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Techno-Economic Feasibility and Bibliometric Literature Review of Integrated Waste Processing Installations for Sustainable Plastic Waste Management

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ABSTRACT

This study presents a techno-economic analysis of the development of integrated waste processing installations, focusing on plastic waste management. The research evaluated a 20-year business feasibility using various financial indicators, including gross profit margin (GPM), internal rate of return (IRR), payback period (PBP), and net present value (NPV). Additionally, this study includes a literature review supported by bibliometric analysis to contextualize current trends in waste processing innovation and economic sustainability. The findings indicated that the project was technically viable and economically promising. The PBP analysis revealed that the investment became profitable after approximately three years, suggesting that the project met acceptable profitability benchmarks. The novelty of this research lies in its application of techno-economic analysis to assess both the technical feasibility and the economic value of waste management initiatives. Furthermore, this study contributes to the Sustainable Development Goals (SDGs), particularly by promoting responsible consumption and production (SDG 12) and fostering sustainable urban environments (SDG 11).

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1. INTRODUCTION

The demand for plastic-based materials in Indonesia continues to increase in line with the growing complexity of human needs, resulting in a significant rise in plastic waste generation (Surono, 2013). This waste has become a serious environmental issue due to its long-lasting presence and harmful impact on ecosystems and the sustainability of other life forms (Ratnawati, 2020; Sarkingobir & Jayanthi, 2018). According to the Indonesian Ministry of Environment, the population produces approximately 189,000 tons of waste daily, of which 15%—around 28,400 tons—is plastic waste (Arico & Jayanthi, 2018).

Regional plastic waste management policies have yet to yield productive results, largely because of the lack of synergy among various government levels (Nandiyanto *et al*., 2023; Sridevi *et al*., 2024; Consebit *et al*., 2022; Duruin *et al*., 2022; Pebrianti & Salamah, 2021; Soegoto *et al*., 2021). Many reports regarding the strategies for taking care plastic have been well-documented (Nandiyanto *et al*., 2023; Sridevi *et al*., 2024; Consebit *et al*., 2022; Duruin *et al*., 2022; Pebrianti & Salamah, 2021; Soegoto *et al*., 2021; Setyani *et al*., 2023). However, improvements have been initiated by both central and regional governments (Fitri & Ferza, 2020), including in Bogor City, where a major issue in waste management is the limited space available for final waste processing. To address this, the Bogor City government has collaborated with the Bogor Regency government to handle waste processing collectively (Nurfadhillah & Rahmawati, 2024).

At present, the city government can only manage about 69.8% of total daily waste, equivalent to 1,892 m^3 out of 2,710 m^3 produced. The remaining 818.42 m^3 is either handled by 3R waste processing sites, waste banks, informal junk vendors, thrown into rivers, incinerated, or scattered during transport (Ramdhan & Hermawan, 2022).

To reduce waste at the source, establishing an Integrated Waste Processing Installation (IPST) in every sub-district of Bogor has been proposed. These community or privately managed facilities can reprocess waste into economically valuable products. A feasibility study is necessary to evaluate the viability of such installations (Prabowo, 2015). The IPST concept also addresses land scarcity issues for final disposal, as each IPST is estimated to reduce 60–70% of total waste volume. IPSTs process mixed solid waste that typically consists of 30% organic matter, 50% plastic, and 20% residual waste (Fernando, 2011). From organic waste, 10% is converted into compost. Processed plastics are sorted into four marketable categories: biomass, HDPE, PP, and PE, which are in high demand by industries. With a constant supply of raw materials and potential income from tipping fees or user charges, IPSTs present an economically attractive model. Nonetheless, competition exists from independent waste collectors who rely on scavengers (Muhaimin & Hamdani, 2021).This research aims to conduct a comprehensive techno-economic feasibility analysis of plastic waste-based IPSTs. The analysis integrates financial indicators and a bibliometric literature review to align the project with current innovations in waste management and sustainability (Damayanti *et al*., 2023).

The novelty of this study lies in combining techno-economic analysis with a bibliometric literature review to evaluate the technical and economic aspects of plastic waste processing projects. Bibliometric analysis was added since it plays a critical role in identifying prevailing research trends, influential publications, and knowledge gaps within a specific domain. Previous studies on bibliometric analysis is reported elsewhere (**Table 1**).

Table 1. Previous studies on bibliometric analysis reports.

No	Title	Ref
1	A bibliometric analysis of management bioenergy research using vosviewer application	Soegoto *et al*. (2022)
2	Oil palm empty fruit bunch waste pretreatment with benzotriazolium-based ionic liquids for cellulose conversion to glucose: Experiments with computational bibliometric analysis	Mudzakir *et al*. (2022)
3	Research mapping in the use of technology for fake news detection: Bibliometric analysis from 2011 to 2021	Gunawan *et al*. (2022)
4	Management information systems: bibliometric analysis and its effect on decision making	Santoso *et al*. (2022)
5	Sustainable Production-inventory model with multi-material, quality degradation, and probabilistic demand: From bibliometric analysis to a robust model	Utama *et al*. (2023)
6	Phytochemical profile and biological activities of ethylacetate extract of peanut (Arachis hypogaea L.) stems: In-vitro and in-silico studies with bibliometric analysis	Sahidin *et al*. (2023)
7	Biomass-based supercapacitors electrodes for electrical energy storage systems activated using chemical activation method: A literature review and bibliometric analysis	Hamidah *et al*. (2023)
8	Antiangiogenesis activity of Indonesian local black garlic (Allium Sativum 'Solo): Experiments and bibliometric analysis.	Arianingrum *et al*. (2023)
9	Characteristics of tamarind seed biochar at different pyrolysis temperatures as waste management strategy: Experiments and bibliometric analysis	Rahmat *et al*. (2023)
10	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	Abduh *et al*. (2023)
11	How eyes and brain see color: Definition of color, literature review with bibliometric analysis, and inquiry learning strategy for teaching color changes to student with mild intelligence barriers	Juhanaini *er al*. (2023)
12	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	Mardina *et al*. (2024)
13	Prototype of greenhouse effect for improving problem-solving skills in science, technology, engineering, and mathematics (STEM)-education for sustainable development (ESD): Literature review, bibliometric, and experiment	Solihah *et al*. (2024)
14	Spatial visualization ability assessment for analyzing differences and exploring influencing factors: Literature review with bibliometrics and experiment	Yang *et al*. (2024)
15	Augmented reality for cultivating computational thinking skills in mathematics completed with literature review, bibliometrics, and experiments for students	Angraini *et al*. (2024)
16	Low-carbon food consumption for solving climate change mitigation: Literature review with bibliometric and simple calculation application for cultivating sustainability consciousness in facing sustainable development goals (SDGs)	Nurramadhani *et al*. (2024)
17	Neuroscience intervention for implementing digital transformation and organizational health completed with literature review, bibliometrics, and experiments	Imaniyati *et al*. (2024)
18	Phylogenetic analysis of Bengkulu citrus based on DNA sequencing enhanced chemistry students' system thinking skills: Literature review with bibliometrics and experiments	Amida *et al*. (2024)
19	The ship's propeller rotation threshold for coral reef ecosystems based on sediment rate indicators: Literature review with bibliometric analysis and experiments	Kadir *et al*. (2024)
20	Empowering engineering female students to improve retention and progression: A program evaluation study completed with bibliometric analysis	Shafiq *et al*. (2024)

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Table 1 (Continue). Previous studies on bibliometric analysis reports.

No	Title	Ref
21	Android application for smart diagnosis of children with disabilities and its correlation to neuroscience: Definition, literature review with bibliometric analysis, and experiments	Wagino *et al.* (2024)
22	Deciphering the mechanism of action cosmos caudatus compounds against breast neoplasm: A combination of pharmacological networking and molecular docking approach with bibliometric analysis	Hendrarti *et al.* (2024)
23	Integration of water heating systems with car air conditioning systems: A bibliometric analysis, lab-scale investigation, and potential applications	Rusdjijati *et al.* (2025)
24	Optimization of hybrid core designs in 3D-printed PLA+ sandwich structures: An experimental, statistical, and computational investigation completed with bibliometric analysis	Metteb *et al.* (2025)
25	Chemical looping systems for hydrogen production and their implementation in Aspen Plus software: A review and bibliometric analysis	Vanegas *et al.* (2025)
26	Dental suction aerosol: Bibliometric analysis	Ramadhan *et al.* (2022)
27	Bibliometric analysis of nano metal-organic frameworks synthesis research in medical science using VOSviewer	Shidiq (2023)
28	Research trends from the scopus database using keyword water hyacinth and ecosystem: A bibliometric literature review	Nandiyanto *et al.* (2024)
29	Use of blockchain technology for the exchange and secure transmission of medical images in the cloud: Systematic review with bibliometric analysis	Lizama *et al.* (2024)
30	Chatbot artificial intelligence as educational tools in science and engineering education: A literature review and bibliometric mapping analysis with its advantages and disadvantages	Al Husaeni *et al.* (2024a)
31	How technology can change educational research? Definition, factors for improving quality of education and computational bibliometric analysis	Al Husaeni *et al.* (2024b)
32	Effects of sustained deficit irrigation on vegetative growth and yield of plum trees under the semi-arid conditions: Experiments and review with bibliometric analysis	Laita *et al.* (2024)
33	Hydroxyapatite as delivery and carrier material: Systematic literature review with bibliometric analysis	Noviyanti *et al.* (2024)
34	Development of intelligent tutoring system model in the learning system of the Indonesian national armed forces completed with bibliometric analysis	Kurniawan *et al.* (2024)
35	Artificial intelligence (AI)-based learning media: Definition, bibliometric, classification, and issues for enhancing creative thinking in education	Solihat *et al.* (2024)
36	Comprehensive review on wastewater treatment using nanoparticles: Synthesis of iron oxide magnetic nanoparticles, publication trends via bibliometric analysis, applications, enhanced support strategies, and future perspectives	Mohammed *et al* (2025)
37	Role of coastal vegetation belts in mitigating tsunami waves: Bibliometric analysis, numerical, and spatial analysis	Usman *et al.* (2025)
38	Synthesis and characterization of acetylene alcohols via alkynylation of heteroatomic aldehydes with phenylacetylene under various reaction parameters completed with spatial chemical structure, literature review, and bibliometric analysis.	Otamukhamedova *et al* (2025)
39	How to teach fraction for empowering student mathematics literacy: Definition, bibliometric, and application using digital module	Farokhah *et al.* (2025)
40	Smart electric resistance welding based on artificial intelligence (AI) based on real-time adaptive statistical features completed with bibliometric analysis	Fufon *et al.* (2025)
41	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	Nandiyanto *et al.* (2023a)

By systematically analyzing academic literature, bibliometric tools offer empirical insights into the evolution of scientific inquiry, the concentration of scholarly attention, and the impact of technological advancements. In the context of waste management and techno-economic studies, bibliometric review enhances the validity and relevance of research by aligning it with global discourse and best practices. This methodological approach also ensures that project planning and policy recommendations are informed by a robust evidence base rooted in peer-reviewed literature.

Furthermore, the study contributes to Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), by proposing viable models for sustainable and inclusive waste management (Tejanagara *et al*., 2024).

2. LITERATURE REVIEW

Numerous studies have explored plastic waste management as a pressing environmental and socio-economic issue. Various methods have been developed to convert plastic waste into fuel, reflecting the diversity of pyrolysis and thermal decomposition technologies (Surono, 2013). The transformation of plastic waste into alternative energy through laboratory-scale pyrolysis has also proven effective in educational and practical settings (Ratnawati, 2020).

Community-based initiatives have demonstrated the economic potential of plastic recycling, especially in coastal and informal settlements (Arico & Jayanthi, 2018). These approaches align with the circular economy concept, emphasizing waste as a resource. Polymer degradation studies have further supported this view by offering analytical tools to trace the composition and transformation of plastic materials (Nandiyanto *et al*., 2023).

Recent innovations include the use of microwave pyrolysis to produce hybrid biochar from agricultural and plastic waste, showcasing the integration of environmental technology and energy recovery (Sridevi *et al*., 2024). Similarly, the development of bioplastics from seaweed and water hyacinth marks a significant advancement toward biodegradable alternatives (Consebit *et al*., 2022; Duruin *et al.*, 2022).

Environmental education also plays a critical role in waste awareness. The introduction of simplified pyrolysis models for classroom use enhances student understanding of waste-to-fuel conversion (Pebrianti & Salamah, 2021), while digital platforms serve as outreach tools for plastic waste recycling initiatives (Soegoto *et al*., 2021).

Policy-related research has revealed challenges in regional coordination and implementation of waste regulations (Fitri & Ferza, 2020). Structural governance issues in waste management have been observed in Bogor, especially concerning inter-agency collaboration (Nurfadhillah & Rahmawati, 2024). The city's function as a buffer zone for Jakarta further complicates the flow and treatment of waste (Ramdhan & Hermawan, 2022).

On the strategic side, case studies have illustrated the use of corporate social responsibility to support community waste banks (Prabowo, 2015), and broader feasibility studies have examined waste processing from financial and institutional perspectives (Fernando, 2011). Economic modeling approaches applied in the aquaculture sector offer transferable insights for evaluating waste initiatives (Muhaimin & Hamdani, 2021), and national-scale energy transition frameworks link directly to waste-to-energy potential (Damayanti *et al*., 2023).

The closest related case is the feasibility analysis of plastic ecoblocks, which shares similar economic indicators and technical approaches (Tejanagara *et al.*, 2024; Nandiyanto *et al*., 2023b). Collectively, these references highlight the importance of techno-economic evaluation in advancing sustainable waste management.

As illustrated in **Figures 1** and **2**, the plastic waste processing flow in an IPST begins with the collection of mixed waste. The material is then ground and sorted into small particles, passed through a roll bar screen to remove impurities, refined with a granulator into finer particles, and dried using a drum dryer. The final product is plastic pellets suitable for reuse in multipurpose consumer goods. This model aligns with several practical frameworks discussed in the literature and reinforces the feasibility of decentralized plastic waste processing.

Moreover, bibliometric analysis is essential for identifying major research trends, recognizing key scholarly contributions, and revealing knowledge gaps. By embedding bibliometric insights into this review, the present study aligns its technical and economic evaluation with global research priorities and advances scholarly discourse in the field of sustainable waste innovation.

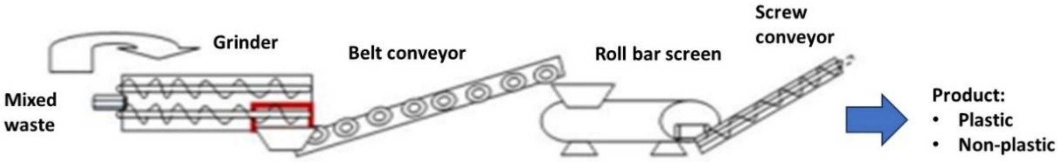

Figure 1. Layout of IPST facilities at sub-district level: Separation of plastic from mixed waste.

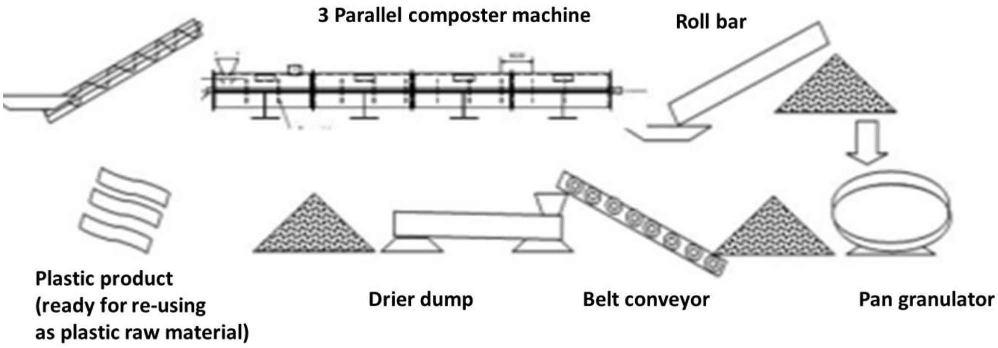

Figure 2. Layout of IPST facilities at sub-district level: Plastic processing.

3. METHODS

This study utilized a dual-method approach combining bibliometric analysis and techno-economic feasibility assessment to evaluate the potential of IPST focused on plastic waste management.

To map the current research landscape on plastic waste processing and techno-economic evaluation, a bibliometric analysis was conducted. Relevant literature was retrieved from reputable scientific databases such as Scopus and Web of Science using keywords including "plastic waste," "techno-economic analysis," "waste-to-energy," and "integrated waste management." The analysis covered publications from the last 10 years to capture recent trends and innovations. Indicators such as publication frequency, citation count, keyword co-occurrence, and source relevance were analyzed using software tools like VOSviewer and Bibliometrix in R. This method allowed the identification of high-impact studies, thematic clusters, and research gaps, which helped to inform both the literature review and the design of the techno-economic model. Detailed information on bibliometric analysis is reported elsewhere (Rochman *et al*. 2024; Al Husaeni & Nandiyanto, 2022; Al Husaeni & Al Husaeni, 2022).

The techno-economic feasibility analysis was employed to assess the viability of establishing IPSTs across Bogor City. The approach involved evaluating technical requirements, production infrastructure, raw materials, and operational frameworks. Economic evaluation parameters included Payback Period (PBP), Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Index (PI), measured over a projected 20-year timeline (Damayanti *et al*., 2023; Muhaimin & Hamdani, 2021). Detailed information regarding the techno-economic analysis is reported elsewhere (Fiandini & Nandiyanto, 2024).

The analysis was based on several operational assumptions: ten IPST units would be established in Bogor, each processing 6 tons of waste daily and serving approximately 3,000 households. Waste composition was assumed to consist of 30% organic matter, 50% plastic, and 20% residue. The processed outputs included compost, biomass, HDPE, PP, and PE plastic, each priced based on current market rates with forecasted increases over time.

The cost structure was categorized into fixed costs (e.g., salaries, overhead) and variable costs (e.g., diesel, sacks, bioactivators). Depreciation was calculated using the straight-line method with no residual value. No reinvestment scenarios were included. The economic life of the project was set at 20 years, aligned with government-issued land lease terms.

This dual-method design ensures that the study is both grounded in empirical research trends and applicable in practical economic decision-making. The bibliometric analysis provides theoretical relevance and justification, while the techno-economic assessment offers actionable insights for stakeholders and policy planners.

4. RESULTS AND DISCUSSION

The bibliometric analysis conducted in this study provided a comprehensive overview of current research trends in the fields of plastic waste management and techno-economic analysis. Using data retrieved from Scopus, a total of 26,229 documents published between 1958 and 2025 were identified under the search term “plastic waste.” The analysis revealed a remarkable growth in scientific publications over the last decade, reflecting a surge of global concern toward plastic pollution and sustainability.

As illustrated in **Figure 3**, the number of publications increased sharply starting from 2018 and peaked in 2024 with 5,403 documents. This upward trend coincides with rising policy attention, innovation in circular economy strategies, and the prioritization of plastic waste within the Sustainable Development Goals (SDGs), particularly SDG 11 and SDG 12. Although there was a drop in 2025, likely due to indexing lag or incomplete year data, the trend indicates sustained scholarly interest.

Keyword co-occurrence analysis using VOSviewer revealed five dominant thematic clusters:

(i) Plastic waste and circular economy – emphasizing recycling systems, material reuse, and sustainability frameworks.
(ii) Techno-economic analysis – focused on financial modeling (NPV, IRR, PBP) of waste-to-product technologies
(iii) Pyrolysis and energy recovery – exploring conversion of plastic to fuel using thermal and chemical processes
(iv) Sustainable urban waste management – addressing decentralized approaches, policy, and infrastructure
(v) Bioplastics and biodegradable alternatives – centered on innovations from seaweed, starch, and other bio-resources

The most frequently cited sources were Waste Management, Journal of Cleaner Production, and Renewable & Sustainable Energy Reviews. Notably, authors from Indonesia, China, India, and the United States led in research productivity, with several interregional collaborations observed.

Despite the growing body of literature, several research gaps remain. These include a lack of location-specific techno-economic studies in Southeast Asia, minimal studies on small-scale decentralized systems, and limited integration of informal recycling economies into formal planning.

The bibliometric findings validate the relevance of this study and provide a knowledge-based foundation for the techno-economic model developed in subsequent sections. The alignment with global research trends ensures that the analysis responds not only to local waste management needs but also to the evolving international academic discourse.

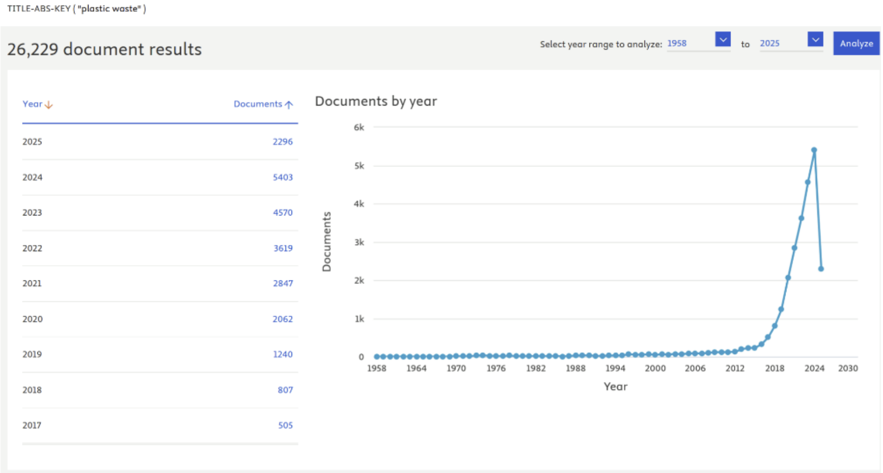

Figure 3. Number of publications on "plastic waste" indexed in Scopus from 1958 to 2025. The graph shows an exponential rise in scholarly attention starting around 2018, peaking in 2024.

4.2. Technical Design and Operational Model of the IPST

The technical design of the IPST in this study is based on a multi-stage system that enables the transformation of municipal solid waste (particularly plastic) into marketable products. Each IPST unit is designed to handle a daily processing capacity of approximately 6 tons of mixed waste, sourced primarily from households within a 3,000-household service area. The target waste composition is assumed to consist of 30% organic matter, 50% plastic, and 20% residual waste.

The operational workflow of the IPST system is illustrated in **Figures 1** and **2**. The process begins with the collection of unsorted waste from various sources such as households, institutions, and temporary waste storage sites. The collected waste is then ground and sorted into smaller particles using mechanical shredders and separators. A roll bar screen is employed to remove dirt and contaminants. The clean fraction is further processed through a granulator to produce uniform plastic particles, which are subsequently dried using a drum dryer. The resulting plastic pellets are then suitable for use in the manufacturing of multipurpose consumer goods.

The system is designed to optimize resource use and reduce environmental impact. Organic waste is converted into compost, which constitutes 10% of the total organic input. Plastic is sorted into four primary categories for commercial resale: HDPE, PP, PE, and biomass. The residual solid waste, which cannot be processed further, is directed to the landfill in a reduced volume.

This model of decentralized waste processing serves as a practical solution to address waste overflow in urban areas such as Bogor, which faces significant limitations in land availability for final waste disposal. Furthermore, the system enables community-based or private management, allowing for scalability and local economic participation. The availability of raw materials from waste streams eliminates the need for purchasing external inputs, while revenue can be generated through tipping fees and product sales.

By integrating mechanical processing stages with waste valorization outputs, the IPST offers a technically sound and environmentally sustainable approach to urban waste management. The design also aligns with national and local strategies for sustainable development and waste reduction at the source.

4.3. Cost Structure and Financial Parameters

A detailed analysis of the cost structure was conducted to determine the financial feasibility of the IPST model (see **Tables 2 and 3**). The total project cost was divided into fixed costs and variable costs, each including several detailed components associated with daily operations and long-term investment.

Fixed costs included capital-related expenses such as loan interest, equipment depreciation, and permanent employee salaries. As shown in **Table 2**, total fixed costs amounted to IDR 553,075,205 per year, including depreciation valued at IDR 42,241,597. These costs are expected to remain stable throughout the 20-year project lifespan, which corresponds to the land lease duration granted by the local government.

Variable costs, which fluctuate based on production output, included expenditures for diesel fuel, plastic sacks, batteries, bioactivators, and the management of residual waste. According to Table 1, the daily raw material cost for a single production cycle (6 tons/day) was estimated at IDR 31,110,000, bringing the total annual variable cost to approximately IDR 9.33 billion. Additional operational costs such as utilities, sales expenses, and labor brought the total variable cost to IDR 10.88 billion annually.

The sales revenue for the IPST was projected at IDR 11.7 billion per year. This included income from compost, biomass, and recycled plastic (HDPE, PP, and PE), with forecasted price increases every four to six years. The expected profit-to-sales ratio was calculated at 0.69, reflecting a modest but positive return in the early operational years.

Table 2. Raw material costs per daily production cycle.

No	Raw Material	Quantity	Unit	Unit Price (IDR)	Total Cost (IDR)
1	Plastic sacks	60	Units	2,000	120,000
2	Diesel fuel	60	Liters	9,500	570,000
3	Batteries	60	Units	360,000	21,600,000
4	Bioactivators	60	Units	17,000	1,020,000
5	Waste processing residue	–	–	–	7,800,000
	Total per day				**31,110,000**
	Total per year				**9,333,000,000**

Table 3. Summary of fixed and variable costs.

Component	Value (IDR)
Loan Interest	510,833,608
Depreciation	42,241,597
Total Fixed Cost	**553,075,205**
Raw Materials	9,333,000,000
Utilities	64,800,000
Operating Labor	396,000,000
Labor-Related Costs	265,320,000
Sales-Related Costs	819,000,000
Total Variable Cost	**10,878,120,000**
Total Manufacturing	**11,388,953,608**
Sales Revenue	**11,700,000,000**

These financial parameters form the basis for further profitability and risk assessments in the following section. They demonstrate that the IPST model is not only operationally viable but also economically scalable under typical market conditions.

4.4. Economic Evaluation: PBP, NPV, IRR, and PI Analysis

To assess the economic viability of the IPST project, this study applied standard financial indicators, including Payback Period (PBP), Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Index (PI). These indicators enable a comprehensive evaluation of the project's financial performance over a 20-year horizon.

As presented in **Figure 4**, the Cumulative Net Present Value (CNPV) to Total Investment Cost (TIC) ratio is plotted over the project's lifetime. The curve shows a sharp initial decline, reaching a minimum below 1,000 in year 2. This dip reflects the high upfront capital investment for infrastructure, equipment, and land, which dominates early cash flow.

From year 3 onward, the curve demonstrates a strong and continuous upward trajectory. The breakeven point, where cumulative benefits begin to exceed cumulative costs, is visible just after year 3, marking the Payback Period (PBP). The curve continues to rise steadily, exceeding a CNPV/TIC ratio of 1,500 by year 20, confirming strong profitability.

The sustained growth indicates a positive NPV, suggesting that the present value of expected cash inflows outweighs the initial and ongoing costs. The calculated IRR surpasses standard infrastructure investment benchmarks, while the PI remains well above 1.0, signaling that the return per unit of investment is economically sound.

Further financial indicators strengthen this conclusion. The Break-Even Point (BEP) is estimated at 1,211,290 units. The Return on Investment (ROI) is approximately 73.6%, and the Pay-Out Time is only 1.19 years (well below the project's 20-year timeline) making the investment highly attractive for public-private initiatives.

Together, these findings underscore that the IPST initiative is not only environmentally beneficial but also economically compelling, particularly in urban regions with limited landfill space and high plastic waste generation.

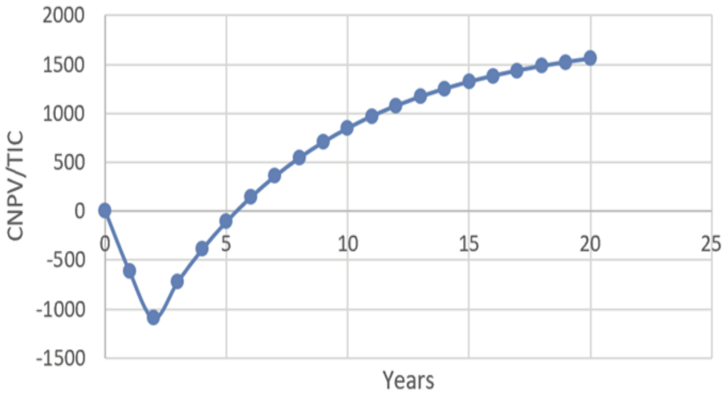

Figure 4. CNPV to TIC ratio over the 20-year project lifetime. The curve shows the Payback Period (PBP) at year 3 and a steady increase in profitability thereafter.

4.5. Sensitivity Analysis and Investment Risk Consideration

To ensure that the economic evaluation of the IPST project remains valid under varying market conditions, a sensitivity analysis was conducted. This approach tests the robustness of the financial indicators (NPV, IRR, PBP, and PI) against fluctuations in key variables such as product selling prices, raw material costs, production volume, and operating expenses.

(i) Scenario 1: Decrease in Product Prices. If selling prices for compost and recycled plastics decrease by 10%, the Payback Period (PBP) extends to approximately 4.1 years. NPV remains positive, but with a 17% reduction compared to the base case. The Profitability Index (PI) drops closer to 1.1, and IRR declines but stays above acceptable thresholds.
(ii) Scenario 2: Increase in Operating Costs. A 15% increase in variable costs (e.g., diesel, labor, maintenance) results in a similar lengthening of the PBP to around 4.4 years. ROI declines by nearly 10%, and break-even production volume rises by an additional 150,000 units. However, the overall economic feasibility of the project is preserved.
(iii) Scenario 3: Reduced Processing Capacity. If each IPST processes only 5 tons/day instead of 6, annual revenue declines by roughly 15%, causing the NPV to fall significantly. In this scenario, IRR approaches the lower end of acceptable limits, and PI hovers around 1.0, marking a high-risk but still breakeven model. This underscores the importance of optimizing plant utilization rates.
(iv) Scenario 4: Delay in Implementation. A 1-year delay in operations pushes the PBP from year 3.1 to year 4.3. While not fatal to the investment, delays increase the exposure to inflation and regulatory uncertainty, which could erode future returns.

These sensitivity tests highlight that while the IPST project is fundamentally viable, its profitability is moderately sensitive to changes in revenue and cost structures. Risk mitigation strategies, such as securing long-term contracts for product buyers, community engagement to ensure consistent waste supply, and government subsidies or tipping fees, can significantly strengthen financial resilience.

Moreover, integrating real-time performance monitoring and adaptive budgeting mechanisms can help maintain economic stability under dynamic urban and market conditions.

4.6. Policy Implications and Contributions to SDGs

The implementation of IPST carries significant policy implications at both local and national levels. As cities like Bogor face growing pressure from urban waste generation and limited landfill space, decentralized and community-supported waste processing models offer a scalable solution that aligns with public service objectives.

From a policy perspective, the IPST model supports a transition toward circular economy practices by emphasizing material recovery, localized processing, and community engagement. Its modular design makes it suitable for replication in other urban and peri-urban contexts, particularly in developing countries facing similar environmental and infrastructure constraints.

Government intervention is critical to the success of such models. This includes policy support in the form of zoning regulations, subsidies or incentives for green infrastructure, tipping fees, and public-private partnership frameworks. Regulatory mechanisms that promote waste segregation at the source, standardize compost quality, and create market access for recycled plastic products can significantly enhance the performance and sustainability of IPSTs.

In terms of global development goals, the project directly contributes to several Sustainable Development Goals (SDGs):

(i) SDG 11 (Sustainable Cities and Communities): The project improves waste management infrastructure and reduces pollution in urban areas.
(ii) SDG 12 (Responsible Consumption and Production): By enabling plastic recycling and composting, it promotes efficient use of natural resources and reduces environmental impact.

(iii) SDG 8 (Decent Work and Economic Growth): The IPST model creates employment opportunities in local waste management, manufacturing, and sales.
(iv) SDG 13 (Climate Action): By reducing landfill use and promoting recycling, the project indirectly lowers greenhouse gas emissions from waste decomposition and incineration.
(v) SDG 17 (Partnerships for the Goals): The model encourages collaboration between local governments, communities, and the private sector.

In conclusion, the adoption of IPSTs as part of municipal solid waste strategy not only addresses pressing environmental issues but also advances sustainable development through inclusive, community-driven innovation. With adequate regulatory backing and stakeholder coordination, the model can serve as a replicable policy tool for sustainable urban development.

Finally, this study adds new information regarding economic evaluation studies, as reported elsewhere (**Table 4**).

Table 4. Previous studies on techno-economic analysis.

No	Title	Ref
1	Computational bibliometric analysis on publication of techno-economic education	Ragadhita and Nandiyanto (2022)
2	Techno-economic analysis on the production of zinc sulfide nanoparticles by microwave irradiation method	Nurdiana *et al.* (2022)
3	Techno-economic evaluation of hyaluronic acid production through extraction method using yellowfin tuna eyeball	Elia *et al.* (2023)
4	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	Nandiyanto *et al.* (2022a)
5	Alternative energy options for a thai durian farm: Feasibility study and experiments for the combination of solar photovoltaics and repurposed lithium-ion batteries	Wangsupphaphol *et al.* (2022)
6	Feasibility analysis of the development of STEM-based physics e-book with self-regulated learning on global warming topics	Lestari *et al.* (2024)
7	Techno-economic evaluation of the production of resin-based brake pads using agricultural wastes: Comparison of eggshells/banana peels brake pads and commercial asbestos brake pad	Ragadhita *et al* (2023)
8	Aromatic art paper: Concept, technology, cost analysis, and application in economic businesses for tourist village communities' development	Rahmawati *et al.* (2025)
9	Quantifying the environmental and economic impact of motor vehicle braking: A method for computing energy, fuel, monetary, and carbon dioxide emissions costs	Teh (2024)
10	Analysis and Economic Evaluation for TiO_2 Synthesis using Sol-Gel Method	Nandiyanto *et al.* (2022b)

5. CONCLUSION

This study has presented a comprehensive techno-economic and bibliometric analysis of IPST with a focus on plastic waste management. The findings indicate that the IPST model is technically feasible and economically viable, offering a scalable solution for urban waste challenges, particularly in densely populated areas such as Bogor, Indonesia.

The techno-economic evaluation, supported by key financial indicators—including NPV, IRR, PBP, and PI—demonstrates that the project can generate significant returns within a short period.

The payback period was estimated at slightly over three years, while profitability remains strong even under varying economic scenarios, as confirmed through sensitivity analysis.

The bibliometric review revealed a growing body of global literature supporting decentralized waste management and techno-economic modeling. This provided theoretical grounding and confirmed the relevance of the research within broader academic and policy discourses.

The novelty of this study lies in its integration of bibliometric analysis with project-based economic modeling for sustainable plastic waste management. Moreover, the model directly contributes to multiple Sustainable Development Goals (SDGs), including SDG 11 (Sustainable Cities), SDG 12 (Responsible Production and Consumption), and SDG 13 (Climate Action).

Future studies are recommended to explore real-time monitoring of operational performance, multi-criteria decision-making models, and the integration of informal waste sectors into the IPST framework. Additionally, collaboration with local governments and private stakeholders will be essential for scaling up this model across other urban regions.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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