

FEASIBILITY STUDY OF FOOD WASTE RECYCLING BUSINESS UTILIZING TTT ENZYME-BASED TECHNOLOGY

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Abstract

Driven by rapid urbanization and population growth, Indonesia is still struggling with food waste management, which raises major environmental, social and economic concerns. Conventional waste disposal methods such as landfilling and open dumping have exacerbated soil contamination, health risks and greenhouse gas emissions, therefore stressing the immediate need for more sustainable solutions. This study evaluates the feasibility of establishing a food waste recycling business utilizing TTT enzyme-based technology, which converts food waste into organic compost fertilizers within merely three hours – allowing significant improvement over traditional composting methods that typically require weeks or months. The research adopts a mixed methods and approaches, combining quantitative data collected from surveys targeting Jabodetabek and Bandung residents with qualitative data gathered from literature reviews and expert interviews. Key findings show that TTT enzyme-based technology promotes sustainable agriculture and support circular economy by offering faster processing, lower costs and greener environmental impact. Financial analysis results in strong viability and investment attractiveness, with a projected annual revenue of IDR 108.5 billion and a net profit margin of 27.66%. This study concludes that TTT enzyme-based technology has the potentials to transform food waste management in Indonesia, therefore fostering environmental sustainability and economic resilience throughout the nation.

Keywords: *food waste recycling, enzyme-based technology, sustainable waste management, circular economy, organic fertilizers.*

INTRODUCTION

As the world's fourth most populous country, Indonesia generates approximately 64 tons of solid waste annually, with food waste accounting for a significant portion. Rapid urbanization, population growth and industrialization have led to Indonesia facing mounting challenges in waste management. Conventional waste disposal methods such as landfilling and open dumping are not only environmentally harmful, but also exacerbate soil contamination, health risks and greenhouse gas emissions. Indonesian households generate approximately 14.73 million tons of food waste annually, with 34% of it still edible (The Food Waste Index Report 2024, UNEP). This staggering amount of food waste is an alarming bell that reminds all stakeholders about the pressing need of finding more sustainable solutions to address the issue.

Unfortunately, the waste management practices adopted in Indonesia currently are mostly inefficient and unsustainable. Composting, despite considered an environmentally friendly method, yet is not practical due to the lengthy processing time that would typically require weeks to months. This inefficiency has led to a growing interest in innovative technologies capable to expedite the composting process. One of such technology is TTT enzyme-based technology that can convert organic waste into organic compost fertilizers within just three hours, offering a promising breakthrough as an alternative to traditional composting methods.

The primary objective of this study is to evaluate the feasibility of establishing a food waste recycling business in Indonesia that utilizes TTT enzyme-based technology at its core. The specific aims of the study include :

1. Investigation into factors influencing people's awareness and willingness to participate in food waste segregation at home, the results of which will be used to formulate waste collection strategies for the food waste recycling business.

2. Assessment of the business potential of a food waste recycling plant utilizing TTT enzyme technology to convert food waste collected from residential areas and hotels into organic compost fertilizers.
3. Formulation of key strategies for sustainable business operations of the food waste recycling business, which include strategies for food waste collection, food waste processing and distribution of organic compost fertilizers.
4. Evaluation of the impact on economic, social and environment of the food waste recycling plant with TTT enzyme technology at its core.

Indonesia urgently needs to address its food waste management, as improper waste disposal has resulted in serious environmental and social implications, including soil and water contamination, increased greenhouse gas emissions, and public health risks. In addition to that, uncontrollable food waste also leads to a huge economic loss, as 1 trillion USD worth of food is wasted every year worldwide. As per estimates, the annual food waste in Indonesia could potentially provide free meals for 9.1 million people, highlighting the needs for more effective food waste management solutions.

TTT enzyme-based technology addresses these challenges in a sustainable and efficient manner. The technology not only reduces the impact of waste on the environment but also contributes to sustainable agriculture and the circular economy by effectively converting food waste it into valuable compost fertilizers within a very short time. This study aims to demonstrate the potential for this technology to be widely adopted in revolutionizing food waste management in Indonesia.

LITERATURE REVIEW

Overview of Food Waste Management Practices

Various methods have been employed to address the growing problem of food waste management, which has become a critical issue globally. Although widely adopted, but conventional methods such as landfilling, composting and anaerobic digestion come with its own set of challenges. Landfilling, for example, is the most common method of waste disposal but is also the most environmentally damaging, as it heavily contaminates soil and water, produce greenhouse gas emissions and pose serious public health risks (Nurhasanah et al., 2021). Compositing is generally more environmentally friendly, but requires large space and takes a long time, making it less feasible to be adopted for large-scale implementation, especially in urban areas (Cai et al., 2022). Anaerobic digestion method that converts organic waste into biogas is a good renewable energy source, but requires substantial upfront investment and technical expertise (Salam et al., 2021).

Enzyme-Based Composting Technology

Enzymes, which act as biological catalysts to accelerate the decomposition of organic waste, has emerged as a promising alternative to traditional composting methods in recent years as it offers significant reduction in the time required for composting. Enzymes such as cellulases, ligninases and proteases accelerate food waste decomposition by breaking down complex organic materials and optimizing carbon-to-nitrogen ratio that is essential to reach compost maturity (Raut et al., 2008).

Innovations in enzyme technology such as membrane-covered aerobic systems and enzyme immobilization techniques such as nanoenzymes and CLEAs have proven to improve enzymatic stability and reusability, allowing efficient large-scale composting (Chakraborty et al., 2023). Studies also show enzyme treatments not only reduce composting time from 52 days to 9 – 12 days, but also enhance soil organic matter and biodiversity that is crucial for sustainable agriculture (Nalladiyil et al., 2023).

TTT enzyme-based technology, developed by a Taiwanese company, is capable to convert organic waste into organic compost fertilizers within merely three hours, offering a significant improvement over conventional composting methods that typically take weeks or months (Xu et al., 2023). Not only it reduces the environmental impact of food waste, but it also produces high-quality organic compost fertilizers that can improve soil fertility and therefore support sustainable agriculture and circular economy.

Food Waste Management in Indonesia

Food waste management in Indonesia remains largely conventional, with heavy dependence on environmentally-damaging methods such as landfilling and open dumping, leading to environmental degradation, land-use conflicts and heavy pollution from open burning and river dumping, posing serious health risks to citizens (Farahdiba et al., 2023). This issue is constantly worsened by rapid urbanization and increase in waste generation

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driven by changing consumption patterns. While some efforts have been made to adopt more sustainable practices such as composting and anaerobic digestion, yet these methods have not seen wide-scale implementation due to challenges in terms of cost-effectiveness, scalability and insufficient government programs and regulatory support. In addition, low public awareness of waste segregation results in mixed and unsorted food waste, which further complicating food waste recycling efforts (Fatimah et al., 2020).

Some other challenges that hinder food waste management include poor waste collection and processing infrastructure, weak private sector involvement and poor enforcement of regulations. Awareness campaigns have been carried out but are still quite minimal, while public participation in waste reduction, reuse, recycling and segregation remains very low, stressing the pressing need for a more extensive and coordinated efforts in food waste management.

Regulatory Framework and Policy Implications

Over the years, several laws and regulations aimed at improving waste management have been enacted by the Indonesian government, including Law No. 18/2008 on Waste Management, the Presidential Regulation No. 97/2017 on National Policies and Strategies for Household Waste Management, The Regulation of the Minister of Environment and Forestry No. P75/MENLHK/ SETJEN/KUM.1/10/2019 concerning roadmap for waste reduction by waste producers, Ministerial Decree of Environmental Department Act No. 13/2012 governing the reduction, reuse and recycling of solid municipal waste through waste bank, Ministerial Decree of Interior No. 33/2010 governing the involvement of community as waste producers in the waste management system and Ministerial Decree of Public Work No. 03/2013 governing household waste management.

Although Indonesian government has shown its recognition on the issue by establishing regulatory framework on waste management, however effective implementation remains a formidable challenge and progress towards waste reduction and treatment has been unpromising, as until 2022 Indonesia has only achieved 25.3% waste reduction and 49.2% waste treatment (Farahdiba et al., 2023). In addition, the existing laws and regulations largely do not specifically address the unique challenges in managing food waste, leading to ineffectiveness and weak strategies being implemented in food waste management, marked by inadequate infrastructure for food waste segregation, collection, disposal and recycling throughout the country.

Food Waste Segregation at Home

Food waste segregation (FWS) at the source is a key ingredient for successful and sustainable urban waste management. Despite government efforts, this initiative is still trapped in various challenges in the form of cultural norms, individual behaviors, infrastructure limitations and lack of strong policy support.

Educational campaigns are essential in promoting FWS, but they are most effective when combined with supporting measures such as clear sorting instructions and financial incentives such as reduced waste service fees (Bernstad, 2014; Wadehra & Mishra, 2018). Studies in Copenhagen also show that households participate more actively when direct benefits or social recognition is offered (Bernstad, 2014). In Thailand, FWS effectiveness also improved by 36% when serious awareness programs including seminars and leaflets were launched, and a financial incentive of USD 7 per ton of segregated organic waste led to a 51% increase in participation (Boonrod et al., 2015). However, the effectiveness of economic incentives depends largely on demographics and social influences. Lower-income households are generally more responsive to financial rewards, as opposed to higher-income households that are more motivated by environmental awareness and concerns. In addition, incentives that are poorly designed may potentially weaken intrinsic motivation and reduce participation once rewards are withdrawn (L. Xu et al., 2021).

The availability of proper infrastructure to support waste segregation also influences people's willingness to segregate waste at source. Fixed collection schedules, color-coded waste bins and easily accessible waste disposal centers will improve participation in FWS at source (Wadehra & Mishra, 2018). A study in Copenhagen also reveals that when waste sorting equipment is made easily available and accessible, proper waste segregation at source improves by 44 – 45% (Bernstad, 2014). However, urban households with limited living space such as apartment dwellers may struggle with FWS at source due to storage constraints (Pedersen & Manhice, 2020).

Gaps in the Literature

While there is a growing body of research on food waste management and composting technologies, there is a lack of comprehensive studies on the feasibility of enzyme-based composting technology in developing countries like Indonesia. Most existing studies focus on developed countries, where infrastructure and regulatory

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frameworks are more advanced. This study aims to fill this gap by providing a detailed analysis of the feasibility of TTT enzyme-based technology in Indonesia, including its economic, social, and environmental impact.

METHOD

This study employs a mixed methods and approaches, combining quantitative data from surveys conducted on households in Jabodetabek (Greater Jakarta) and Bandung with qualitative insights from expert interviews and literature reviews. The research design and methods for data collection and analysis are summarized as follows :

Survey on FWS at Source Behavior

A structured questionnaire was developed and distributed both online and offline to obtain a stratified random sample of residents in Jabodetabek (Greater Jakarta) and Bandung. The questionnaire included both open and close ended questions designed to collect data on awareness, attitudes and behaviors towards food waste segregation at source, as well as the impact of economic incentives, convenience in waste segregation, accessibility to waste disposal centers and social influence on people's participation in FWS at source.

Survey was conducted over a period of two months, collecting data from 206 respondents in total, which was then analyzed using descriptive statistics such as cross-tabulation and chi-square tests to evaluate how demographic variables influence food waste segregation behaviors.

Organic Fertilizer Market Analysis

The assessment on market potential of organic compost fertilizers was conducted by adopting a desk-based approach, in which data was collected from various sources, including industry reports, government publications and online marketplaces. Thematic analysis was then conducted categorize the data collected, including market size, growth potential and key trends.

Feasibility Assessment

A thorough evaluation involving investment analysis, cost analysis, financial projections and profitability assessment was adopted to determine the feasibility of establishing a food waste recycling business that converts food waste collected from residential areas and hotels into organic compost fertilizers utilizing TTT enzyme-based technology.

Key metrics examined include Return on Investment (ROI), Net Present Value (NPV), Internal Rate of Return (IRR), Breakeven Point (BEP) and Payback Period, with financial data collected from various sources, including TTT company, online marketplaces and industry benchmarks. Sensitivity analysis was also performed to assess the impact of changes in key variables, such as selling price, raw material costs, and operational expenses.

RESULTS AND DISCUSSION

Household Participation in Food Waste Segregation at Source

A survey conducted on 206 residents in Jabodetabek and Bandung from May to June 2024 revealed that while some people have adopted FWS at home as a habit, overall awareness remain low. People's participation in food waste segregation at source vary significantly across demographic groups, with women, older adults, married individuals with children, those with higher education level and middle-income households to have better awareness and therefore more likely to willingly participate.

The lack of dedicated waste bins and collection centers is the major barrier to FWS at source adoption, cited by 48.5% of respondents as the number one reason why they have not adopted FWS as a habit. Accessibility to waste disposal facilities is also an important success factor, as 29.6% of landed house residents prefer waste disposal points to be within 20 meters of their homes, while 47.1% of apartment dwellers favor collection points on each floor of their apartment buildings. This indicates that without convenient waste disposal and collection infrastructure, participation will remain inconsistent.

Educational campaigns play a key role in increasing participation in FWS at source. While 58.8% of respondents have read relevant materials and 67% have watched related media content, yet direct engagement such as community meetings and educational seminars is seen as more effective, particularly when food, drinks and entertainment are provided in such events.

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Economic incentives are very key to motivate active participation in FWS at source, with 73.3% of respondents favoring rewards such as utility bill reductions or reward point collection. Community recognition programs are also seen as appealing, as valued by 62.6% of respondents, but excessive awards such as “Environmental Hero” are regarded as unnecessary. Surprisingly, 59.2% of respondents also support penalties for non-compliance, given that enforcement is carried out effectively.

Social influence may significantly shape people’s behavior towards FWS at source, with nuclear family members being the strongest influencers, followed by extended family members, community leaders. Survey results also indicate that public figures such as politicians and celebrities may have less influence, especially on women and younger individuals.

Market Potential for Organic Fertilizers

The organic fertilizer market in Indonesia is experiencing a relatively slow growth that is driven mainly by improving sustainability awareness and increasingly popular green farming practices. Dominated by key players such as PT. Petrokimia Gresik, PT. Pupuk Indonesia, PT. Pupuk Sriwijaya, PT. Pupuk Kujang and others, the market is projected to reach USD 1.574 billion by 2029 from its current level of USD 1.019 billion as of 2024, enjoying a CAGR of 9.09%.

Although the market initially enjoyed strong growth between 2017 and 2019 that was driven by rising demand in agricultural consumption and estate crops, yet the market suffered from sharp decline in demand due to COVID-19 global pandemic disruptions, reduction in government subsidies, policy shifts and preference for chemical fertilizers since 2020. Nevertheless, it is projected that the market will slowly bounce back and reach its pre-pandemic level of 700,000 to 750,000 tons in the next few years.

Table 1. Market volume of fertilizers in Indonesia (2017 to 2022)

YEAR	2017	2018	2019	2020	2021	2022
Consumption/Export	Ton/Year	Ton/Year	Ton/Year	Ton/Year	Ton/Year	Ton/Year
1. UREA						
1.1 Agriculture	4.106.887	4.100.520	3.719.397	3.921.178	3.668.565	4.378.887
1.2 Estate Crops	1.016.296	1.564.487	1.175.140	1.098.144	1.209.314	906,908
Total	5.123.183	5.665.007	4.894.537	5.019.322	4.877.879	5.285.795
1.3 Industry	847,214	600,189	531,12	975.115)	860,486	527,209
Total Domestic	5.970.397	6.265.196	5.425.657	5.994.437	5.738.365	5.813.004
1.4 Export	766,864	1.141.720	1.860.700	2.379.861	1.974.166	1.747.855
Total UREA Sales	6.737.261	7.406.916	7.286.357	8.374.298	7.712.530	7.560.860
2. Fosfat/SP-36						
2.1 Agriculture	851,744	853,511	815,036	531,437	390,115	197,024
2.2 Estate Crops	8,221	8,103	4,07	1,729)	1,701	62,934
Total	859,965	861,614	819,106	533.166)	391,816	259,958
2.3 Industry	305	93	89	982	10,886	2,405
Total Domestic	860,27	861,707	819,195	534,148	402,701	262,363
3. ZA/AS						
3.1 Agriculture	961,304	997,327	1.006.768	762,834	686,016	292,024
3.2 Estate Crops	18,169	6,707	10,213	17,547	37,257	17,104
Total	979,473	1.004.034	1.016.981	780,381	723,273	309,128
3.3 Industry	1,032	670	187	15,048	48,972	1,195
Total Domestic	980.505)	1.004.704	1.017.168	795,429	772,245	310,323
4. NPK	2.597.586	2.802.246	3.088.176	3.159.311	3.301.209	3.257.054
5. Organic						
5.1 Agriculture	688.134	730.184	755.719	622.613	517.796	302.196
5.2 Estate Crops	5.028	3.489	11.597	1.671	1.014	166
Total	693.162	733.673	767.316	624.284	518.810	302.362

Source : PT. Pupuk Indonesia (2022)

The proposed food waste recycling company aims to capture a 2 to 3% share of the organic fertilizer market in the initial stage, with a target sales volume of 15,000 tons of organic compost fertilizers annually.

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Business Plan and Strategies

The proposed food waste recycling company, temporarily named Green Cycle for ease of reference, is designed and launched to address the growing food waste problem in Indonesia while promoting sustainable agriculture through the production of high-quality organic compost fertilizers.

At the core of Green Cycle's business is the circular economy model, where food waste is reused and recycled into valuable resources. Green Cycle's business model will focus on three main business activities : food waste collection, food waste processing or fertilizer production and fertilizer distribution to ensure efficiency, scalability and profitability in its business operations.

<p>Key Partners</p> <ul style="list-style-type: none"> • Technology Providers • Food Waste Providers • Distribution Partners • Logistics Partners • Research Institutions • Municipal and Provincial Government • Environment NGOs 	<p>Key Activities</p> <ul style="list-style-type: none"> • Food Waste Collection • Food Waste Processing • Fertilizer Production • Product Quality Control • Service Quality Control • Marketing & Sales • Distribution • Customer Relationship Management 	<p>Value Propositions</p> <ul style="list-style-type: none"> • Recycling Efficiency • Environment Stewardship • Quality Organic Fertilizers • Sustainable Farming • Food Waste Disposal Incentives 	<p>Customer Relationships</p> <ul style="list-style-type: none"> • Customer Care • Response Center • Food Waste Collection Mobile App • Food Waste Disposal Incentives • Community Engagement 	<p>Customer Segments</p> <ul style="list-style-type: none"> • Agricultural Cooperatives • Fertilizer Distribution Partners • Organic Fertilizer Manufacturers • Urban Farming Operators • Landscape Contractors • Home Gardeners • Food Waste Providers • Hotels
<p>Key Resources</p> <ul style="list-style-type: none"> • Enzyme Technology • Food Waste Recycling Factory • Smart Waste Bins • Waste Collection Fleet • Financial Resources • Human Resources 		<p>Channels</p> <ul style="list-style-type: none"> • Direct Sales • Online Platforms • Distribution Partners • Trade Shows & Exhibitions • Community Outreach 		
<p>Cost Structure</p> <ul style="list-style-type: none"> • Technology Investment • Production Costs • Food Waste Collection Costs • Distribution Costs • Labor Costs • Marketing & Sales Costs • Incentives for Food Waste Providers 			<p>Revenue Streams</p> <ul style="list-style-type: none"> • Sales of Organic Compost Fertilizer Products • Food Waste Collection Services • Advertisement 	

Figure 1 : Business Model of Green Cycle

1. Food Waste Collection

Green Cycle will collect food waste directly from households, hotels and traditional markets around Jabodetabek, with key strategies include building dedicated food waste collection shelters that are equipped with smart waste bins to facilitate waste segregation at residential areas. These smart waste bins are equipped with weighing mechanisms and user identification systems, allowing participating residents to earn rewards every time they dispose of their sorted food waste.

To encourage active participation from the general public, households or residents who actively participate by disposing off their food waste in a properly segregated fashion at Green Cycle's dedicated food waste collection shelters will be able to collect point rewards that can be converted into shopping vouchers and utility bill discounts.

Businesses such as hotels and restaurants will be offered a cost-effective waste collection service of IDR 1,500 per kilogram of food waste collected, with a value proposition of scheduled daily collection service, offered 6 days per week except Sundays.

Additionally, Green Cycle will also actively engage communities in target markets through educational campaigns, workshops and programs to raise awareness and motivate wide-scale participation in FWS at source.

2. Food Waste Processing and Fertilizer Production

The food waste collected from residential areas, hotels, restaurants and traditional markets is then sent to Green Cycle's food waste processing plant and converted into organic compost fertilizers within three hours

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by using TTT enzyme-based technology that functions to accelerate the composting process, reduce processing time and limit space requirements, making the operations highly efficient. .

Green Cycle's food waste processing facility is capable of a daily handling capacity of 200 tons of food waste based on a 24-hour operations. The waste recycling business will be set up and run based on maximum capacity to achieve economies of scale and optimal efficiencies, thereby allowing the fertilizer produced to enjoy cost advantages.

3. Fertilizer Distribution

The final compost fertilizer products will be distributed to each target market by employing multi-channel marketing strategy. Direct sales will be adopted to target large-scale agricultural agricultural cooperatives and other fertilizer manufacturers, offering attractive bulk purchase discounts. Meanwhile, online channels including dedicated company website and online marketplaces such as Tokopedia and Shopee will cater to small-scale farmers and home gardeners.

To keep on expanding its market reach, Green Cycle will actively participate in relevant trade shows and exhibitions to showcase its organic compost fertilizers and network with industry stakeholders. Building strategic partnerships with agricultural communities and NGOs to promote organic farming and sustainable agriculture is also a key market development strategy.

Financial Projections

Green Cycle's financial projections are conducted based on a 10-year business plan with the following assumptions and calculations :

1. Initial Investment: The total initial investment required to set up Geen Cycle's operations is IDR 136.6 billion, including the acquisition costs of facilities and equipment related to plant building, warehouse, waste recycling, waste collection and office, as well as a 6-month working capital, detailed in Table 2 below.

Table 2. List of Initial Investment for Green Cycle

Asset	Condition	Qty	U.o.M	Unit Price (IDR)	Total Amount (IDR)
Building Facilities & Equipments					362.119.024
1. Canopy Fabrication	New	100	m2	500.000	50.000.000
2. Lighting					270.047.000
3. CCTV					42.072.024
Waste Recycling Facilities & Equipments					57.373.152.000
1. Kitchen Waste Processing Unit	New	1	set	46.944.000.000	46.944.000.000
2. Diesel Generator (1000 KVA)	Used	2	unit	2.013.201.000	4.026.402.000
3. Diesel Generator (1500 KVA)	Used	2	unit	3.201.375.000	6.402.750.000
Waste Collection Facilities & Equipments					43.860.500.000
1. Waste Collection Shelters	New	208	units	150.000.000	31.250.000.000
2. Smart Waste Bins	New	208	units	18.386.400	3.830.500.000
3. Waste Collection Trucks	New	20	units	439.000.000	8.780.000.000
Warehouse Facilities & Equipments					1.264.058.784
1. Warehouse Shelves					439.442.784
2. Reach Truck	New	2	units	187.000.000	374.000.000
3. Forklift	Used	2	units	200.000.000	400.000.000
4. Pallet Mover	New	4	unit	12.654.000	50.616.000
Office Furnitures & Equipments					322.394.000
1. Office Furnitures					80.096.000
2. Air Conditioners					204.798.000
3. Printers	New	3	units	10.800.000	32.400.000
4. Shredding Machine	New	3	units	1.700.000	5.100.000
Software & Applications					800.000.000
1. ERP Software	New	1	set	300.000.000	500.000.000
2. Waste Collection Mobile App	New	1	lot	300.000.000	300.000.000
Initial Working Capital					32.596.847.363
1. Initial Working Capital (6-month)		6	months	5.432.807.894	32.596.847.363
TOTAL INITIAL INVESTMENT					136.579.071.171

Source : The author's calculation (2025)

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2. Sales Revenue :
 - a. Sales of Organic Compost Fertilizers : With an annual sales of 15,000 tons and an average price of IDR 6,000 per kg, this revenue stream is likely to generate IDR 90 billion in annual revenue.
 - b. Waste Collection Services : Offering a small charge of IDR 1,000 per kg and targeting to collect 20 tons of food waste from hotels and large-scale restaurants, this revenue stream is likely to generate IDR 6 billion in annual revenue.
 - c. Advertising Revenue : With a rental fee of IDR 10 million per month and an average occupancy rate of 50%, then the annual revenue expected from advertising screens of Green Cycle's 208 waste collection shelters is IDR 12.5 billion.
3. Production Cost Structure :
 - a. Raw Materials : The cost of food waste collection, TTT enzyme and packaging amounts to IDR 34.75 billion, or accounts for 32.03% of total annual revenue.
 - b. Direct Labor : Salaries and benefits of workers directly involved in waste collection and waste processing amounts to 14.80 billion, or accounts for 13.64% of total annual revenue.
 - c. Factory Overhead : Utility expenses, rental expenses, depreciation and salaries and benefits of indirect labor involved in waste collection and waste processing amounts to IDR 6.48 billion, or accounts for 5.97% of total annual revenue.
 - d. Depreciation : Depreciation of plant building, waste processing machinery and equipment, warehouse facilities and waste collection infrastructure amounts to IDR 13.02 billion, or accounts for 12% of total annual revenue.
4. General Administration and Selling Expenses :
 - a. General Administration Expenses : Salaries and benefits of executives, managers and staff, software maintenance expenses, depreciation of office equipment and other amounts to IDR 3.35 million annually, or accounts for 3.09% of total annual revenue.
 - b. Selling Expenses : Salaries and benefits of sales and marketing personnel, sales and marketing expenses and other related selling expenses amounts to IDR 6.1 billion, or accounts for 5.62% of total annual revenue.
5. Profitability : Green Cycle's gross profit margin is projected at IDR 39.45 billion, or 36.36% of total annual revenue, while its net profit margin amounts to IDR 30.01 billion, or 27.66%, as summarized in Table 3 below.

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Table 3. Profit & Loss Projection of Green Cycle

DESCRIPTION	U.o.M	Monthly	Yearly	% to Sales Revenue
SALES REVENUE	'000 IDR	9.041.667	108.500.000	100,00%
<i>Sales of Compost Organic Fertilizers</i>	'000 IDR	<i>7.500.000</i>	<i>90.000.000</i>	<i>82,95%</i>
<i>Sales Volume</i>	<i>ton</i>	<i>1.250</i>	<i>15.000</i>	
<i>Avg. Price Per Kg</i>	<i>IDR / kg</i>	<i>6.000</i>	<i>6.000</i>	
<i>Waste Collection Service from Hotels</i>	'000 IDR	<i>500.000</i>	<i>6.000.000</i>	<i>5,53%</i>
<i>Collection Volume</i>	<i>ton</i>	<i>500</i>	<i>6.000</i>	
<i>Collection Price per Kg</i>	<i>IDR / kg</i>	<i>1.000</i>	<i>1.000</i>	
<i>Advertisement (Waste Collection Shelters)</i>	'000 IDR	<i>1.041.667</i>	<i>12.500.000</i>	<i>11,52%</i>
<i>Number of Waste Collection Shelters</i>	<i>Units</i>	<i>208</i>	<i>208</i>	
<i>Advertisement Price Per Month</i>	'000 IDR	<i>10.000</i>	<i>10.000</i>	
<i>Occupancy Rate</i>	<i>%</i>	<i>50%</i>	<i>50%</i>	
COGS	'000 IDR	5.753.802	69.045.626	63,64%
<i>Raw Materials</i>	'000 IDR	<i>2.896.070</i>	<i>34.752.846</i>	<i>32,03%</i>
<i>Direct Labor</i>	'000 IDR	<i>1.233.232</i>	<i>14.798.786</i>	<i>13,64%</i>
<i>Factory Overhead</i>	'000 IDR	<i>539.876</i>	<i>6.478.508</i>	<i>5,97%</i>
<i>Depreciation</i>	'000 IDR	<i>1.084.624</i>	<i>13.015.486</i>	<i>12,00%</i>
GROSS PROFIT	'000 IDR	3.287.865	39.454.374	36,36%
GENERAL ADMINISTRATION EXPENSES	'000 IDR	279.087	3.349.044	3,09%
<i>Administration</i>	'000 IDR	<i>255.704</i>	<i>3.068.446</i>	<i>2,83%</i>
<i>Depreciation & Amortization</i>	'000 IDR	<i>23.383</i>	<i>280.599</i>	<i>0,26%</i>
SELLING EXPENSES	'000 IDR	507.926	6.095.110	5,62%
<i>Salaries & Benefits</i>	'000 IDR	<i>57.926</i>	<i>695.110</i>	<i>0,64%</i>
<i>Sales Expenses</i>	'000 IDR	<i>100.000</i>	<i>1.200.000</i>	<i>1,11%</i>
<i>Marketing Expenses</i>	'000 IDR	<i>300.000</i>	<i>3.600.000</i>	<i>3,32%</i>
<i>Others</i>	'000 IDR	<i>50.000</i>	<i>600.000</i>	<i>0,55%</i>
NET PROFIT BEFORE TAXES	'000 IDR	2.500.852	30.010.221	27,66%
EBITDA	'000 IDR	3.608.859	43.306.305	39,91%

Source : The author's calculation (2025)

Financial Feasibility of Green Cycle

The financial analysis reveals that Green Cycle's business model is a highly viable one, with a projected annual revenue of IDR 108.5 billion and a net profit margin of 27.66%. The return on investment (ROI) is estimated at 21.97%, with a payback period of 4 years and 7 months. BEP analysis shows that Green Cycle needs to generate IDR 47.11 billion of revenue to effectively cover its fixed costs, which is almost half of its annual revenue, indicating a very healthy profit margin, as detailed in the calculation shown in Table 4 below.

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Table 4. ROI, BEP & Payback Period of Green Cycle

Metrics	Description	Formula	Value in IDR ('000 IDR)	Value in %	Other Value	Remarks
Profit & Loss	Sales Revenue		108.500.000	100,00%		
	COGS		69.045.626	63,64%		
	Raw Materials		34.752.846	32,03%		
	Direct Labor		14.798.786	13,64%		
	Factory Overhead		6.478.508	5,97%		
	Factory Building Rental		573.000	0,53%		
	Others		5.905.508	5,44%		
	Depreciation		13.015.486	12,00%		
	Gross Profit		39.454.374	36,36%		
	General Administration Expenses		3.349.044	3,09%		
	Administration		3.068.446	2,83%		
	Depreciation & Amortization		280.599	0,26%		
	Selling Expenses		6.095.110	5,62%		
Net Profit		30.010.221	27,66%			
ROI	Initial Investment		136.579.071			
	Return on Investment	Net Profit / Initial Investment		21,97%		
BEP	Total Fixed Cost		23.032.640			
	Factory Building Rental		573.000			
	Depreciation in COGS		13.015.486			
	General Administration		3.349.044			
	Selling Expenses		6.095.110			
	Total Variable Cost		55.457.140			
	Raw Materials		34.752.846			
	Direct Labor		14.798.786			
	Factory Overhead		5.905.508			
	Excluding Factory Building					
Contributing Margin Ratio (CMR)	(Sales Revenue – Total Variable Costs) / Sales Revenue]			48,89%		
Breakeven Point (BEP)	Total Fixed Costs / CMR		47.113.625			
Payback Period	Payback Period	Initial Investment / Net Profit			4,55	4 years 7 months

Source : The author's calculation (2025)

Assuming that Green Cycle aims to run its waste recycling business at full capacity consistently for at least 10 years, then with a 3% inflationary rate and a realistic 10% discount rate that represents the sum of risk free rate of 4% and business risk premium of 6%, calculation the Net Present Value (NPV) of Green Cycle's business arrives at IDR 70 billion, suggesting strong profitability and financial sustainability. The Internal Rate of Return (IRR) results in 20.33%, indicating that Green Cycle may generate an annualized return of 20.33% on the initial investment over the minimum 10-year period of its business operations. This strong IRR further suggests that Environzen is a highly attractive investment opportunity as the expected return exceeds the typical cost of capital of around 10 – 12%. Detailed calculations of NPV and IRR are shown in Table 5 and Table 6 below.

Table 5. NPV of Green Cycle

Description	Net Cash Flow (Rp.)	(1 + Discount Rate)	NPV (Rp.)
1st Year	30.010.220.700	110%	27.282.018.818
2nd Year	30.910.527.321	121%	25.545.890.348
3rd Year	31.837.843.141	133%	23.920.242.781
4th Year	32.792.978.435	146%	22.398.045.513
5th Year	33.776.767.788	161%	20.972.715.344
6th Year	34.790.070.822	177%	19.638.088.004
7th Year	35.833.772.947	195%	18.388.391.494
8th Year	36.908.786.135	214%	17.218.221.127
9th Year	38.016.049.719	236%	16.122.516.146
10th Year	39.156.531.211	259%	15.096.537.846
		TOTAL	206.582.667.420
Net NPV			70.003.596.249

Source : The author's calculation (2025)

Table 6. IRR of Green Cycle

Description	Net Cash Flow (Rp.)
0 Year	- 136.579.071.171
1st Year	30.010.220.700
2nd Year	30.910.527.321
3rd Year	31.837.843.141
4th Year	32.792.978.435
5th Year	33.776.767.788
6th Year	34.790.070.822
7th Year	35.833.772.947
8th Year	36.908.786.135
9th Year	38.016.049.719
10th Year	39.156.531.211
IRR	20,33%

Source : The author's calculation (2025)

Sensitivity analysis conducted on Green Cycle's business showed that the business is vulnerable to decreases in selling price, with a 10% price reduction resulting in a negative NPV. However, the business remains

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resilient to increases in raw material and operational costs, with a 20% increase in raw material costs reducing the IRR to 11.60%, as shown in Table 7, Table 8 and Table 9 below.

Table 7. Sensitivity Analysis to Changes in Selling Price for Green Cycle

Description	Base Figures ('000 Rp.)	Changes in Operational Costs					
		+20%	+15%	+10%	-10%	-15%	-20%
SALES REVENUE	108.500.000	108.500.000	108.500.000	108.500.000	108.500.000	108.500.000	108.500.000
Compost Organic Fertilizers	90.000.000	90.000.000	90.000.000	90.000.000	90.000.000	90.000.000	90.000.000
Food Waste Collection Service	6.000.000	6.000.000	6.000.000	6.000.000	6.000.000	6.000.000	6.000.000
Advertisement	12.500.000	12.500.000	12.500.000	12.500.000	12.500.000	12.500.000	12.500.000
COGS	69.045.626	73.301.084	72.237.220	71.173.355	66.917.896	65.854.032	64.790.167
Raw Materials	34.752.846	34.752.846	34.752.846	34.752.846	34.752.846	34.752.846	34.752.846
Direct Labor	14.798.786	17.758.543	17.018.604	16.278.665	13.318.907	12.578.968	11.839.029
Factory Overhead	6.478.508	7.774.209	7.450.284	7.126.358	5.830.657	5.506.731	5.182.806
Depreciation	13.015.486	13.015.486	13.015.486	13.015.486	13.015.486	13.015.486	13.015.486
GROSS PROFIT	39.454.374	35.198.916	36.262.780	37.326.645	41.582.104	42.645.968	43.709.833
GENERAL ADMINISTRATION	3.349.044	3.962.733	3.809.311	3.655.889	3.042.200	2.888.777	2.735.355
Administration	3.068.446	3.682.135	3.528.712	3.375.290	2.761.601	2.608.179	2.454.756
Depreciation & Amortization	280.599	280.599	280.599	280.599	280.599	280.599	280.599
SELLING EXPENSES	6.095.110	7.314.132	7.009.376	6.704.621	5.485.599	5.180.843	4.876.088
Salaries & Benefits	695.110	834.132	799.376	764.621	625.599	590.843	556.088
Sales Expenses	1.200.000	1.440.000	1.380.000	1.320.000	1.080.000	1.020.000	960.000
Marketing Expenses	3.600.000	4.320.000	4.140.000	3.960.000	3.240.000	3.060.000	2.880.000
Others	600.000	720.000	690.000	660.000	540.000	510.000	480.000
NPBT	30.010.221	23.922.051	25.444.093	26.966.136	33.054.306	34.576.348	36.098.390
NPV Calculation							
Year 0	NCF	-136.579.071	-136.579.071	-136.579.071	-136.579.071	-136.579.071	-136.579.071
Year 1	NCF	30.010.221	23.922.051	25.444.093	26.966.136	33.054.306	34.576.348
	Discount Rate	0,91	0,91	0,91	0,91	0,91	0,91
	NPV	27.282.019	21.747.319	23.130.994	24.514.669	30.049.369	31.433.044
Year 2	NCF	30.910.527	24.639.712	26.207.416	27.775.120	34.045.935	35.613.638
	Discount Rate	0,83	0,83	0,83	0,83	0,83	0,83
	NPV	25.545.890	20.363.399	21.659.022	22.954.645	28.137.136	29.432.759
Year 3	NCF	31.837.843	25.378.904	26.993.639	28.608.373	35.067.313	36.682.048
	Discount Rate	0,75	0,75	0,75	0,75	0,75	0,75
	NPV	23.920.243	19.067.546	20.280.720	21.493.894	26.346.591	27.559.765
Year 4	NCF	32.792.978	26.140.271	27.803.448	29.466.625	36.119.332	37.782.509
	Discount Rate	0,68	0,68	0,68	0,68	0,68	0,68
	NPV	22.398.046	17.854.157	18.990.129	20.126.101	24.669.990	25.805.962
Year 5	NCF	33.776.768	26.924.479	28.637.551	30.350.623	37.202.912	38.915.984
	Discount Rate	0,62	0,62	0,62	0,62	0,62	0,62
	NPV	20.972.715	16.717.983	17.781.666	18.845.349	23.100.081	24.163.764
Year 6	NCF	34.790.071	27.732.213	29.496.678	31.261.142	38.319.000	40.083.464
	Discount Rate	0,56	0,56	0,56	0,56	0,56	0,56
	NPV	19.638.088	15.654.112	16.650.106	17.646.100	21.630.076	22.626.070
Year 7	NCF	35.833.773	28.564.180	30.381.578	32.198.976	39.468.569	41.285.968
	Discount Rate	0,51	0,51	0,51	0,51	0,51	0,51
	NPV	18.388.391	14.657.941	15.590.553	16.523.166	20.253.617	21.186.230
Year 8	NCF	36.908.786	29.421.105	31.293.025	33.164.946	40.652.627	42.524.547
	Discount Rate	0,47	0,47	0,47	0,47	0,47	0,47
	NPV	17.218.221	13.725.163	14.598.427	15.471.692	18.964.750	19.838.015
Year 9	NCF	38.016.050	30.303.738	32.231.816	34.159.894	41.872.205	43.800.283
	Discount Rate	0,42	0,42	0,42	0,42	0,42	0,42
	NPV	16.122.516	12.851.743	13.669.436	14.487.130	17.757.903	18.575.596
Year 10	NCF	39.156.531	31.212.851	33.198.771	35.184.691	43.128.372	45.114.292
	Discount Rate	0,39	0,39	0,39	0,39	0,39	0,39
	NPV	15.096.538	12.033.905	12.799.563	13.565.221	16.627.854	17.393.512
Net NPV		70.003.596	28.094.196	38.571.546	49.048.896	90.958.296	101.435.646
IRR Calculation							
Year 0		-136.579.071	-136.579.071	-136.579.071	-136.579.071	-136.579.071	-136.579.071
Year 1		30.010.221	23.922.051	25.444.093	26.966.136	33.054.306	34.576.348
Year 2		30.910.527	24.639.712	26.207.416	27.775.120	34.045.935	35.613.638
Year 3		31.837.843	25.378.904	26.993.639	28.608.373	35.067.313	36.682.048
Year 4		32.792.978	26.140.271	27.803.448	29.466.625	36.119.332	37.782.509
Year 5		33.776.768	26.924.479	28.637.551	30.350.623	37.202.912	38.915.984
Year 6		34.790.071	27.732.213	29.496.678	31.261.142	38.319.000	40.083.464
Year 7		35.833.773	28.564.180	30.381.578	32.198.976	39.468.569	41.285.968
Year 8		36.908.786	29.421.105	31.293.025	33.164.946	40.652.627	42.524.547
Year 9		38.016.050	30.303.738	32.231.816	34.159.894	41.872.205	43.800.283
Year 10		39.156.531	31.212.851	33.198.771	35.184.691	43.128.372	45.114.292
IRR		20,33%	14,37%	15,91%	17,42%	23,15%	24,52%

Source : The author's calculation (2025)

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97/2017. Additionally, by incentivizing FWS at source, Green Cycle also contributes to enhance public awareness and engagement in responsible waste management.

Green Cycle is a business that promote environmental awareness and encourage households and businesses to adopt sustainable waste management practices. By transforming food waste into compost organic fertilizers, Green Cycle supports the development of circular economy where waste is continuously reused and recycled.

Green Cycle also generates job opportunities across the entire in food waste management value chain, including jobs in waste collection, food waste recycling and fertilizer distribution, contributing to local economic development. Additionally, the growth of compost organic fertilizer may also encourage local entrepreneurship in sustainable agriculture.

CONCLUSION

Summary of Key Findings

The study highlights that people's participation in food waste segregation at source is influenced by demographic, convenience and incentives. Women, older adults, married individuals and middle-income households demonstrate higher engagement in general, while accessibility to waste collection points also plays a crucial role. A balanced approach that combines both attractive incentives and penalties for non-compliance will serve well in motivating participation. Additionally, educational campaigns, community programs and collaborations with influencers are also powerful to increase awareness and encourage long-term behavioral change towards food waste segregation at source.

Establishing a food waste recycling business utilizing TTT enzyme-based technology is financially viable. With a projected annual revenue that is almost twice its BEP, an ROI of 21.97%, a relatively short Payback Period of 4 years and 7 months, an solidly positive NPV, and an IRR of 20.33%, the business promises robust profitability and financial stability, making it a compelling investment opportunity in the waste management sector.

Recommendations for Stakeholders

The success and sustainability of Green Cycle's as a business depend on active engagement and strong collaboration among key stakeholders, as each group plays a crucial role in driving sustainable food waste management. Green Cycle's management team should commit serious investment in R&D to launch products with strong competitive advantages that can command premium pricing in the market, optimize costs through bulk purchasing, automation and other efficiency programs and launch risk management programs to ensure long-term business resilience. Government and policymakers should extend more regulatory and infrastructure support by enforcing waste segregation laws, providing financial incentives, investing in waste management infrastructures and launching nationwide educational campaigns that will raise awareness about food waste segregation and recycling. Investors can accelerate the expansion of this green business by providing long-term capital, facilitating strategic partnerships and funding more research and innovation projects in food waste recycling sector. Last but not least, environmental NGOs and advocacy groups can further support this mission by advocating policy reforms, launching awareness campaigns, providing trainings to farming communities and developing circular economy models that reuse and recycle waste into valuable resources.

Green Cycle as a business has the potential to serve as leading catalyst for sustainable food waste management and environmental stewardship in Indonesia. However, the success and sustainability of Green Cycle's business model depend not solely on its management, but also on the active collaboration of all stakeholders involved in the value chain, each of which has a critical role to play in driving substantial change to address food waste management issue in Indonesia, whether through supportive policies, community engagement, financial investment and environmental advocacy.

With strong collaborative efforts, stakeholders can collectively create a robust ecosystem that not only supports Environzen's continuous growth but also ensure the achievement of broader environmental goals and the transition to a circular economy that support long term economic resilience, paving the way for a greener and more sustainable future.

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