ideal for both day and evening events in any environment. When the sealed liner is full, it can be easily removed and replaced without the need for messy desludging or exposure to

Figure 5. The Kaloola Waterless Toilet Trailer

[4] **Faecal sludge** can be defined as *a mixture of human excreta (urine and faeces), water and solid wastes (e.g. toilet paper). In this case, although there is no water, the waste is still classified faecal sludge*.

waste. This makes it low-maintenance and more cost-effective (Kaloola, 2025).

2.1 Partnership Goal and sub-goals of the P4G-funded project

In April 2024, a partnership formed between the Bremen Overseas Research and Development Association (BORDA) and Loowatt (as Kaloola) to advance a project funded by Unilever TRANSFORM and the South African Water Research Commission (WRC) aimed at turning Kaloola into a profitable business that is ready to:

i. receive local investment,
ii. be Broad-Based Black Economic Empowerment (BBBEE) compliant,
iii. scale up commercially in South Africa, and
iv. reduce carbon emissions through adoption of circular waste processing methods.

This was in partnership eThekwini (Durban) Municipality-water and sanitation unit, EWS, which is the utility in Durban.

The goal of the Kaloola-BORDA partnership, within the P4G funding period, is:

a) Broad-Based Black Economic Empowerment (BBBEE) compliant,
b) Scale up commercially in South Africa and
c) Identify feasible and viable treatment options for container-based toilets to reduce carbon emissions and have a closed loop system.

The sub-goals to be met are: Sub-Goal 1 - Strengthen Sales and Marketing; Sub-Goal 2: - Strengthen Enabling Environment and Sub-Goal 3 - Sustainable business and supporting team.

3 Methodology and Business model

3.1 Service-driven and customer-centric model

The Business Model chosen: Kaloola operates as a *monthly subscription sanitation service*.

An initial feasibility study was conducted by an independent party, Khanyisa Projects, to test user acceptance in an informal settlement with eThekwini Municipality. This was done with funding from the Water Research Commission. Through this research, they were able to determine the maximum amount of money customers were willing to pay for the toilet, which was R350. This subscription amount includes: the toilet, the top structure and weekly servicing. Servicing the toilets takes just a few moments and is a clean, easy job for servicers, with no heavy trucks or bad smells. There is no exposure to waste (by customers and servicing contractors), no waste building up around your home, and no faecal plume from misting flush water, all thanks to the unique sealing technology. Included in the weekly servicing is cleaning of the toilet, replacing the polymer film liner roll (6 metres in length), replacing the barrel that captures the waste and toilet paper.

3.2 Circular economy and sustainable approach

In Madagascar, the toilet captures waste as fresh feedstock for circular processing and then entities like *GasyGrow*[5] deliver the full potential of the circular economy by converting waste to biogas and fertiliser using anaerobic digestion. In South Africa, with funding from various entities such as Unilever TRANSFORM, the Water Research Commission and P4G, the Kaloola team is conducting scientific and evidence-based research to understand the best options for beneficiation of the waste and the polymer film to achieve a circular economy. This initiative aligns with broader sustainability goals and could contribute significantly to waste management and resource recovery efforts (Keohane, 2024).

[5] **Reference** '*Loowatt Madagascar*': https://loowatt.mg/

3.3 Kaloola Home and Kaloola Commercial

In 2025, Kaloola registered as a non-profit company (NPC) as 'Kaloola Home' to focus on the household customers whilst Kaloola, as a Pty Ltd, will focus on commercial trailer hire services. Future plans are to minimse operations under the PTY, and focus activities under the NPC. Through co-financing from Loowatt Ltd., Kaloola self-funded a demonstration trailer unit in 2024 which was first presented at Durban July for user experience and customer feedback, to very successful reviews. In Q4-2024 Kaloola began discussions with commercial lenders with the aim to construct at least 4 more trailers in 2025, such that the Durban fleet can begin to build traction as a viable business arm that can help cover overheads for the NPC. The business is now reassessing the best way to attain financing for the trailers, which will be operated by NPC, contributing to the entity's margins and overheads. Kaloola plans to gain traction in these two markets first before potentially moving to secure municipal contracts with the eThekwini municipality and later within other regions in South Africa.

4 Results

The results of the partnership, in terms of ESG and financial metrices, are covered in *section 4.1* and *4.2* below. For more details on specific outcomes from the partnership, please see article on P4G website on this link: https://p4gpartnerships.org/pioneering-green-partnerships/all-p4g-partnerships/kaloola-borda . The summary of the results from the research work that was done by UKZN WASH R&D Centre, to meet Goal c) and sub-goals 2 and 3 of the P4G funding period, can be found in *section 9.2*. These results are instrumental in disseminating the knowledge and to provide input into the POLICY BRIEF knowledge product. This report will be finalised by the end of the project.

4.1 ESG Metrics

The environmental, social, and governance (ESG) three pillars define responsible business behaviour. Environmental metrics for sustainability measure pollution, resource use, and carbon emissions. Social sustainability metrics track community impacts, employee welfare, and consumer satisfaction. Governance focuses on corporate governance, including corporate policies, ethics, and leadership transparency. Consideration of ESG factors can contribute to the environmental and economic performance of organisations in terms of investment and sustainability (Aksoy *et al.*, 2022; Ahmad *et al.*, 2024). The measured ESG metrices (**Table 1**) and the financial metrices (**Table 2**), for the Kaloola project, can be found in the tables below.

Table 1. Environmental, Social, and Governance (ESG) Metrics for Kaloola before and after P4G intervention

ESG Metrics	Before P4G Funding	After P4G Funding	Description
Carbon Emissions (tonnes CO_2e)	30 tonnes/yr	150 tonnes/yr	Based on a crude estimate - every latrine or open defecation scenario we offset arguably offsets 1T CO2e per year.
People positively affected	150	1,000	Based on 5 toilet users per household
Jobs created	9	13	Jobs created outside of the commercial partner
Gender Diversity (% female employees)	45%	65%	N/A
Compliance and Risk Management	Was not in a position to report	Converted Pty to a NPC and applied for PBO status. PPE registers SOP's developed around the Processing procedure	N/A

ESG Metrics	Before P4G Funding	After P4G Funding	Description
ESG Reporting and Transparency	The business was not in a position to provide these reports	The business is in a position to provide annual ESG reports with the 2025 report expected Q1-26	N/A
Board Diversity	0%	50%	% of Women of the board members

4.2 Financial Metrics

Table 2. The Financial metrics for Kaloola before and after P4G intervention

Financial Metrics	Before	After
Revenue	R209,476	R446,844
Gross Profit	(6,052.76)	(533,944.76)
EBITDA	R47,032.73	R185,146.07
Net Income	R39,784.26	R86,921.72
Operating Expenses	R98,033.08	R589,465.43
Cash Flow	R2,379,67	R500
Number of Consumers	100	156
Number of Offtake Agreements	100	150
Client Growth Ratio YoY	50%	100%
Gross Margin Ratio	-2.89%	-119.49%
Gross EBITDA Ratio	-777.05%	34.68%
Debt-to-Equity Ratio	0	0
Customer Acquisition Cost (CAC)	N/A	N/A
Lifetime Value (LTV)	N/A	N/A
Investment Achieved	R0	R1,056,600.00

4.3 Customer experience and feedback to date

There is a dedicated Customer Care Liaison who works closely with the clients and community members. The feedback Kaloola has received from our community members has been overwhelmingly positive. Customers consistently highlight the dignity, convenience, and comfort that Kaloola has brought into their lives. Many also appreciate our reliable servicing and the added benefit of local employment opportunities created through our operations. Kaloola is not just providing sanitation—it's restoring dignity, supporting livelihoods, and helping communities thrive. Three of Kaloola's customers (**Table 3**) granted consent to include them in the reporting.

Table 3. Customer feedback and experience from some clients

Customer 1: Mr Vayi Memela (83yr old)
Household user

"*I moved into this residence in 1996, and back then we only had communal toilets and showers. Now imagine, in my old age, having to queue for my turn—only to rush because someone else is waiting right after me. It was far from comfortable.*
"So when Kaloola came along, I was truly relieved. I now have my own household toilet just a few steps from my door. This has made a world of difference, especially as I'm not only elderly but also partially blind. Kaloola has brought real comfort and dignity to my life."

Customer 2: Ms Bonakele Mphanza
Household user and member of local committee

"*As one of the committee members, I can personally vouch for how much easier life has become with Kaloola. I no longer have to walk a long distance to use shared facilities—not even in heavy rain!" [she laughs]*
"In this community, we may not have much, but thanks to Kaloola, we now have access to dignified sanitation. That's something I truly can't emphasize enough. Kaloola has made a real impact here—not just through their services, but also by employing our local youth. They're now able to support their families, which means so much. I truly hope Kaloola expands into more communities like ours."

Customer 3: Mr Sibonakaliso Khoza
Local business owner and user

"*I run my own business, Shisanyama (eat out), and we previously relied on communal toilets, which were often overused and poorly maintained. That's when we turned to Kaloola as a better alternative. Their toilets are always clean, well-maintained, and serviced on time—I couldn't be happier. Now, my customers have access to safe, clean, and conveniently located toilets. This encourages them to stay longer and enjoy themselves, which ultimately benefits my business because they end up spending more*."

5 National Platform involvement

The Department of Forestry, Fisheries, and the Environment (DFFE) is the focal point for the partnership in South Africa and also fulfils the role of co-chair of the National Platform (NP) in partnership with the National Business Initiative (NBI). For this particular partnership, there was minimal involvement from the National Platform. The partnership engaged with the platform in May 2024 when the DFEE and NBI accompanied P4G to site visits and kick-off meetings at the beginning of the funding period. The following engagement was at the Vietnam Summit

in April 2025, when the Deputy Minister of DFEE met with he South African delegation to learn about the partnerships. The focus for DFFE was rotted in scaling up low carbon, inclusive and climate resilient interventions, as well as wildlife management, environment and climate change as well as fisheries and aquaculture. This bore a strong alignment to the other South African partnerships that dealt with renewable energy, electric vehicles and food systems/agriculture.

A more fitting NP for this partnership would have been the Department of Water and Sanitation.

6 Investor engagement

The following events were used to engage with potential funders/investors:

1. Africarena Summit (Kenya, 2024)
    - Kaloola pitched for funding and attained some interest, but no investment followed
2. Pitch to uMngeni-uThukela Water CSI (2024/25)
    - Kaloola attained a grant for circa US$50K to support sanitation service expansion
3. P4G Vietnam Summit (2025)
    - Kaloola raised awareness among international investors

As of this writing, Kaloola is registered as Kaloola Home NPC with confirmed PBO status. They are working hard to secure funds to cover the CAPEX costs required for service expansion. Loowatt Ltd. (UK) is subsidising their overheads until they reach EBITDA+, which we aim to have happen in mid-2026.

7 Challenges and solutions

Overall, a fair number of challenges were encountered during the grant period (**Table 4**), related primarily to access to finance, market-building, and the enabling environment.

Table 4. Challenges encountered during the project and possible solutions

Topic	Challenges	Solutions
1. Access to CAPEX finance for toilet assets	The Kaloola Home service model has already shown potential to be more cost effective than alternatives being funded by municipalities on both a CAPEX and OPEX basis, but access to supply chain finance remains remote. More work remains to be done to ensure that the home services can successfully scale up.	Kaloola Home formally registered as an NPC in early 2025, and in the near term will seek to fill the home toilets financing demand through grants from CSI budgets of large corporates. The first such financing was awarded to the company from Umgeni Water, of R 1.1M in June 2025. Going forward the business aims to build mechanisms that enable results-based financing from a wider range of funders.
2. Developing and proving South Africa's first B2C customer-paid toilet model	Kaloola faced early scepticism from municipal stakeholders about the potential and demand for customers to pay for individual home toilets in a context where 'free basic' services are available, and needed to develop new ways of accessing informal settlement markets to drive adoption and sales of service contracts.	Kaloola was able to get buy-in from local ward committees about the potential for the service enough to enter communities and commence sales. By late 2024 they were able to develop a sales and marketing method using 'activation events' in the local communities, while also leveraging community referrals and customer

Topic	Challenges	Solutions
		champions. They now have a waitlist of customers wanting toilets.
3. Government and regulator perception of Kaloola's product and service	South Africa has a long history of the use of bucket toilets informal settlements that has created a stigma for waterless toilet solutions. Sight unseen, we understand that some voices in key regulatory bodies such as the Department of Water and Sanitation still perceive our product as a form of 'bucket system'.	High levels of customer satisfaction and on-time payments plus customer referrals serve to prove that Kaloola toilets are different. The CSI funds leveraged in item 1 above was because the investor was finally swayed by customer feedback and satisfaction, when we brought them on site. Doing more public events such as launching and expanding the commercial service in VIP areas (such as backstage Durban July) help to change perception. But the most important way for stakeholders, particularly the regulator, to gain appreciation and understanding that Kaloola is using a form of flush toilet, will require further direct engagement through product demonstrations and through interacting with our current customers.
4. CAPEX cost reduction of toilets and superstructures	Kaloola will be able to deliver lower cost products if we can relocate production into South Africa and present a product where the toilet superstructure (cabin) is more integrated with the toilet. Localisation will also further increase local benefits through job creation and eliminate costs related to imports.	Kaloola has commenced production localisation including the required engineering work supported by Loowatt Ltd., ad discussions with South African manufacturers who could become potential partners.
5. Entrenched existing systems (CABs and Chemical toilets)	SA municipalities are slow to consider changing existing status quo systems; this appears to be especially true in supply chain divisions that have longstanding supplier relationships to deliver chemical toilets and maintain CABS.	Kaloola has nonetheless seen a trend in the appreciable unpopularity of chemical toilets, and political interest in adoption new systems. Kaloola must invest further in marketing and lobbying to spread awareness with municipal service providers that there are new ways to deliver high-quality non sewered sanitation to homes.
6. Circular economy sanitation solutions	At their current scale, Kaloola is not producing enough feedstock to make large scale machinery to support the circular economy cost-effective.	During the course of the grant, the business made significant advances in creating more agile, low-cost solutions for (a) waste separation – polymer film from organic waste to allow for separate processing (b) waste beneficiation with analysis completed, and work underway to secure funds for an agile, decentralised unit that converts waste to energy while recapturing nutrients.

8 Lessons learnt

The collaboration enabled the team to come away with several key lessons that will support our ability to secure investment funding and scale up the business:

1. With the right technologies and tools in place, there is confirmed demand for user-paid, in-home toilets in South Africa's informal settlements

2. When taking agency to choose an individual home toilet, customer treat their toilets better, like a part of home, significantly reducing risks of vandalism
3. User-paid models could offer municipalities a dramatically more cost-effective solution for delivering non-sewered sanitation services at scale
4. Subsidies are not needed to pay for OPEX in Kaloola's B2C business model once a certain scale is reached (now estimated at 400 toilets)
5. To support CAPEX financing, co-financing through cross subsidies from commercial services, CSI budgets, and potentially results-based financing could unlock enough capital to support B2C service expansion
6. There are significant opportunities for circular economy waste management of the toilet system outputs.

9 Concluding remarks

9.1 Support beyond grant funding

Kaloola Home NPC is working on a 3-staged plan to build business resilience and support rapid expansion in South Africa. P4G could potentially support all stages:

Stage 1: Continued service expansion. The NPC requires connections with CSI funders interested in immediate impact, which they can achieve through financing 800 further toilets for Kaloola to install in 2026. We have a waitlist of customers, and with 1,000 toilets in service the business will also be self-sustaining and in a position to reinvest in its own growth. P4G could help us find grant funders.

Stage 2: In tandem with stage 1, we are building out opportunities for commercial trailer hire. This may take the form of a joint venture with partners. Whatever form it takes, P4G could help link Kaloola to potential clients and customers for our toilet trailers.

Stage 3: By early 2027, Kaloola aims to have established a Revolving Capital Sanitation Asset Financing Facility (RECSAFF) which is in concept note stage as Loowatt was invited to develop a concept that can support much more meaningful scale in South Africa. This will require participation of public, private and philanthropic funding bodies in South Africa, who can over time not only support widescale impact, but become pioneers in innovative financing for non-sewered sanitation. P4G could engage with our concept note development in an information sharing session and help link us to relevant potential partners. P4G could potentially supply technical assistance and/or catalytic financing to help us quickly move the needle such that the RECSAFF can be established to support expansion into the 10,000+ toilets in operation within the next 3 years.

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11 Other

11.1 Value-added knowledge product 1: Project documentary

To document the business case and the project, a mini documentary was shot as value-added product of the project. It included members of the project team from Kaloola and BORDA, and also much needed input from the researchers at UKZN WASH R&D Centra, as well as the project manager fromP4G.

Link: https://youtu.be/0u4wdPElrAA?si=M2OR3iHstuEebAmw

11.2 Value-added knowledge product 2: Waste valorisation and Treatment options (MscEng work)

LOOWATT (KALOOLA) SLUDGE CHARACTERIZATION AND TECHNO-ECONOMIC ANALYSIS WITHIN A CIRCULAR ECONOMY FRAMEWORK

Final Draft Report

by

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Executive Summary

Proper management of sanitation waste is essential to ensure public health, protecting the environment and promoting sustainable development. However, the infrastructure required for effective sanitation management is costly to assemble and maintain, particularly in developing nations where water and sanitation systems are inadequate. Resource recovery from sanitation systems presents a sustainable solution, enabling the extraction of water, energy, and nutrients from waste streams. The LOOWATT (Kaloola) waterless toilet system, introduced in Durban, South Africa, captures and stores human waste in sealed liners to minimize bacterial exposure and odour. However, effective treatment and valorisation of the sludge remain a challenge. This study evaluated the physio-chemical characteristics of faecal sludge and the plastic liner collected from the Kaloola/Loowatt sanitation systems in Durban, along with investigations into potential treatment and valorization pathways that aligned with circular economy principles. Critical parameters that were subject to laboratory analysis included Chemical Oxygen Demand (COD), pH, nutrient concentrations such as phosphorous and nitrogen, microbial content, moisture content, total and volatile solids, ash content, viscosity, calorific value and electrical conductivity. The results indicated sludge with high moisture content (88%), moderate organic load and nutrient levels for resource recovery. The plastic liner analysis presented challenges due to its inert and non-biodegradable nature, hence treatment options such as pyrolysis would be recommended as a potential treatment and valorization pathway. Through the utilization of structured decision-making tools such as RAG analysis, decision matrix table and scoring system, anaerobic digestion and co-composting emerged as the most viable treatment options for the sludge based on the results. The low sludge production rates limited economic viability, hence co-processing with municipal organic waste was recommended to enhance feasibility. A techno-economic analysis, inclusive of capital costs, operational expenses, and revenue potential from valorised products was performed for further assessment. The techno-economic analysis of anaerobic digestion revealed a project that is not feasible, with a net present value (NPV) of R -98 044,85 and return on investment (ROI) of -13,5%. A sensitivity analysis conducted revealed increasing key metrics such as food waste concentration and decreasing capital costs would result in a breakeven NPV.

An environmental assessment based on CO_2 emissions compared a traditional waste disposal method in landfilling alongside the proposed anaerobic digestion technology to help us further understand sustainable waste management practices. In terms of greenhouse gas emissions, anaerobic digestion offers much clearer environmental advantages over landfilling. This process not only reduces overall carbon footprint, but also reduces the harmful emissions and odours released into the atmosphere. Although landfilling produces greenhouse gases in the form of methane and CO_2 due to the decomposition of the waste, anaerobic digestion process is able to capture the methane and convert it into biogas, a renewable energy source.

3.5 RAG Analysis

The RAG (red, amber, green) analysis in this report is used to determine the suitability and effectiveness of the common treatment methods of faecal sludge based on the parameters analysed. A RAG table is generally used in project management when determining the status of an ongoing project. It follows similar protocol to the 'traffic light system' to help with visual interpretation and prioritizing potential actions after making decisions (ClearPoint Stategy, 2025).

In the current analysis, the red indicates that the treatment is not ideal as it requires significant changes to improve the process viability. The amber indicates the treatment is suitable, but may require monitoring and/or potential adjustments to improve process optimization. The green indicates the process is highly efficient as the parameters align well with the treatment methods and the process conditions are favourable. An example of a RAG table is shown below.

Table 2: Example of a RAG table

PARAMETER	OPTION 1	OPTION 2
1		
2		
3		

Table 5: RAG Table showing treatment methods for the sludge.

Parameter	Literature Range	Anaerobic Digestion	Composting	Land Application	Biochar Production	Struvite Precipitation	Building Material	LaDePa
Ascaris eggs	15-150 g							
COD (380 - 1118 mg/L)	20- 50000 mg/L							
pH (7.79 - 8.14)	6.5 – 8 (8.2)							
Phosphates (4.8 - 9.3 mg/L)	4 – 15 mg/L							
Orthophosphates (4.4 - 6.1 mg/L)	3 – 9 mg/L							
TKN (28.34 mg/L – total average)	67 mg/L							

Moisture Content (87 - 90%)	-							
Volatile Solids (68 - 99%)	-							
Calorific Value (11.47 - 21.98 MJ/Kg)	8 – 25.6 MJ/Kg							
Electrical Conductivity (1323 - 20950 µS/cm)	-							
Viscosity	-							

5. Conclusion

This project evaluated faecal sludge from the LOOWATT (Kaloola) sanitation system to identify sustainable treatment and valorisation pathways within a circular economy framework. Laboratory characterisation, techno-economic analysis, and environmental impact evaluation were undertaken to guide feasible management strategies.

The sludge analysis showed high moisture content (87–90 percent), moderate COD values (390–1079 mg/L), and nutrient levels that support recovery, with average TKN of 28.32 mg/L and total phosphate concentrations between 4.8 and 9.3 mg/L. Volatile solids accounted for over 80 percent of the total solids, indicating energy potential, while calorific values averaged 19.3 MJ/kg. Microbial testing revealed extremely high contamination, with E. coli concentrations up to 10^{11} MPN/g and Ascaris egg counts as high as 71.4 per gram, confirming that untreated application is unsafe. Plastic liner analysis indicated calorific values of 29–35 MJ/kg when clean, comparable to coal, although smearing reduced energy yield and consistency.

Comparative evaluation of treatment methods showed anaerobic digestion and co-composting as the most suitable options. Anaerobic digestion benefits from high moisture and organic content, generating renewable biogas and digestate for fertilizer substitution, though relatively low COD may limit yields unless co-digested with food waste. Composting is equally viable due to favourable pH and nutrient content, producing pathogen-free soil amendments if moisture is corrected with bulking agents. Other methods such as biochar production, building material applications, and LaDePa face limitations related to energy demands or technological maturity, while struvite precipitation is constrained by low phosphorus levels. For plastic liners, pyrolysis is recommended over incineration, enabling resource recovery and lower emissions.

Techno-economic analysis of anaerobic digestion showed the process was not feasible at current sludge volumes (~100–150 kg/day), with an NPV of –R98,044.85 and a ROI of –13.5 percent. Sensitivity analysis indicated that reducing capital costs, increasing tipping fees, or raising food waste inputs could move the project towards profitability. Co-digestion with municipal organics is therefore essential for economic viability.

The environmental assessment confirmed that anaerobic digestion has a clear advantage over landfilling, which produced ~500 kg CO_2e/day due to methane emissions. By capturing methane for energy, anaerobic digestion reduced the carbon footprint and displaced fossil fuel use to an extent. Pyrolysis of liners was also shown to be environmentally preferable to incineration. In conclusion, anaerobic digestion and composting represent the most sustainable and context-appropriate pathways for sludge from the LOOWATT system, provided that integration with municipal organic waste and pyrolysis of liners are pursued to achieve economic feasibility and climate benefits.