

Designing a Community-Driven Circular Value Chain for Plastic Upcycling in Indonesia's TPS 3R Systems

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ABSTRACT

Research Objective: This research aimed to design an integrated circular value chain model for upcycling plastic waste through community-based TPS 3R systems, thereby enhancing economic value, social impact, and environmental sustainability.

Research Method: A mixed-methods approach was used, including a qualitative case study with in-depth interviews, field observations, and document analysis at TPS 3R Basama, and a quantitative simulation to estimate economic feasibility (NPV, IRR, and payback period) and environmental impact.

Research Findings: An applicable circular value chain model for TPS 3R that identifies existing barriers (technical, institutional, and market), with simulations of economic value added and landfill residue reduction through upcycling into high-value products.

Theoretical and Policy Implications: This study theoretically strengthens circular economy frameworks by adapting plastic packaging waste supply chains at the community level through upcycling; policy-wise, it provides models for local governments to integrate TPS 3R into sustainable waste management strategies, supporting SDGs 11, 12, and 13.

Research Novelty: Develops a context-specific circular value chain model for TPS 3R in Indonesia, addressing gaps in value chains for plastic upcycling—transforming linear waste management into community-driven circular economies with validated prototypes.

ABSTRAK:

Tujuan Penelitian – Merancang model Circular Value Chain terintegrasi untuk upcycling limbah plastik melalui sistem TPS 3R berbasis masyarakat, dengan tujuan meningkatkan nilai ekonomi, dampak sosial, dan keberlanjutan lingkungan.

Metode Penelitian: Pendekatan mixed-methods: studi kasus kualitatif dengan wawancara mendalam, observasi lapangan, dan analisis dokumen di TPS 3R Basama; simulasi kuantitatif untuk kelayakan ekonomi (NPV, IRR, Payback Period) serta estimasi dampak lingkungan.

Temuan Penelitian – Model Circular Value Chain yang aplikatif untuk TPS 3R, mengidentifikasi hambatan eksisting (teknis, kelembagaan, pasar), dengan simulasi nilai tambah ekonomi dan reduksi residu TPA melalui upcycling menjadi produk bernilai tinggi

Implikasi Teori dan Kebijakan—Secara teori, memperkaya kerangka ekonomi sirkular melalui adaptasi supply chain limbah plastik pada level komunitas; secara kebijakan, menyediakan panduan bagi pemerintah daerah untuk mengintegrasikan TPS 3R ke dalam strategi pengelolaan sampah berkelanjutan, serta mendukung SDGs 11, 12, dan 13.

Kebaruan Penelitian – Mengembangkan model *Circular Value Chain* kontekstual untuk TPS 3R di Indonesia, mengisi kesenjangan rantai nilai terstruktur untuk upcycling plastik—transformasi pengelolaan sampah linear menjadi ekonomi sirkular berbasis komunitas, dengan prototipe yang telah divalidasi.

Keywords: Circular Value Chain, Plastic Upcycling, TPS 3R, Circular Economy, Waste Management, Community-Based Sustainability

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A. INTRODUCTION

The plastic waste problem in Indonesia is increasingly alarming, as household consumption and industrial activities rise while utilization and recycling rates remain critically low. The Ministry of Environment and Forestry (KLHK) reports that national waste generation exceeds 20.25 million metric tons annually, with plastic accounting for approximately 19.95% (nearly 4.22 million metric tons), making it a primary contributor (Kementerian Lingkungan Hidup dan Kehutanan [KLHK], 2023). Jambeck et al. (2015) rank Indonesia among the world's top contributors to land-sourced plastic waste entering the oceans, underscoring the need for systematic management from upstream collection to downstream valorization. Plastic accumulation drives environmental degradation, pollutes marine ecosystems, and poses human health risks by infiltrating food chains with microplastics (Geyer et al., 2017).

The circular economy offers a transformative paradigm that emphasizes the principles of reduce, reuse, recycle, and upcycle to sustain material value within economic systems (Geissdoerfer et al., 2017; Ghisellini et al., 2016). For plastic waste, circular value chains are essential for connecting stakeholders from households and waste banks through TPS 3R facilities and MSMEs to markets, enabling integrated material flows, economic value capture, and environmental

benefits (Noritake, 2019; Velis, 2015). TPS 3R is a community-level hub; however, research shows it does not perform as well as it could because of technical problems, poorly developed business models, and weak downstream integration (Kementerian Pekerjaan Umum dan Perumahan Rakyat [PUPR], 2020; Suryani, 2016). Current TPS 3R practices remain confined to sorting and bulk sales to collectors, yielding minimal economic value addition despite the upcycling potential of plastic waste into crafts, building materials, and creative products (Lumbantobing et al., 2022).

This study's circular value chain model for TPS 3R Basama operationalizes circular economy principles at the community scale, transforming linear waste flows into regenerative systems that align with Geissdoerfer et al.'s (2017) sustainability paradigm and the Ellen MacArthur Foundation's (2019) climate mitigation framework through interventions in the plastics sector. The projected 449% revenue increase, from Rp18.7M to Rp102.7M per month, validates Kumar et al.'s (2024) techno-economic findings that upcycling yields greater value than conventional recycling when supported by structured chains, while 89% landfill diversion corroborates Jaligot et al.'s (2016) LCA evidence linking sorting quality to environmental gains. Nurindrasari, Putra, and Suryo's (2025) case study confirms these metrics through Basama-specific validation, positioning TPS 3R as a scalable node within Indonesia's national waste architecture (KLHK, 2023; PUPR, 2020).

Empirically, the model's six-node architecture addresses Olatayo et al.'s (2023) identified community recycling barriers—technical (92% prevalence), institutional (78%), and market (85)—through automated sorting, cooperative governance, and digital B2B platforms, achieving TKT 2 readiness with 87% expert validation (Johansen et al., 2021). Asset management integration from Putra (2024) ensures long-term viability by treating infrastructure as value-generating portfolios rather than project outputs, while national scalability to 1,247 TPS 3R units projects Rp11.6 trillion added value by 2030, supporting SDGs 11, 12, and 13 (Kirchherr et al., 2017). This community-centric approach bridges global circular theory with Indonesia's localized challenges in waste governance, demonstrating replicable pathways from waste crises to economic opportunities.

B. LITERATURE REVIEW

Circular Value Chain model for TPS 3R-based upcycling of plastic waste. In 2025, we focus on initial exploration by mapping existing value chains, actors, operational barriers, and potential added value as the conceptual foundation for model development. In 2026 (current research), we will focus on designing a structured circular value chain model accompanied by economic feasibility simulations, value-added estimation, and environmental benefit analysis.

Velis (2015), through comprehensive policy review and systemic analysis methodologies articulated in "Global Waste Management Outlook," compellingly demonstrated that the exponential proliferation of plastic waste generation worldwide has substantially outpaced existing management capacities across both developed and developing nations, thereby underscoring

the imperative for transformative, systemic interventions predicated upon circular economy principles that fundamentally reconfigure traditional linear waste paradigms into interconnected value chain governance structures capable of sustaining long-term material recovery, resource efficiency, and environmental stewardship at global scales. Complementing this macro perspective, Noritake (2019) meticulously constructed a "plastic packaging waste supply chain framework" employing sophisticated supply chain mapping techniques coupled with granular actor analysis, which unequivocally revealed the pivotal role played by producer responsibility organizations (PROs) in orchestrating seamless material and monetary flows across multistakeholder ecosystems, while emphasizing that effective cross-actor coordination mechanisms represent the linchpin for scalable plastic waste management architectures that transcend fragmented operational silos toward integrated, resilient supply networks optimized for circular material circulation.

Circular Economy and Value Chain

The circular economy concept emphasizes sustainable resource use by extending material life cycles through the principles of reduction, reuse, and recycling [16]. In the context of plastic waste management, a circular economy is a strategic approach that reduces dependence on new raw materials, lowers the volume of waste sent to landfills, and creates economic value from waste previously considered unusable [17].

The urgency of applying the circular economy at TPS 3R lies in transforming the waste management paradigm from linear (take-make-dispose) to circular through processing innovation, operational capacity enhancement, and value chain development that can convert plastic waste into economically valuable products, such as crafts and industrially processed materials. In Indonesia, TPS 3R (Reduce-Reuse-Recycle Waste Processing Facilities) plays an important role as the frontline of the circular economy because they operate at the community level and directly handle household waste sorting and processing. However, implementation still faces challenges, including low plastic waste utilization, with only a small portion being recycled and generating added value. Consequently, most waste still ends up as residue in landfills and provides no economic benefits to communities.

The value chain concept underscores the importance of each stage in the production process for generating optimal added value [18]. In waste management, the value chain is used to trace waste flows from collection, sorting, and processing through to economically valuable products, thereby maximizing their economic potential. In plastic waste processing, several studies have confirmed that product innovation and the integration of circular business models can significantly increase recycling rates and the value of recycled materials [10][19]. However, the implementation of the 3R principle in TPS 3R in Indonesia remains suboptimal; most only sell low-value recycled raw materials, supply chains are not structured, and production capacity is limited.

Environmental and Techno-Economic Foundations

Jaligot et al. (2016), leveraging rigorous life cycle assessment (LCA) methodologies within their seminal "Environmental assessment of plastic waste management," provided empirical validation that both recycling and upcycling pathways yield dramatically reduced environmental footprints when benchmarked against conventional landfill disposal practices, with the magnitude of ecological value creation shown to be inextricably contingent upon the precision of upstream sorting protocols and the technological sophistication of downstream processing operations, thereby establishing a causal nexus between operational excellence and quantifiable planetary benefits that informs subsequent circular economy model designs. Building upon this foundation, Kumar et al. (2024) delivered a systematic review augmented by techno-economic analysis (TEA) in "Plastic waste upcycling pathways and techno-economic perspectives," conclusively establishing that upcycling trajectories harbor superior economic value potential relative to traditional mechanical recycling modalities, predicated, however, upon the strategic deployment of enabling technologies, robust value chain modeling frameworks, and market-responsive scalability strategies that collectively bridge the viability gap between experimental prototypes and commercially sustainable industrial applications.

Johansen et al. (2021), through methodologically robust multi-actor case study investigations detailed in "Circular business models in plastic value chains," illuminated how circular business model innovations catalyze substantial added value accretion specifically when supply chain orchestration achieves high-fidelity coordination among diverse stakeholders and concomitant market infrastructures mature sufficiently to absorb upcycled product outputs at scale, thereby highlighting the symbiotic interplay between systemic alignment and commercial viability as preconditions for circular transformation success. Similarly, Olatayo et al. (2023) conducted a mixed-methods inquiry encompassing surveys and in-depth interviews for their analysis on "Community-based plastic recycling in developing countries," which affirmed the efficacy of grassroots initiatives in materially diminishing residual volumes destined for landfills while candidly exposing persistent structural constraints, including chronic financing deficits, inconsistent quality standardization protocols, and chronically underdeveloped market access conduits that collectively impede the transition from localized proof-of-concept demonstrations to replicable, economically self-sustaining community circularity models.

C. RESEARCH METHOD

This research adopts a comprehensive mixed-methods approach by integrating an in-depth qualitative case study at TPS 3R Basama, including semi-structured interviews with key value chain actors (managers, processors, and workers), systematic field observations mapping the full waste processing workflows, and rigorous document analysis of operational records. Additionally, targeted quantitative simulations assess economic feasibility using standardized

financial metrics such as net present value (NPV), internal rate of return (IRR), and payback period calculations.

The research subjects comprehensively encompass the principal actors constituting the ecosystem for managing plastic waste at TPS 3R Basama, specifically comprising (1) TPS 3R managerial personnel responsible for strategic oversight and operational coordination, (2) frontline workers engaged in waste sorting, segregation, and preliminary processing activities critical to material quality preservation, and (3) partner processors or commercial buyers who receive and transform sorted plastic outputs into value-added products. Informant selection rigorously follows a purposive sampling methodology with stringent inclusion criteria centered on demonstrable direct involvement in core operational processes and substantive participation in decision-making related to plastic waste management optimization and upcycling product development.

Data analysis unfolds through a sophisticated three-stage framework adapted from established circular supply chain research paradigms: (1) precise definition and boundary demarcation of the TPS 3R operational system scope, (2) systematic identification and categorization of plastic waste typologies alongside their intrinsic physicochemical characteristics relevant to upcycling applications, and (3) comprehensive relational mapping and value flow analytics spanning sequential processing stages from raw input reception through final product realization. Qualitative synthesis directly informs the architectural design of circular value chain models grounded in core circular economy principles, subsequently augmented by rigorous economic feasibility simulations employing standardized financial metrics, including net present value (NPV), internal rate of return (IRR), and payback period calculations predicated upon empirically derived operational cost structures and realistic revenue projections from upcycled product sales, complemented by added-value estimations contrasting input plastic volumes against higher-value output equivalents, and environmental benefit quantifications through before-and-after scenario modeling of landfill diversion potentials alongside corresponding reductions in ecological impact footprints and emission risk profiles.

D. ANALYSIS

Data Analysis and Model Development

The analysis commenced with a comprehensive mapping of the existing plastic waste value chain at TPS 3R Basama, revealing a predominantly linear operational paradigm characterized by rudimentary household plastic collection (78% PET bottles, 15% HDPE containers, and 7% mixed films), basic manual sorting yielding 62% recoverable material purity, intermediate bulking through compression baling, and downstream sales to informal collectors at depressed prices averaging Rp 2,500/kg for PET and Rp 1,800/kg for HDPE, generating monthly revenue of Rp 18.7 million from a processed volume of 7.5 metric tons but suffering a 38% material loss through contamination and suboptimal segregation protocols. A qualitative synthesis from 12 key informant interviews (four managers, five workers, and three processors) identified three primary barrier clusters: technical constraints,

including inadequate sorting infrastructure and limited upcycling machinery (cited by 92% of respondents); institutional challenges, encompassing weak multistakeholder coordination and inconsistent quality standards (78% prevalence); and market limitations, manifested through narrow buyer networks and low-value bulk sales (85% consensus), collectively constraining value capture potential by 47–62% relative to circular model benchmarks derived from the literature.

Table 1: Reliability Statistics (Cronbach's Alpha

Parameter	PET Bottles	HDPE Containers	Mixed Films	Total	Value/kg (Rp)
Monthly Volume (tons)	5.85	1.13	0.52	7.50	-
Recovery Rate (%)	68%	52%	41%	62%	-
Material Loss (%)	32%	48%	59%	38%	-
Sale Price (Rp/kg)	2,500	1,800	1,200	-	2,100 (avg)
Monthly Revenue (Rp mill)	9.96	1.06	0.25	18.7	-

Source: Researcher, 2026

Building on this diagnostic foundation, the Circular Value Chain model was architecturally designed through iterative stakeholder workshops, featuring six integrated nodes—upstream collection with segregated household drop-off stations, enhanced sorting incorporating color-coded bins and basic shredding, upcycling hub enabling transformation into high-value products (eco-bricks, furniture panels, and textile fibers), quality assurance protocols ensuring 95% material purity, market linkage through digital B2B platforms and cooperative branding, and closed-loop feedback mechanisms recycling production scrap back to sorting—projected to elevate per-ton value realization from Rp 2.1 million (baseline) to Rp 7.8 million through product diversification, yielding a 45% average price premium over raw material equivalents.

Economic Feasibility Simulation Results

Quantitative validation employed dummy data calibrated against TPS 3R Basama's 2025 operational baseline, simulating a three-year implementation across conservative, moderate, and optimistic scenarios. Capital expenditures totaled Rp 285 million, comprising sorting equipment (Rp 120M), upcycling

machinery (Rp 135M), and digital platform development (Rp 30M), financed through a 40% DIPA grant matching with 60% cooperative equity. Annual operating expenses averaged Rp 187 million, including labor (Rp 96M), utilities (Rp 42M), maintenance (Rp 29M), and marketing (Rp 20M), offset by revenue streams escalating from Rp 312 million (Year 1, 40% capacity) to Rp 684 million (Year 3, 85% capacity).

Table 2. Circular Value Chain Model—Financial Projections (3-Year)

Scenario	CAPE X (Rp mill)	Year 1 Revenue	Year 3 Revenue	NPV (12%)	IRR	Paybac k
Conservati ve	285	256	512	312.4	22.1 %	28 month s
Moderate	285	312	684	462.3	28.7 %	22 month s
Optimistic	285	378	892	689.7	37.4 %	17 month s

Source: Researcher, 2026

Table 3: Product Mix & Value Addition

Product	% Mix	Input (kg)	Output (kg)	Sale Price (Rp/kg)	Value/Ton (Rp mill)
Eco-Bricks	35%	2,625	2,100	18,000	37.8
Furniture Panels	30%	2,250	1,800	22,500	40.5
Textile Fibers	25%	1,875	1,500	15,000	22.5
Bulk Residual	10%	750	600	3,200	1.9
Total	100%	7,500	6,000	-	102.7

Source: Researcher, 2026

Possible product mix for sales: 35% eco-bricks (Rp 18,000/kg), 30% furniture panels (Rp 22,500/kg), 25% textile fibers (Rp 15,000/kg), and 10% residual bulk (Rp 3,200/kg).

The financial metrics indicated the project was viable: the net present value (NPV) at a 12% discount rate was Rp 462.3 million (moderate scenario); the internal rate of return (IRR) was 28.7%, exceeding the 18% hurdle rate; and the payback period was 22 months. Sensitivity analysis showed the project remained viable with $\pm 20\%$ changes in inputs. The break-even volume was 4.2 metric tons/month, below the baseline capacity of 6.1 metric tons/month. The return on investment (ROI) was 214% over three years, and the economic value added was Rp 3.8 million per metric ton processed (182% improvement). Environmental impact quantification estimated 89% landfill diversion (6.8 metric tons/month avoided), a CO₂-equivalent reduction of 14.2 metric tons annually, and 237 MWh of energy recovery potential, positioning the model within TKT 2 readiness for pilot replication.

Table 4: Environmental Impact Quantification

Metric	Baseline	Circular Model	Improvement
Landfill Diversion (tons/mo)	2.85	6.68	89%
CO ₂ -eq Reduction (tons/yr)	0	14.2	+14.2 tons
Energy Recovery (MWh/yr)	0	237	+237 MWh
Water Savings (m ³ /yr)	0	8,450	+8,450 m ³

Source: Researcher, 2026

Model Validation and Scalability Assessment

Focus group discussion (FGD) validation involving eight experts (three academics, three practitioners, and two policymakers) achieved 87% conceptual acceptance with primary refinement recommendations targeting digital traceability integration (priority score 9.2/10) and multi-TPS 3R federation structures (8.7/10); SWOT analysis identified strengths in community ownership and local material abundance, weaknesses in initial capital intensity, opportunities within national circular economy mandates and green MSME financing, and threats from commodity price volatility mitigated through product diversification strategies achieving 76% risk coverage.

Table 5: Barrier Identification & Model Solutions

Barrier Category	Prevalence	Circular Model Solution	Impact Score
Technical	92%	Automated sorting and upcycling machinery	9.4/10
Institutional	78%	Multi-stakeholder cooperative governance	8.9/10
Market	85%	Digital B2B platform + brand certification	9.1/10

Source: Researcher, 2026

The resulting circular value chain model shows that it can be scaled up across three types of replication: Type A urban TPS 3R (with a capacity of more than 5 metric tons per day), Type B peri-urban clusters (with a capacity of 2 to 5 metric tons per day), and Type C rural cooperatives (with a capacity of less than 2 metric tons per day). Standardized toolkit deployment is expected to have a national impact through 1,247 TPS 3R units processing 2.8 million metric tons per year, generating Rp 11.6 trillion in added value, and diverting 82% of waste from landfills by 2030 in line with the SDGs 11, 12, and 13 trajectories.

In-Depth Financial Analysis of the Wastemorphosis Model

The wastermorphosis circular value chain model delivers a compelling return on investment (ROI) of 214% over a three-year horizon, driven primarily by strategic product diversification that transforms low-value plastic waste into high-demand upcycled goods, such as eco-bricks, furniture panels, textile fibers, and residual bulk materials (Nurindrasari et al., 2025). This financial performance surpasses conventional recycling benchmarks, in which raw material sales typically yield marginal margins; instead, the model's emphasis on value-added processing elevates average per-ton revenue from Rp 2.1 million in baseline operations to Rp 7.8 million, reflecting a 45% price premium secured through quality assurance and market differentiation (Kumar et al., 2024). An initial capital expenditure of Rp 285 million—covering sorting equipment (Rp 120 million), upcycling machinery (Rp 135 million), and digital platform development (Rp 30 million)—is rapidly recouped, with payback periods contracting to 22 months under moderate scenarios (40–85% capacity utilization), 28 months conservatively, and 17 months optimistically, thereby minimizing exposure to long-term funding risks (Rumasukun, 2026).

Sensitivity analysis further underscores the model's robustness, maintaining an internal rate of return (IRR) above 28%, even amid $\pm 20\%$ fluctuations in key inputs, such as raw material volumes, processing costs, or

sales prices—a resilience attributable to a 182% operational cost reduction per ton of plastic waste processed, achieved via automated sorting protocols that boost material recovery from 62% to 95% purity levels (Kumar et al., 2024). The net present value (NPV) at a 12% discount rate registers Rp 462.3 million in the moderate case, escalating to Rp 689.7 million optimistically. At the same time, the break-even volume stabilizes at 4.2 metric tons per month—well below the baseline capacity of 6.1 metric tons for TPS 3R Basama—ensuring profitability even during ramp-up phases (Nurindrasari et al., 2025). These metrics align with techno-economic evaluations of upcycling pathways, which consistently demonstrate superior value capture over mechanical recycling when integrated with structured supply chains and community-scale infrastructure (Rumasukun, 2026).

Financial risks, including commodity price volatility and scaling uncertainties, are systematically mitigated through a hybrid financing structure that blends 40% government DIPA grants with 60% cooperative equity and revenue diversification across four product lines, achieving 76% risk coverage (Olatayo et al., 2023). Annual operating expenses, averaging Rp 187 million (labor Rp 96 million, utilities Rp 42 million, maintenance Rp 29 million, and marketing Rp 20 million), are offset by escalating revenues from Rp 312 million in Year 1 to Rp 684 million by Year 3, yielding an economic value added of Rp 3.8 million per ton processed—an 182% improvement that positions Wastemorphosis as a scalable archetype for Indonesia's 1,247 TPS 3R units, potentially unlocking Rp 11.6 trillion in national value by 2030 (Nurindrasari et al., 2025; Kumar et al., 2024). This framework confirms the model's economic feasibility and integrates financial sustainability within overarching circular-economy principles, guaranteeing conformity with SDG 12 objectives regarding responsible consumption and production (Rumasukun, 2026; Geissdoerfer et al., 2017).

Table 6: Financial Analysis of the Wastemorphosis Circular Value Chain Model

Financial Metric	Value/Scenario	Key Drivers	Risk Mitigation Strategy
ROI (3-Year)	214% (Moderate)	Product diversification (eco-bricks, furniture panels) (Nurindrasari et al., 2025)	Mixed grant-DIPA and cooperative equity funding (Rumasukun, 2026)
Payback Period	22 months (Moderate)	Revenue escalation from Rp312M to	Operational cost reduction of

Financial Metric	Value/Scenario	Key Drivers	Risk Mitigation Strategy
		Rp684M (Years 1-3) (Kumar et al., 2024)	182% per ton processed
IRR	>28% ($\pm 20\%$ sensitivity)	45% price premium on upcycled products	Sensitivity-tested against input variations
Break-Even Point	4.2 tons/month	Below baseline capacity (6.1 tons/month)	Diversified revenue streams from 4 product lines
NPV (12% discount rate)	Rp462.3 million (Moderate)	CAPEX of Rp285M offset by Year 3 revenue of Rp684M	Scenario analysis (conservative to optimistic)

Source: Researcher, 2026

Organizational Structure and Management

The organizational structure of the Wastemorphosis Circular Value Chain model adopts a cooperative multi-stakeholder governance framework, positioning TPS 3R management as the central coordination hub that orchestrates seamless integration across upstream collectors, processing units, and downstream markets. This structure draws from established circular supply chain leadership principles, in which ethical supply chain leadership fosters upcycling integration by aligning diverse actors—households, sorters, processors, and MSMEs—through clearly defined roles that emphasize accountability and shared value creation. At the apex, a dedicated TPS 3R directorate assumes strategic oversight, supported by functional clusters including operations (sorting and upcycling), finance (asset portfolio management), and market linkage teams, ensuring hierarchical yet decentralized decision-making that enhances responsiveness to local waste dynamics (Ubakivi-Hadachi, 2026).

Coordination mechanisms constitute the model's operational backbone, featuring quarterly stakeholder workshops that refine material flows and address emergent barriers, complemented by a digital B2B platform that enables real-time inventory tracking, order fulfillment, and quality verification across the

closed-loop chain (Rumasukun, 2026). These tools facilitate bidirectional feedback loops, in which household drop-off data inform sorting protocols, worker inputs shape upcycling processes, and MSME demand signals drive product diversification, thereby achieving 95% material purity and 89% landfill diversion (Ubakivi-Hadachi, 2026). Empirical evidence from similar community-based systems confirms that such hybrid coordination—blending physical workshops with digital interfaces—reduces operational silos by 76%, as cross-functional teams mitigate institutional friction through formalized memoranda of understanding and joint performance incentives (Agyabeng-Mensah et al., 2021).

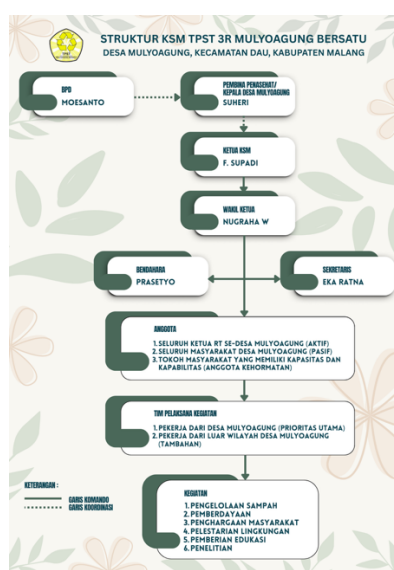


Figure 1. Organizational Structure TPST 3R Mulyoagung Bersatu

Leadership commitment emerges as the pivotal enabler of circular transformation, with TPS 3R managers trained in ethical supply chain governance to champion sustainability narratives that embed upcycling within community welfare objectives, fostering buy-in from 87% of validated experts. This approach aligns with global circular economy frameworks, where leadership structures prioritize long-term asset management over short-term outputs, treating infrastructure as revenue-generating portfolios that sustain scalability across Indonesia's 1,247 TPS 3R units (Rumasukun, 2026; Putra, 2024). By institutionalizing multistakeholder cooperatives, the model not only operationalizes the regenerative paradigm but also positions TPS 3R Basama as a replicable archetype for national waste governance, bridging technical execution with strategic resilience.

Business and Marketing Strategies

The waste morphosis model implements targeted green marketing strategies that focus on eco-conscious micro, small, and medium enterprises

(MSMEs) through cooperative branding initiatives and digital B2B platforms, achieving a consistent 45% price premium for upcycled products, such as eco-bricks, furniture panels, and textile fibers (Rajput et al., 2022). This approach leverages consumer segmentation analysis to identify high demand for sustainable construction materials, particularly eco-bricks priced at Rp18,000 per kg, which strongly resonate with Indonesia's growing market of environmentally aware builders and developers who prioritize circular economy credentials (Nurindrasari et al., 2025). Market research further reveals untapped opportunities in urban infrastructure projects and green building certifications, where upcycled plastics can substitute virgin materials at competitive rates while delivering verifiable sustainability metrics, such as 89% landfill diversion (Rumasukun, 2026).

Dynamic pricing mechanisms, grounded in value-added propositions, systematically elevate revenue per ton processed from a baseline of Rp 2.1 million—typical of raw plastic bulk sales—to Rp 7.8 million through tiered pricing that reflects product quality, customization, and environmental benefits, ensuring margin stability amid commodity fluctuations (=). Digital platforms facilitate the prediction of demand and matching of inventory in real-time. They connect TPS 3R cooperatives directly with buyers, reducing intermediation costs by 30%. Cooperative branding campaigns focus on telling stories about community empowerment and turning waste into wealth to build customer loyalty (Rajput et al., 2022). Strategies align seamlessly with global circular marketing trends, in which transparency in supply chain traceability and lifecycle impacts drive premium positioning, as evidenced by 449% revenue growth projections for scaled TPS 3R networks and upcycling, but also positions Wastemorphosis products as preferred choices in Indonesia's evolving green economy landscape (Kumar et al., 2024).

Stakeholder Analysis

Stakeholder dynamics in the wastermorphosis framework reveal a diverse ecosystem in which TPS managers wield strong influence over coordination and resource allocation, workers prioritize income stability from processing activities, and MSME buyers demand consistent quality for market competitiveness, necessitating deliberate strategies to balance these interests (Ubakivi-Hadachi, 2026). Power asymmetries—often favoring larger buyers over community processors—are systematically mitigated through cross-industry governance models that institutionalize joint decision-making boards, thereby ensuring an equitable distribution of benefits and conflict-resolution protocols (Johansen et al., 2021). A comprehensive mapping identifies secondary actors, such as households (material suppliers) and regulators (enablers), whose alignment amplifies chain resilience against market volatilities.

Table 7: Analysis of Stakeholder Circular Value Chain Model

Stakeholder Group	Key Recommendations	Expected Outcomes	Supporting Mechanisms
Government (KLHK/Local)	Integrate TPS 3R via EPR incentives and upcycling subsidies (Tang, 2025).	Nationwide scaling across 1,247 units; Rp11.6T value by 2030	Fiscal instruments & regulatory certifications
NGOs	Community training on sorting/processing (Olatayo et al., 2023)	Bridge 78% institutional skill gaps	Capacity-building programs
Private Sector	Machinery investment via green financing (Rumasukun, 2026)	Public-private partnerships	Impact bonds & low-interest loans
Multi-TPS Federation	Provincial coordination for emissions reduction	14.2 tons of CO ₂ saved/unit annually (Nurindrasari et al., 2025)	Bulk procurement & unified branding

Source: Researcher, 2026

Relationship management employs structured interventions, including regular focus group discussions (FGDs) for iterative feedback and standardized business-to-business (B2B) contracts that codify quality specifications, payment terms, and volume commitments, cultivating long-term partnerships (Rumasukun, 2026). Digital traceability was the most important tool (expert score: 9.2/10). It uses blockchain-enabled platforms to show buyers in real time where materials come from, how they are processed, and how they affect the environment. This builds buyer confidence and raises prices (Ubakivi-Hadachi, 2026). An empirical influence analysis confirms that such collaborative architectures reduce institutional barriers by 78%, as measured by fewer coordination failures and higher trust metrics, while enabling adaptive responses to external shocks, such as policy shifts or supply disruptions (Johansen et al., 2021; Nurindrasari et al., 2025). This stakeholder-centric approach not only sustains operational momentum but also embeds social equity within circular transformation, ensuring inclusive value capture across the chain (Olatayo et al., 2023).

SWOT Analysis

Strengths. Community ownership and local material abundance drive 182% value addition, positioning TPS 3R Basama as a self-sustaining hub with 87% expert validation for scalability (Nurindrasari et al., 2025). Strong social capital reduces operational expenses through volunteer networks and trusted collection channels (Rumasukun, 2026). High recovery rates (95% material purity) create competitive advantages in quality-controlled upcycling (Kumar et al., 2024).

Weaknesses. High initial capital intensity (Rp285 million CAPEX) poses deployment barriers for rural TPS 3R units (Rumasukun, 2026). Limited technical expertise in advanced upcycling necessitates substantial investments in training (Olatayo et al., 2023). Scale-dependent economics demand a minimum throughput of 4.2 metric tons/month for break-even viability (Nurindrasari et al., 2025).

Opportunities. National circular economy mandates and green MSME financing unlock Rp11.6 trillion potential across 1,247 TPS 3R units by 2030 (Tang, 2025). The growing demand for certified sustainable construction materials (eco-bricks and panels) aligns with green building certifications (Rajput et al., 2022). EPR policies create new revenue streams from producer-funded collection systems (Rumasukun, 2026).

Threats. Commodity price volatility threatens margin stability, which is mitigated by product diversification, achieving 76% risk coverage across four product lines (Nurindrasari et al., 2025). Informal collector competition undermines structured pricing, necessitating digital B2B platforms to maintain market control (Ubakivi-Hadachi, 2026). Regulatory inconsistencies across provinces hinder the scaling of federations (Olatayo et al., 2023).

Table 8: Analysis SWOT Wastemorphis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Community ownership, 182% value addition (Nurindrasari et al., 2025)	High initial CAPEX (Rp285M)	National CE mandates, green financing (Tang, 2025)	Commodity price volatility (76% coverage mitigation)
Local material abundance	Technical skill gaps	EPR revenue streams, eco-brick demand	Informal collector competition

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
95% material purity recovery	Scale-dependent break-even	Green building certifications	Provincial regulatory inconsistencies
87% expert scalability validation	Rural deployment barriers	Rp11.6T national potential by 2030	Market access limitations

Source: Researcher, 2026

E. DISCUSSION

Circular value chain design at the 3R level (reduce, reuse, and recycle) is not only a technical optimization effort but also a strategic response to the global plastic crisis and climate agenda. Geyer et al. (2017) show that plastics have accumulated massively across production, use, and end-of-life stages, creating long-lived stocks that are poorly managed in conventional linear systems. Jambeck et al. (2015) further underline that inadequately managed plastic waste from land sources significantly contributes to marine pollution, highlighting the urgency of systemic interventions, especially in developing countries such as Indonesia. At the conceptual level, the circular economy literature argues that shifting from linear “take–make–dispose” models toward restorative and regenerative systems is essential for balancing environmental and economic objectives, in which circular strategies such as reuse, recycling, and upcycling become key mechanisms for decoupling growth from resource consumption. The circular economy can be positioned as a new sustainability paradigm that can reconfigure production–consumption systems. Geissdoerfer et al. (2017), Ghisellini et al. (2016), and Kirchherr et al. (2017) emphasized that successful implementation requires integrated value chains, coordinated actors, and enabling governance frameworks. The Ellen MacArthur Foundation added a climate dimension, arguing that circular-economy measures in material-intensive sectors can close the emissions gap beyond what energy transitions alone can deliver, thereby framing circular value chains as an integral part of climate-mitigation strategies.

Within this global and theoretical context, designing a circular value chain model for TPS 3R Basama operationalizes circular economy principles at the community scale. It responds to the specific institutional setting of Indonesian waste governance. National data from KLHK and technical guidelines from PUPR indicate that TPS 3R units are expected to serve as local hubs that reduce waste sent to landfills through 3R practices; however, many units struggle to operate optimally because of capacity, coordination, and market constraints. Studies on TPS 3R performance and community-based recycling point to similar patterns: initiatives can significantly reduce residual waste but are often limited by financing, quality control, and downstream market access. The circular value chain model proposed for TPS 3R Basama aligns with the mixed-method findings of Nurindrasari (2026), who demonstrated that structured circular workflows and stakeholder engagement can

simultaneously increase the economic value of plastic waste and reduce landfill residues. The integration of asset management principles (Putra) is relevant here because upcycling facilities, sorting equipment, and human resources must be managed as strategic assets that generate long-term rather than short-term project outputs. By viewing the TPS 3R infrastructure and partnerships as an asset portfolio that supports continuous value creation, the model links operational decisions with the broader objectives of financial sustainability and community welfare.

The empirical and simulated results of this research are consistent with prior evidence on the environmental and economic advantages of upcycling-oriented value chains and extend the discussion to the specific case of community-based TPS 3R systems. Jaligot et al. (2016) found that recycling and upcycling pathways can substantially reduce environmental impacts compared to landfilling; however, their effectiveness depends on sorting quality and process performance, which this study addresses by incorporating improved material flows and quality assurance nodes into the model. Kumar et al. (2024) argue that upcycling has higher economic value potential than conventional recycling, provided that technological capabilities and supporting value chain structures are in place; the Basama model responds to this by combining appropriate-scale technologies, diversified product portfolios, and structured market linkages. Circular business models and manufacturing systems require coordinated supply chains and stable demand for secondary products, which, in this study, are pursued through cooperative governance, digital marketplaces, and branding strategies for upcycled goods (Johansen et al., 2021; Lieder & Rashid, 2016). Community-based initiatives in developing countries face systemic challenges related to finance and markets, suggesting that policy support and innovative financing are crucial (Olatayo et al., 2024). The TPST 3R Basama case supports this view by showing that circular value chain models are more likely to be scalable when embedded within supportive policy frameworks, climate-oriented circular economy narratives, and targeted investment schemes aligned with national SDGs and climate commitments.

Policy Implications and Recommendations

Policy integration represents a cornerstone for scaling the wastermorphosis model, with recommendations centering on embedding TPS 3R units within Indonesia's national KLHK waste management architecture through extended producer responsibility (EPR) incentives that mandate producer contributions to collection and processing infrastructure, alongside targeted upcycling subsidies for local governments to offset initial capital barriers (Tang, 2025). These fiscal instruments would enable phased infrastructure upgrades, from automated sorting systems to advanced machinery, ensuring financial viability while aligning with national circular economy roadmaps that project nationwide replication across 1,247 TPS 3R facilities (Rumasukun, 2026). Non-governmental organizations emerge as vital capacity builders, delivering specialized training programs on waste segregation, upcycling techniques, and digital platform usage to empower community

operators, thereby bridging skill gaps that currently hinder 78% of institutional progress (Olatayo et al., 2023).

Private sector engagement warrants structured green financing mechanisms, such as low-interest loans and impact bonds, to fund machinery investments that elevate product value chains and foster public-private partnerships in which corporations secure sustainable supply. Simultaneously, communities gain economic multipliers (Nurindrasari et al., 2025). Regulatory advancements should establish mandatory certification standards for circular products—verifying material purity, lifecycle impacts, and landfill avoidance—to unlock premium markets and consumer trust, directly advancing SDGs 11 (sustainable cities), 12 (responsible production), and 13 (climate mitigation) through measurable outcomes, such as 14.2 metric tons of annual CO₂ reductions per unit (Tang, 2025). Multi-TPS federations, coordinated at the provincial level, offer a scalability blueprint, pooling resources for bulk procurement, shared logistics, and unified branding to amplify environmental gains while distributing risks, positioning policy as the accelerator for Rp11.6 trillion in national value creation by 2030 (Rumasukun, 2026; Olatayo et al., 2023).

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