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Designing A Circular Value Chain Model for Plastic Waste Upcycling

Case Study in TPS 3R Basama

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Abstract

Introduction/Main Objectives: This research aims to design a circular value chain model that enhances the economic and sustainability potential of plastic waste upcycled into handicrafts.

Background Problems: Plastic waste remains a critical environmental issue in Indonesia, and community waste management units such as TPS 3R Basama often face challenges in converting collected materials into valuable products.

Research Methods: A mixed-method approach integrates field observations, stakeholder interviews (collectors, managers, and processors), cost and feasibility analysis. Circular Economy principles and value chain frameworks guide the workflow mapping, value-added estimation, and assessment of environmental benefits.

Finding/Results: The study shows that implementing a circular value chain model at TPS 3R Basama increases the economic value of plastic waste by up to 12 times while reducing potential landfill residues by 720 kg per year.

Conclusion: The circular value chain model is financially and environmentally feasible to enhance TPS 3R productivity as a sustainable circular economy unit.

Keywords: Circular Model; Value Chain; Plastic Waste; Circular Value Chain; Value Added.

Introduction

Introduction The problem of plastic waste in Indonesia is increasingly serious as public and industrial consumption increases, while the level of utilization is still very low (son et al, 2025). Global plastic production continued to rise significantly during the last century and now produces amounts of waste that exceeds the ability of the earth to accommodate it (Velis, 2015). Globally, the world produces 350 to 400 million tons of plastic waste every year (Khamimah, 2021), the average increase in plastic waste generation during 2010 - 2024 continues to increase from 11% to 17%. Even estimated the total global plastic waste depiction will reach 3 billion tons in 2050 (Defitri, 2023). The accumulation of plastic waste has become a real threat to ecosystems and human health. Based on the results of the Sustainable Waste Indonesia (SWI) study with Indonesian Plastic Recyclers (IPR) through interviews of more than 700 industrial actors and secondary data from the July-December 2024 period, it is known that only around 1.238 million tons of plastic waste that worked collected and recycled per year from a total of 5,543 million tons of plastic waste produced. That is, the new national recycling rate reaches around 22%, so that most waste has the potential to become a residue that pollutes the environment.

The reduce-reuse-recycle waste processing site (TPS 3R) is expected to be a solution to reduce the burden of the Final Disposal Place (TPA) through the process of sorting and community-based processing (Sumarab et al, 2022).

However, many 3R polling stations in Indonesia have not operated optimally. One of them is a 3R TPS in Malang City which has a capacity of 60 tons of garbage per month, but is only able to process 6 tons per month. From these volumes, only 10% of plastic waste was successfully processed and had economic value, while the remaining 90% were immediately thrown into the TPA Supit Urang Sukun Malang. Similar conditions also occur in many 3R polling stations in other regions, which indicates the lack of use of plastic waste into a value-added product.

In fact, plastic waste has the potential to be processed into a product of selling such as (Handycraft that can improve community welfare if managed with the support of innovation and proper business strategy. Some 3R polling stations have been proven to be successful in processing products worth selling like handicraft on previous research. But there are still many 3R polling stations in Indonesia that have not been able to optimize such value-value products. The low level of utilization affirms the gap between the economic potential of plastic waste with the implementation of current management.

The urgency of this research lies in the need to find an integrated solution to optimize plastic waste conversion into higher economic value products and positive environmental and social impacts. Previous studies have highlighted the role of technology and innovation in supporting the economy circular (Kumar et al., 2024; Erickson et al., 2024; Jaligot et al., 2016; Olatayo et al., 2023; Johansen et al., 2021). However, most of them are still focusing on conventional recycling and have not reviewed how the business model and value chain at the community level, especially TPS 3R, can be developed in a sustainable manner.

Therefore, research gap appears on the lack of studies that map the value chain) processing plastic waste at TPS 3R in depth by integrating aspects of increased value added, financial feasibility, and environmental contributions. Novelty this research lies in the development of a circular value chain model that can increase management revenues, empower the community, and reduce residual waste significantly. Thus, this research is important to develop a more productive and sustainable plastic waste management strategy, so that TPS 3R does not only function as a waste sorting facility but can develop into a circular economic unit that provides simultaneous economic, environmental and social benefits.

Literature Study

Circular Economy

Circular Economy concept emphasizes sustainable resource utilization by extending the material life cycle through the principle of reduce, reuse, and recycling (Ogunmakinde, 2024). In the context of plastic waste management, circular economy becomes a strategic approach that can reduce dependence on new raw materials, reduce the volume of waste that ends in the landfill, and create economic value from waste which was previously considered useless (Lumbantobing et al, 2023). Thus, waste management is no longer just disposal activity but is part of a productive and regenerative economic system. In Indonesia, TPS 3R (reduce-reuse-recycle waste processing place) plays an important role as the leading guard in circular economy because it is at the community level that directly handles the sorting and processing of household waste. However, the implementation still faces challenges such as the low use of plastic waste which is only a small portion can be recycled and produces added value. As a result, most of the garbage remains end up as a residue in TPA and does not provide economic benefits for the community. The urgency of the implementation of Circular Economy at TPS 3R lies in need to change the waste management paradigm of linear ("take-use-throw") into circular through processing innovation, operational capacity building, and the development of the value chain that can change plastic waste into Economic value products such as industrial crafts and materials. With the strengthening of the Circular Economy model, TPS 3R has the potential to become a sustainable community business unit, increase community income, expand employment, while reducing significant landfill or TPA loads.

Value Chain

Value Chain Concept Value Chain emphasizes the importance of each stage in the production process to produce optimal added value (World Bank, 2020). In the context of waste management, value chain is used to trace the waste flow of the process of gathering, sorting, processing, to become economic value products, so that the economic potential can be maximized. In processing plastic waste, some studies confirm that product innovation and integration of circular business models are significantly able to increase the selling value of recycling results (Velis, 2015; Eriksen et al., 2024). However, the implementation of the principle at TPS 3R in Indonesia is still not optimal; Most only sell raw recycling materials with low values, while the supply chain has not been structured and the production capacity is limited. Therefore, the application of Value Chain's analysis became urgent to change the operation of TPS 3R of just conventional sorting towards a more productive circular economic system, increasing community income, and reducing the volume of waste that ended in the landfill or TPA.

Research Methods

Research Methods This study uses a case study approach and is implemented at TPS 3R Basama. Case studies were carried out at the TPS 3R Basama in Sukun, which is one of the largest 3R polling stations in Malang City and representation of the condition of TPS 3R in general in Indonesia. It is hoped that this study can produce a model that can be adapted to other 3R polling stations in the territory of Indonesia. The design of the research method was developed by adapting previous studies focusing on circular supply chain in community waste management units. Data collection is carried out through field observation, in-depth interviews, and internal search documents related to financial data, assets, human resources, and operational administration. Interview informants consist of TPS managers, sorting workers, and purposive processing partners. The interview guidelines were compiled based on previous

studies and included managerial issues, processing processes, and the potential for the development of upcycle products.

Data analysis was carried out through three modified stages of the previous research framework to obtain more comprehensive research results, namely: (1) Definition of the scope of the TPS 3R system, (2) Identification of plastic waste categories, and (3) relationship analysis and flow of values between stages Processing. The results of the analysis are used to design the circular value chain based on the circular economic principle. Furthermore, the research simulated the calculation of economic feasibility and the environmental impact of the proposed model. Financial analysis was carried out through measurement of NPV, IRR, and Payback Period based on the basic assumptions of operational costs and the potential for upcycle product revenue. Estimated value added is calculated through a comparison between the volume of plastic supply and high-value product output produced. Meanwhile, the assessment of the environmental benefits is compiled by comparing the scenario of the application of the model against the potential for waste reduction sent to the TPA and the reducing risk of emissions.

Result

Waste Plastic Categorization & Relationship Analysis

Based on the results of interviews and observations, researchers conducted a scope definition, which determined the scope and limit to the study of plastic waste processing research into ready-to-use items. With the condition of TPS 3R, ready-to-use items that allow it to be developed are handicraft products. This is based on raw materials (plastic waste) which are indeed easier to use as a handicraft product. In addition, plastic waste as a handicraft will increase the selling value more optimally and have more market potential segment choices.

In connection with potential plastic waste at TPS 3R Basama, identification of plastic waste categories and snowball sampling, which results in an identified plastic waste listed in the following table:

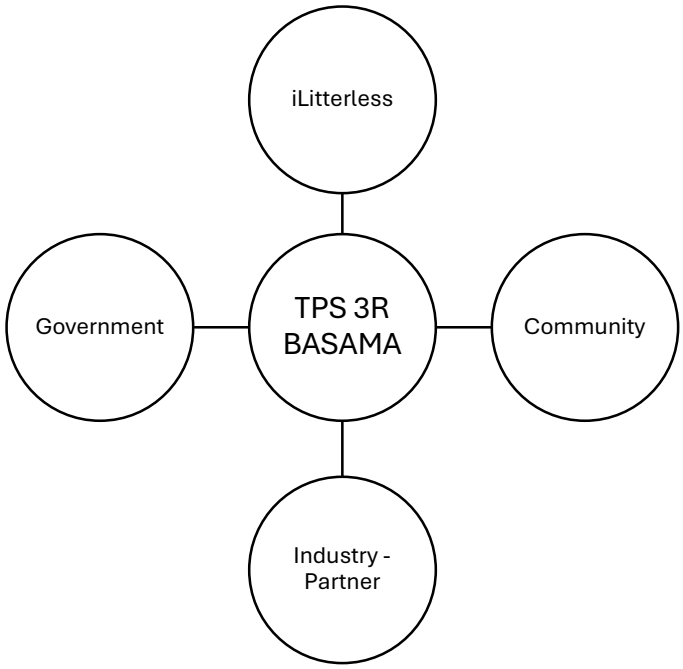
Table 1. Plastic Waste List

Description	Quantity	Unit
Facility Name		
Number of Personnel	13	Person
Incoming Waste Volume	4,5	Kg/day
Livestock Feed Raw Material		
Food Scraps	30	Kg/day
Food, Twigs, and Leaves	25	Kg/day
Recyclable Raw Material		
Plastic and Paper	37	Kg/day
Flexible Plastics	55	Kg/day
Paper and Cardboard	66	Kg/day
Glass	20	Kg/day
Fabric / Textiles	2	Kg/day
Metals (Ferrous and Non-Ferrous)		
Others		
Documentation and Equipment		
Recording System	Daily	
Platform Scale	2	Unit
Volume of Compost Produced	Not Yet Optimal	
Compost output sold / provided free of charge	Provided free of charge	
Waste Cart	0	Unit
Waste Motorcycle	3	Unit

Pickup Truck	1	Unit
Upcycle/Craft Raw Material		
Rigid Plastics	8	Kg/day
Flexible Plastics	15	Kg/day
Paper and Cardboard	14	Kg/day
Glass		
Fabric/Textiles	5	Kg/day
Metals (Ferrous and Non-Ferrous)	6	Kg/day
Others		Kg/day
Total managed Wasted	101	
Percentages of Managed Waste	7,3	Kg/day

Source: TPS 3R Basama, 2025

The plastic waste categorization was confirmed triangulated well on the TPS 3R Basama with one of the biggest partners, namely iLitterless as an educational institution for sorting waste and services in a special waste management system in the cafe in Malang. TPS 3R also accommodates the garbage obtained from the residents of Bandungrejosari Sukun District Malang. Furthermore, the results of processing non-organic waste are sold on third parties, namely the related industries. TPS 3R also received support and assistance from the Malang City Government and several college agencies. Thus, it can be mapped the relationship of analysis as follows:



Source: Collected Data, 2025

Figure 1. Relationship Analysis of TPS 3R Basama

Circular Value Chain Model

Circular Value Chain Model The conditions that occurred at TPS 3R Basama also occurred in most polling stations in Indonesia. The potential of plastic waste owned is still not optimal so that it is useful to be processed into a handcrafting production that is worth selling. In addition, it is also a solution to reducing plastic waste in Indonesia. Circular Value Chain Model is adapted from a successful plastic waste supply chain one of them in Portugal with the Integrated System for the Management of Packaging Waste (SIGRE) system, which is formed to fulfill legal obligations related to policy Extended Producer Responsibility (expanded

producer responsibility). This system is a collective management mechanism funded by organizations in the packaging value chain. The system shows the scheme of how the system works, the main relationship between stakeholders, as well as the flow of material and finance that occurs. Here's a picture of the SIGRE system:

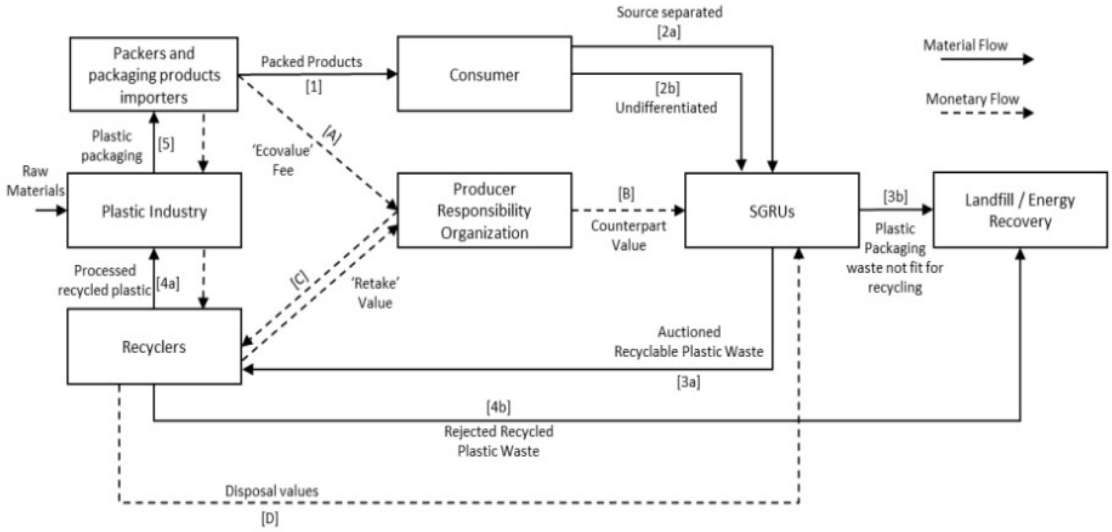
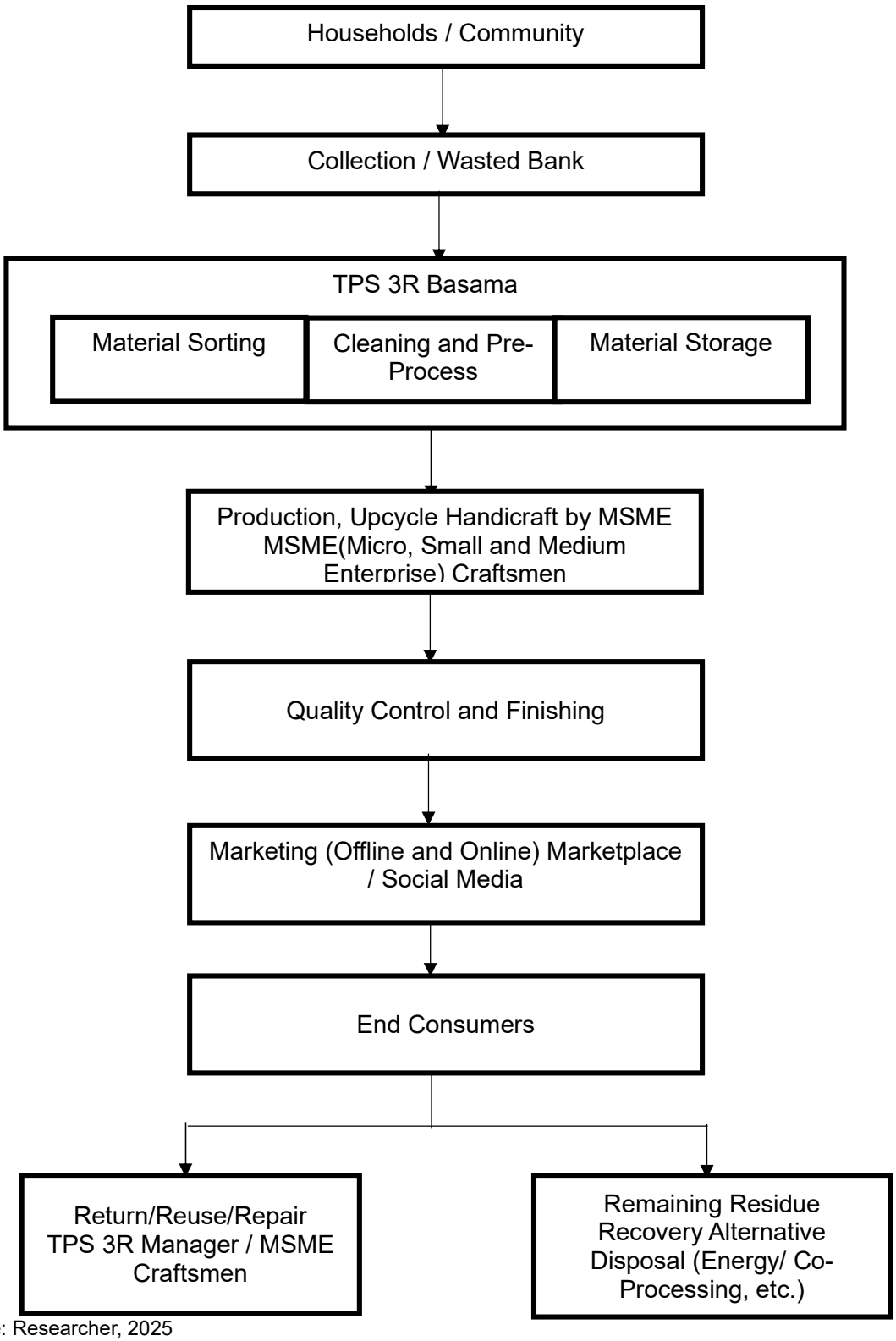


Figure 2. Plastic Packaging Waste Supply Chain – SIGRE

Conditions at TPS 3R Basama still require a series of simple circular value chain mechanisms because of the beginning of the baseline project. This ensures that the basic use of plastic waste is preferably optimal. Here is a picture of the Circular Value Chain model that adapts from the SIGRE and is adjusted to the condition of the TPS 3R Basama:



Source: Researcher, 2025

Figure 3. Circular Value Chain Model - TPS 3R Basama

Simulation Calculating Cost and Feasibility Analysis

Here's the calculation of simulation calculation with price data and estimates obtained from the results of observation and interviews:

Table 2. Basic data

No.	Component	Value or Amount
1	Plastic Waste Capacity per Month	60 kg
2	Selling Price of Raw Plastic	Rp 2.500/kg
3	Selling Price of Upcycle Handicraft	Rp 10.000/pcs
4	Plastic Required per Product Unit	1 kg 10 pcs
5	Production cost per unit	Rp 7.000
6	Equipment investment	Rp 100.000.000
7	Discount Rate (r) for NPV	10% per year
8	Business Horizon	5 year

Source: Researcher, 2025

Based on the data, if plastic waste is sold as raw waste, around 60kg x Rp 2,500 / kg = Rp 150,000 per month, the economic value is very low. Whereas if the upcycle becomes a handicraft, then:

turnover per kg = 10 pcs x Rp. 10,000 = Rp. 100,000

Fee per kg = 10 pcs x Rp. 7,000 = Rp. 70,000

Net Profit per Kg = Rp. 30,000

Net Profit per Month = 60kg x Rp. 30,000 = Rp. 1,800,000

Net Income per Year= Rp. 21,600,000

Furthermore, for feasibility analysis using the estimated cash flow of Rp. 21,600,000 per year for 5 years, namely:

$NPV = (\sum CFt / (1 + r)^t) - Investment$ 1

the results of calculation =

NPV = -rp20.691.273 (negative)

is thus not financially feasible in current conditions.

Internal Rate of Return (IRR) with 2.62% results. It is still far below the 10% discount rate. Furthermore, for the payback period as follows: PP = Rp. 100,000,000 / Rp. 21,600,000 = 4.63 years ago back in capital at the end of the 4th year towards the 5th.

This feasibility study aims to analyze the economic potential of plastic waste processing into an upcycle product in the form of handicrafts at TPS 3R Basama. At present, plastic waste collected only has a low selling value if sold as raw waste, which is around Rp 2,500 per kilogram. With a collection capacity of 60 kilograms per month, the economic value produced is only Rp 150,000 per month. This finding shows that the conventional approach has not contributed significantly to the TPS income and improving community welfare.

Through the circular value chain scheme, the plastic collected is processed into a value-added craft product. Based on simulation, one kilogram of plastic can be processed into 10 products with an average selling price of Rp 10,000 per unit. Production costs per unit of Rp. 7,000, so there is a margin of Rp. 3,000 per unit or Rp. 30,000 per kilogram. With a capacity of 60 kilograms per month, the net profit obtained reaches Rp 1,800,000 per month or Rp. 21,600,000 per year. This figure is far greater than the income from raw waste sales.

Furthermore, the financial feasibility analysis was carried out using the Net Present Value (NPV) indicator, the Internal Rate of Return (IRR), and Payback Period. The investment needed to support the upcycle production activity is estimated at Rp. 100,000,000 and assuming the age of a five-year project and a 10% discount rate, the calculation results indicate that NPV is negatively worth Rp. 20,691,273. In addition, the IRR value only reached 2.62%, it was far below the discount rate used so the project did not meet the standard of financial feasibility. While Payback Period was recorded for 4.63 years, which showed the return time of capital was quite long and was at the end of the project life.

Based on these results, the plastic waste processing project becomes a craft product that is not financially feasible in the current conditions. However, identified economic potential is very promising when strengthening in market aspects, production efficiency, and capacity building. Strategies such as improving the quality of product design, digital marketing, expansion of supply volume waste, and funding support from CSR or partnerships can significantly improve feasibility indicators. Thus, although the results of financial analysis show that this project is not feasible in the basic scenario, the opportunity to increase its economic value is very large. This feasibility study confirms the transformation of TPS 3R transformation than just a garbage sorting unit becomes a productive, inclusive, and sustainable circular economic entity.

Value Added Estimation & Assessment of Environmental Benefits

The application of the Circular Value Chain model at the TPS 3R Basama results in a significant increase in value added to the processed plastic waste. At present, one kilogram of plastic waste is only worth around Rp 2,500 if sold as raw waste. However, through the upcycling process, every kilogram of plastic can be converted into 10 craft products with a total selling value of Rp 100,000, after deducting production costs of Rp. 70,000 produce a net added value of Rp. 30,000 per kilogram. With the potential processing of 60 kilograms per month, the total value of the economy is created by Rp. 1,800,000 per month or Rp. 21,600,000 per year, which shows that upcycling can increase the economic value of plastic up to 12 times compared to sales as raw waste. In addition to financial contributions, the application of this model provides significant environmental benefits. Of a total of 60 kilograms of plastic that entered the TPS 3R Basama per month, so far around 90% still potentially become a residue and end up at the TPA. With an upcycling scheme, the volume of waste sent to the TPA can be reduced directly by 60 kilograms per month, or equivalent to 720 kilograms per year, thus reducing the pressure on the Supit Urang TPA which has experienced excess capacity. In addition, the reduction of plastic residues also contributes to a decrease in potential greenhouse gas emissions and microplastic pollution in the environment. This finding confirms that the integration of the practice of circular economics at TPS 3R not only creates local economic growth but also strengthens the important role of the polling station in supporting the target reduction of plastic waste and environmental sustainability nationally.

Discussion

The discussion of this study indicates that the application of circular value chain in the upcycling of plastic waste in TPS 3R Basama can produce economic, social and environmental benefits simultaneously. This finding strengthens the urgency of the transformation of the community waste management system, given the current conditions show that more than 90%

inorganic waste is still not utilized, causing environmental burdens and high operational costs at the polling stations. By converting low-value plastic waste into a craft product, the value of the resulting value has increased significantly up to Rp18,950,000 per month. These economic benefits mainly flow to local craftsmen, mostly women, thus strengthening family economic empowerment and improving social inclusion.

Theoretically, the results of this study strengthen Circular Economy Theory which views waste as a resource that can be reprocessed to maintain its economic value. The resulting closing-the-loop model shows that upcycling activities can reduce dependence on linear supply chains and create a new economic cycle at the community level. In line with Value Chain Theory (Porter, 1985), this study also proves that the creation of value does not stop at the production stage but is spread evenly to all actors involved in the supply chain, ranging from the settings, craftsmen, to the TPS manager. In addition, in line with the Empowerment Theory, this study confirms that increasing individual and community capacity through craft-based economic activities can trigger the growth of autonomy and social independence.

The study also closed the GAP Research which had been emerging in the 3R polish management literature in Indonesia, where the focus of research tended to only be in the capacity building and reducing waste generation, but not many examined the comprehensive circular economic model that was able to integrate economic value, environmental impact, and community empowerment at once. By measuring the reduction of co-emissions of 14.4 tons per year, this study shows quantitative evidence of environmental benefits that are rarely presented in community level research. This finding confirms that plastic upcycling contributes a real contribution to climate change mitigation through a reduction in plastic disposal in TPA.

In terms of managerial implications, these findings provide concrete guidance for TPS 3R and stakeholders to strengthen the sustainability of the model, namely through standardization of product quality, network marketing expansion, periodic design and production training, collaboration with MSMEs and e-commerce platforms, as well as government policy support and company CSR. With the support of a stronger marketing strategy, this model can be replicated at other 3R polling stations in Indonesia, which expand the impact of the community-based green economy. Overall, the results of this discussion asserted that the transformation towards a community-based circular economy is not only a technical solution for plastic waste management, but also a sustainable development strategy that is able to encourage local economic growth, improve environmental quality, and empowerment of vulnerable groups in society.

Conclusion

Conclusion This study indicates that the application of artificial intelligence-based sustainability accounting (AI) in MSMEs in Indonesia can create value added both financially and the environment. The results of the study reveal that the digitization of sustainability reporting increases operational efficiency, reduces costs, and strengthens transparency in resource use. The benefits of measurable environment such as reducing emissions and waste reductions prove that MSMEs can contribute to the achievement of sustainable development goals without inhibiting business competitiveness. This finding fills the research gap by providing empirical evidence related to how environmentally friendly digital technology can present the economic value of the environment at the level of micro and small business.

Theoretically, this study enriches the application of Value-Added Theory and stakeholder-based sustainability accounting framework in the context of developing countries, especially in the MSME ecosystem. In terms of practice, these findings provide clear managerial implications: MSME players need to view digital adoption and sustainability reporting as strategic investment, not just the burden of compliance. The government and support agencies

also need to strengthen infrastructure, incentives, and digital literacy programs to accelerate the green transformation of the MSME sector. Overall, this study confirms that AI-based sustainability accounting is not only worthy of implementation in MSMEs, but also an important element in encouraging inclusive and sustainable economic development in Indonesia.

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