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Social Innovation and Empowerment in Waste Management in Jelekong, Bandung Regency

Rafa'na Rahman[1*], Anggi Putra Kedua[2], Annisa Reinelia Warman[3], Balgis[4], Erwin Syahputra Rambe[5], Luthfiya A'yuni[6], Rahmawati Santoso[7], Vieri Muhammad Naufal[8], Wina Siti Maesaroh[9], Sonny Yuliar[10]

[1,2,3,4,5,6,7,8,9,10]School of Architecture, Planning and Policy Development, Institut Teknologi Bandung, Bandung, Indonesia

*Email: rafarahmanids@gmail.com

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Abstract: *Waste management challenges have continued to evolve in tandem with rapid population growth, which directly contributes to increasing volumes of waste. This study investigates the innovation transition in waste management practices at PUSPA Jelekong, located in Bandung Regency, Indonesia. Employing a descriptive qualitative approach, the research draws on primary data (observations and interviews) as well as secondary sources (literature and regulatory documents). The analysis is framed using Frank Geels' Multi-Level Perspective (MLP), which conceptualizes sociotechnical transitions across three analytical levels: niches, regimes, and landscapes. The study delineates three key phases of transition: prior to 2019, the period between 2019 and 2022, and from 2023 onward. The findings reveal a substantial transformation in PUSPA Jelekong's waste management system from a previously inadequate framework to a more integrated and innovative model. The MLP framework proves instrumental in identifying stable landscape pressures, cross-level actor interactions, and critical factors driving the transition. Moreover, the process reflects a broader shift in the social function of waste. Through PUSPA's educational initiatives, waste has been increasingly a shift toward practices that may support the development of a community-based circular economy.*

***Keywords*:** Waste Management; PUSPA; Innovation; MLP; Transition

A. INTRODUCTION

The global surge in human population has been closely correlated with rising volumes of municipal solid waste, as growth in population density intensifies environmental pressures (El-Haggar, 2007). Worldwide, municipal solid waste generation is estimated at 2.01 billion tons annually and is projected to reach 3.40 billion tons by 2050, a trajectory largely driven by urbanization, population growth, and unsustainable consumption—patterns that are likewise evident across regions of Indonesia (Kaza et al., 2018; Gupta et al., 2015; Misganaw & Teffera, 2021). Conceptually, waste is commonly defined as any solid material considered to have no immediate value (Alipour et al., 2025). In developing countries, however, the challenge is particularly acute because household waste typically contains a high proportion of organics which, if improperly treated, can contaminate the environment and emit harmful substances (Wilson et al., 2012). These global dynamics set the stage for understanding how similar pressures materialize at the subnational level.

The global surge in human population has been strongly correlated with increasing volumes of municipal solid (El-Haggar, 2007) . As populations grow, so too does the quantity of waste generated, which is a direct consequence of environmental pressure driven by population density. According to Kaza et al. (2018), the world generates approximately 2.01 billion tons of municipal solid waste annually, a figure projected to rise to 3.40 billion tons by 2050. This increase is largely attributed to urbanization, population growth, and unsustainable consumption, trends that are also evident across various regions of Indonesia (Kaza et al., 2018; Gupta et al., 2015; Misganaw & Teffera, 2021).

Waste is commonly defined as any solid material considered to have no immediate value (Alipour et al., 2025). In developing countries, managing waste remains a particularly complex challenge due to the high organic content of household waste, which, if not properly treated, can contaminate the environment and emit harmful substances (Wilson et al., 2012).

In 2022 alone, Bandung Regency produced an estimated 468,351.94 tons of waste, placing immense pressure on local waste management infrastructure amid escalating urbanization and consumption (*Portal Satu Data Kab. Bandung*, 2025). One of the critical waste-related issues occurs in Baleendah District, an area that experiences recurrent flooding during the rainy season. This condition is exacerbated by the fact that, in 2019, only 23.96% of waste was collected, leaving as much as 76.04% unmanaged (Sekarningrum et al., 2024).

In response, former Regent Dadang M. Naser (2016–2021) initiated the development of the Waste Management and Utilization Education Center (PUSPA) in Jelekong Village, Baleendah District. Built on a site of 11,100 m², PUSPA is equipped with various waste treatment technologies, including Refuse-Derived Fuel (RDF), enabling the conversion of waste into alternative energy sources that can replace coal (Salaripoor et al., 2025). The PUSPA Jelekong approach embodies active community participation in waste governance, aligning with findings by Cabias et al. (2024), who highlight the role of environmental education and social incentives in successful waste systems. PUSPA functions as both a waste treatment center and an educational hub for promoting zero-waste and circular economy practices, while simultaneously generating local livelihoods through value-added waste products.

Within this broader backdrop, Bandung Regency generated an estimated 468,351.94 tons of waste in 2022, straining collection and treatment capacity amid rapid urbanization (Portal Satu Data Kab. Bandung, 2025). The challenge is particularly acute in Baleendah District, which faces recurrent rainy-season flooding alongside low collection coverage—only 23.96% in 2019, leaving 76.04% unmanaged (Sekarningrum et al., 2024). The conjunction of hydrometeorological risk and service gaps illustrates how global waste-generation trends intersect with local vulnerabilities, amplifying environmental and public-health externalities. To address these gaps, the regency established the Waste Management and Utilization Education Center (PUSPA) in Jelekong, Baleendah, as a hub that integrates waste treatment with public education and structured community participation. Operationally, PUSPA deploys technologies such as refuse-derived fuel (RDF) to reduce landfill pressure and generate alternative energy, while its educational programs and social incentives cultivate pro-environmental behavior—an approach consistent with evidence on drivers of effective waste systems (Salaripoor et al., 2025; Cabias et al., 2024). Taken together, these measures position PUSPA as a bridging mechanism that links macro-level waste pressures to meso-level service delivery and micro-level behavior change.

This study aims to analyze the transition of a conventional waste management facility into an educationally oriented waste processing center. This transformation seeks to enhance community participation and promote greater awareness of sustainable waste practices and local environmental stewardship. To examine the dynamics of this shift, the study employs the Multi-Level Perspective (MLP) framework, which facilitates a nuanced exploration of socio-technical transitions across niche, regime, and landscape levels. This approach allows for a comprehensive analysis of the actor interactions and systemic factors that influence the trajectory of this transition.

Several studies have examined waste management from diverse angles. One line of work highlights how penta-helix collaboration can be mobilized to address emergency waste crises (Jannah, 2023). Another analyzes biodrying alongside a mechanical "one-day process" to produce sustainable refuse-derived fuel (RDF) (Budiyantoro, 2024). A further strand explores a hybrid model that combines open dumping with sanitary landfill, unpacking political-ecology dynamics through associations among human and non-human actors at the Sarimukti landfill site (Rochman, 2024). Departing from these relatively single-focus approaches, the present research emphasizes a systemic transformation—from a conventional transfer station (TPS) into a community-based waste-management ecosystem that integrates social, economic, and environmental dimensions. Persistent constraints such as limited service access and low public awareness underscore the need for community empowerment through continuous education and infrastructure development. Evidence from educational interventions using audiovisual and leaflet media shows significant gains in knowledge, attitudes, and practices regarding waste handling, highlighting the central role of environmental education in shaping sustainable behavior (Nurhayati et al., 2020).

Several previous studies have addressed waste management from different perspectives. For instance, examined the role of penta helix collaboration in addressing the emergency waste crisis (Jannah, 2023). In a similar domain, Budiyantoro (2024) analyzed the use of biodrying and mechanical "one-day process" methods in producing sustainable refuse-derived fuel (RDF). Meanwhile, Rochman (2024) explored waste processing through a hybrid system of open dumping and sanitary landfill. His study revealed the dynamics of political ecology by examining both practical and conceptual waste issues through the lens of human and non-human actor associations circulating within the Sarimukti landfill site. Unlike the aforementioned studies that tend to focus on a single aspect, this research emphasizes a systemic transformation from a conventional waste transfer station (TPS) into a community-based waste management ecosystem that integrates social, economic, and environmental dimensions. Effective waste management is often hindered by limited access to waste services and low public awareness, underscoring the need for community empowerment through continuous education and infrastructure development. Studies show that educational interventions using–audiovisual and leaflet media significantly improve public knowledge, attitudes, and practices regarding waste handling, highlighting the critical role of environmental education in shaping sustainable behavior (Nurhayati et al., 2020).

PUSPA, as an innovative initiative in local-scale waste management, aligns with the ideals of sustainable development through the application of circular economy principles. It demonstrates how waste can be transformed into valuable commodities by integrating technology and community education. Accordingly, this study seeks to answer the research question of how PUSPA Jelekong has transitioned from a conventional waste disposal site into an integrated waste and community-empowerment oriented waste management center. This study presents a transformative documentation of a traditional TPS into an educational center for waste processing, offering a scalable and replicable model for sustainable waste management in local contexts.

B. METHOD

This study employs a descriptive qualitative design using both primary data (in-depth interviews and field observations) and secondary data consisted of government reports, statistical records, and regulatory documents relevant to waste management in Bandung Regency. A case study approach focuses on PUSPA Jelekong's innovations from 2019 to 2024, enabling a comprehensive analysis of its dynamic innovation system. Data are interpreted through the Innovation System framework based on Geels' Multi-Level Perspective (MLP), which maps the integration of novel practices within broader sociotechnical regimes. Systemic innovation, according to Geels (2005), encompasses not only technical product changes but also transformations in policies, infrastructure, industrial structures, and symbolic meanings. In the PUSPA Jelekong case, systemic innovation is examined through the interaction of social and technical elements that collectively enable sociotechnical transitions. These elements are shaped by human actors and stabilized by regimes that reinforce system inertia and path dependencies. This study explores how such elements influence innovation diffusion across different phases of transition.

This study applies Frank Geels' Multi-Level Perspective (MLP) to analyze innovation transitions at PUSPA Jelekong. As an integrative framework, the MLP captures interactions across three levels: niches (spaces for developing novel practices), regimes (dominant rules and institutions), and landscapes (broader societal trends). It helps conceptualize how innovation dynamics unfold within environmental and sociotechnical systems. Each level corresponds to a configuration of heterogeneous elements and actor networks, with increasing degrees of structural stability from niche to landscape (Geels, 2005). This research aims to identify and analyze these three levels within the innovation transition process of PUSPA Jelekong, which has evolved into an education-oriented waste management facility. By integrating analysis across the niche, regime, and landscape levels, the MLP provides a comprehensive understanding of the complex interactions among actors, institutions, and environmental factors that shape the innovation trajectory of PUSPA Jelekong.

C. LITERATURE REVIEW

1. Multi-Level Perspective (MLP)

Multi-Level Perspective (MLP) conceptualizes sociotechnical transitions as the outcome of interactions across three levels: the landscape (slow-moving macro trends), the regime (dominant rules, practices, and infrastructures), and niches (protected spaces for radical innovation). A pivotal mechanism is translation: the interpretive and political work through which actors align problems, solutions, and legitimacy across levels. Translation is not simple diffusion; it entails rendering evidence, risks, and benefits commensurable for heterogeneous audiences. When translation succeeds, landscape signals become actionable agendas in regimes, while niche learnings are reformulated as performance metrics and rules. Absent such work, pressures dissipate or innovations remain confined. Hence transitions are not deterministic but hinge on coalitions, narratives, and standards that stabilize new alignments (Geels, 2011; Geels & Schot, 2007).

a. Landscape

At the landscape level, macro pressures—climate crises, digitalization, or geopolitical shocks—open windows of opportunity. Their effects are never automatic; they must be translated into policy targets, roadmaps, and market expectations. Translation here operates via problem framing, moral–economic justification, and the articulation of measurable performance indicators that decision centers accept. Focusing events can accelerate these processes when coalitions connect landscape narratives to concrete instruments (e.g., standards, price signals). Strong translations flow into regimes as mandates or incentives; weak ones evaporate as rhetoric. The quality of translation thus determines whether landscape trends drive material change or merely provide a discursive backdrop(Geels, 2011; Geels & Schot, 2007).

b. Regimes

Within regimes, interlinked rules, professional routines, business models, and infrastructures stabilize the dominant technology and favor incremental innovation. Regimes act as filters, “domesticating” novelties to fit existing standards, supply chains, and compliance logics. When landscape pressures and niche promises cannot be translated into regime terms, cracks appear—manifest in cost/performance failures or legitimacy loss. These cracks trigger standard revisions, incumbent repositioning, and openings for alternatives. Hybrid coalitions—incumbents allied with niche entrants—often play the role of double translators, recording innovation into risk–benefit arguments legible to managers and regulators. Through iterative cycles, rules and routines gradually reconfigure toward new designs more consistent with landscape signals (Geels, 2004, 2011).

c. Niches

Turning to niches, these protected spaces foster technical and social experimentation via shielding, nurturing, and empowering. Shielding buffers experiments from mainstream selection; nurturing builds technical and organizational learning; empowering develops pathways for scaling into broader markets and rule sets. Translation within niches entails forging shared expectations, actor networks, and success metrics—first-order learning on performance and second-order learning on goals and design principles. Practical devices such as demonstrators, pilots, and plausible use-cases serve as boundary objects that different communities can understand. Crucially, niche outputs must be rendered legible to regimes—compatibility with standards, certification processes, and risk assurances—or they risk cooptation as minor add-ons or failure to enter markets (Schot & Geels, 2008; Smith & Raven, 2012).

d. Fit and Strech

Finally, fit-and-conform versus stretch-and-transform strategies clarify how niches gain traction. Fit adapts innovations to existing infrastructures, standards, and incentives—through modular interfaces, adapters, or peripheral pilots. Stretch seeks to recalibrate the rules themselves—redefining performance criteria, revising standards, creating new markets, or aligning niche narratives with landscape pressures. In practice, successful trajectories often combine both: start with fit to secure access and credibility, then pivot to stretch as evidence and coalitions strengthen. Translation is the glue enabling this choreography: packaging trial data into regulatory arguments, bridging technical language and policy frames, and reformulating public value into market demand. When fit-and-stretch are staged sequentially and attuned to landscape signals, regime transformation becomes markedly more likely (Schot & Geels, 2008; Smith & Raven, 2012).

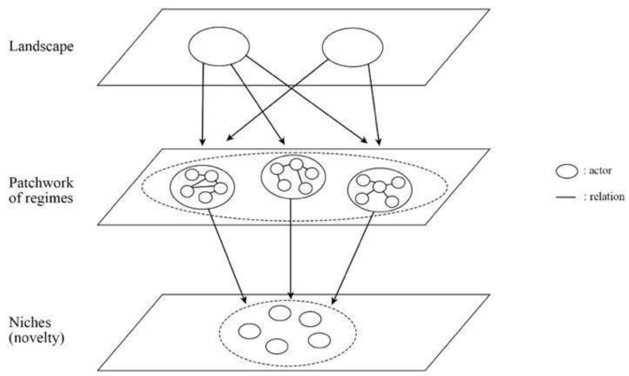

Figure 1. Multiple levels as a nested hierarchy
Source: Analysis results, 2025

D. RESULTS AND DISCUSSION

1. Transition Process

a. Phase I (Pre-2019)

a) Landscape

Worldwide, the amount of municipal solid waste generated annually is expected to increase from an estimated 2.01 billion tons to 3.40 billion tons by 2050. This trajectory is primarily caused by urbanization, population growth, and unsustainable consumption—trends that are also very apparent throughout Indonesia (Gupta et al., 2015; Misganaw & Teffera, 2021). The industrial sector alone produces various types of waste—solid, liquid, and gaseous—many of which remain unmanaged (Santoso et al., 2024).

The urgency of effective waste management is also reinforced at the legal and institutional level. The right to a healthy environment is guaranteed under Article 28H, (1) of the 1945 Constitution of the Republic of Indonesia, which obligates the state to maintain environmental quality. At the national level, Law No. 18/2008 on Waste Management requires local governments to manage household and household-like waste. In response, Bandung Regency issued Regional Regency Regulation No. 21 of

2009 on Waste Management, later revised under Regional Regulation No. 15 of 2012 during the administration of Regent Dadang M. Naser. This was further operationalized through Regent Regulation No. 55 of 2013, all of which emphasize waste reduction as the core principle of local governance.

b) Regime

Administratively, Bandung Regency is located in West Java Province and covers an area of 1,767.96 km². The population of the regency increased from 3,027,233 in 2007 to 3,633,437 in 2021. Assuming an average waste generation rate of 0.35 kg per person per day, a figure given by Damanhuri (Damanhuri et al., 2010), the total daily waste produced exceeds 1,271,700 kilograms, or approximately 1,271.7 tons. A critical turning point in the region's waste management history was the landslide disaster at the Leuwigajah Final Disposal Site (TPA) in Cimahi City on February 21, 2005 (Chaerul et al., 2007; Damanhuri et al., 2009). At the time, TPA Leuwigajah served as a regional landfill for three jurisdictions: Bandung City, Cimahi City, and Bandung Regency (prior to the administrative division that established West Bandung Regency)(Rahayu et al., 2013).

The disaster, triggered by unmanaged waste accumulation, led to the collapse of the landfill (Lavigne et al., 2014). In response to the crisis, the Jelekong landfill in Baleendah District, Bandung Regency, was designated as a temporary disposal site. Originally, TPA Jelekong was designed to handle only 50 to 60 garbage trucks per day. However, following the Leuwigajah tragedy, the incoming waste volume surged to over 300 trucks daily. This dramatic increase led to significant waste accumulation, directly affecting the surrounding environment and the quality of life for nearby communities, particularly in Ciparia and Cilayung villages. Residents reported severe issues including foul odors, water and soil contamination, and health disturbances. This situation underscores the urgent need for an integrated and sustainable waste management system in the Bandung metropolitan area.

c) Niche

Between 2012 and 2018, the Bandung Regency Government implemented follow-up measures in response to Bandung Regency Regulation No. 15 of 2012 amending Regulation No. 21 of 2009 on Waste Management and Regent Regulation No. 55 of 2013, which provided implementation guidelines. These regulatory actions coincided with growing public concern over the large volumes of waste that had accumulated following the Leuwigajah landfill disaster, especially among communities living near the Jelekong Final Disposal Site (TPA) in Baleendah District. During this period, TPA Jelekong began undergoing a transitional phase in its waste management system. There was a growing awareness of the need to adopt sustainable waste management principles, particularly the Reduce, Reuse, and Recycle (3R) concept. Although implementation was still limited in scope, this shift marked an important early step toward reducing dependence on conventional, environmentally unsound landfill-based systems. However, the application of 3R principles at TPA Jelekong faced multiple challenges. Waste treatment facilities were limited and, at times, left idle due to insufficient infrastructure support and underdeveloped management systems. Nevertheless, some initiatives were carried out, such as the delivery of shredded waste from the Ciroyom Temporary Waste Storage Site (TPS) to the former Jelekong landfill for further processing. These efforts served as preliminary attempts to repurpose organic waste and reduce the volume of waste directed to final disposal.

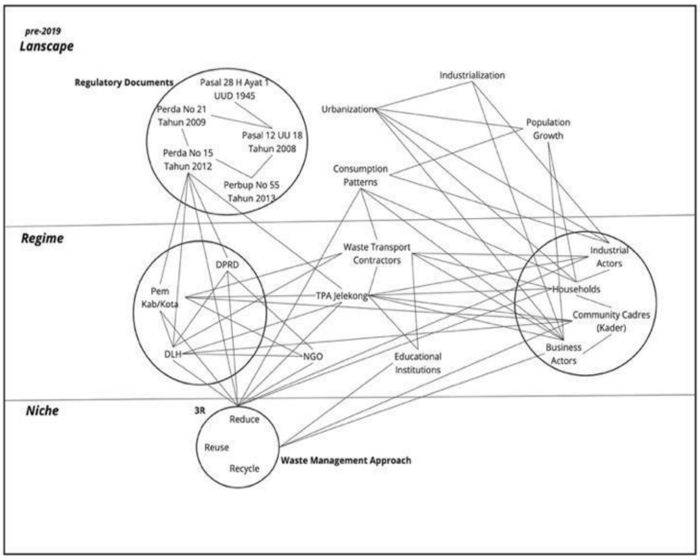

Figure 2. Nested hierarchy in Phase I
Source: Analysis results, 2025

b. Phase II (2019 – 2022)

a) Landscape

Rapid population growth directly contributes to the increasing volume of waste. A study by Gupta et al. (2015) and Santoso et al. (2024) demonstrates a positive correlation between population growth in Bojonegoro District and the rise in household waste generation, primarily driven by heightened consumption levels. Industrialization is another significant factor accelerating the escalation of waste volumes. Santoso found that population expansion, infrastructure development, and industrial activities have collectively contributed to increased waste production. Industrial processes often generate solid, liquid, and gaseous waste, much of which remains inadequately managed (Santoso et al., 2024).

The right of every citizen to enjoy a healthy environment is enshrined in Article 28H(1) of the 1945 Constitution of the Republic of Indonesia, forming the legal foundation for government obligations to ensure a livable environment—one mechanism of which is through effective waste management. At the regional level, these responsibilities are further outlined in local regulations in accordance with Law No. 18 of 2008 on Waste Management. During the administration of Regent Dadang M. Naser, Bandung Regency enacted Regional Regulation No. 15 of 2012, which amended previous legislation, along with Regent Regulation No. 55 of 2013 as its implementation guideline. While these policies retained a focus on waste reduction, they were enhanced with public outreach initiatives, collaborative research on waste processing technologies, and the promotion of recycled and compost-based community products. Under the subsequent leadership of Regent M. Dadang Supriatna, the existing regulations were deemed misaligned with the evolving socio-legal context and community dynamics. Consequently, Regional Regulation No. 15 of 2012 was repealed and replaced with Regional Regulation No. 1 of 2022. This new regulation adopts a broader orientation, encompassing not only waste reduction and treatment, but also community empowerment efforts through the establishment of waste banks and community-based educational centers for waste management and utilization.

b) Regime

The implementation of 3R (Reduce, Reuse, Recycle) activities at the Jelekong Final Disposal Site (TPA Jelekong) reflects an ongoing transition toward more sustainable waste management practices. Under the Reduce principle, TPA Jelekong initiated efforts to minimize waste generation at its source by educating nearby communities on the importance of separating organic and inorganic waste prior to disposal. These initiatives were carried out through environmental awareness campaigns and socialization programs aimed at reducing the use of single-use products. In line with the Reuse principle, several activities focused on repurposing used items that still held utilitarian value. Non-organic waste such as plastic bottles, cardboard, and other used materials were collected by both sanitation workers and community members for resale or transformation into handicrafts. Under the Recycle principle, TPA Jelekong undertook basic processing of organic waste into compost and facilitated the separation of recyclable inorganic waste for delivery to waste banks or recycling centers. During the initial phase, recycling activities were relatively rudimentary. Waste was sorted manually by workers or informal waste pickers, and composting was carried out using open windrow techniques without the aid of shredders or modern fermentation technologies. The processing relied heavily on human labor and basic tools.

c) Niche

Between 2019 and 2022, the Jelekong Final Disposal Site (TPA Jelekong) in Baleendah District, Bandung Regency, underwent a significant transformation in its waste management system. This shift was driven by the increasing urgency to mitigate environmental impacts caused by waste accumulation and by the local government's commitment to implementing a more integrated and sustainable waste management approach. A key milestone in this transition was the establishment and development of the Waste Management and Utilization Education Center (PUSPA), supported by the Ministry of Environment and Forestry (MoEF). With this support, PUSPA began integrating educational activities with waste processing and developed the Waste Recycling Center (PDU) as part of a more modern facility. During this period, core activities at TPA Jelekong included waste segregation, composting of organic waste, Black Soldier Fly (BSF) farming for organic waste bioconversion, peuyeumisasi (fermentation-based processing), and TOSS (Waste Processing at Source) technology for converting organic and inorganic waste into solid fuel briquettes. Additionally, the “Ngopi Kancing” program utilized dairy cow manure to cultivate Lumbricus rubellus earthworms.

Organic waste processing using black soldier fly (Hermetia illucens) offers a sustainable, environmentally-friendly, and cost-effective method for treating organic waste (Diener et al., 2011; Rehman et al., 2022; Singh & Kumari, 2019). The BSF method involves placing BSF eggs onto organic waste—primarily sourced from local markets. Once hatched, the larvae rapidly consume and break down the waste into simpler organic material, reducing overall volume by up to 79% (Magee et al., 2021). The process yields high-value byproducts such as compost and organic fertilizer. After approximately two weeks, mature larvae are harvested and repurposed as a protein-rich animal feed (Siddiqui et al., 2022). The peuyeumisasi and TOSS processes convert waste into solid fuel briquettes. These methods use bioactivator liquids and fermentation techniques, reminiscent of the traditional Sundanese food fermentation process known as peuyeum. The bioactivator-induced fermentation reduces and densifies the waste volume. The compressed waste is then mechanically processed into solid fuel briquettes, suitable for use in industrial ovens. The "Ngopi Kancing" initiative involves co-cultivating dairy cow manure and segregated organic waste with Lumbricus rubellus worms in specially constructed vermiculture facilities (approximately three units of 25 m^2 each). After three months, the worms are harvested for use as high-quality livestock feed, while the resulting vermicast (vermicompost or kascing) is sold as premium organic fertilizer. To manage residual waste—unfit for recycling, composting, or bioconversion—TPA Jelekong deployed an incinerator with a processing capacity of approximately 2.8 tons per day. This third-generation "Stungta" incinerator, developed by PT Top Tekno Indo (Hejotekno) in collaboration with PT Pindad (Persero), features a double-burner system, emission filters, and advanced gas treatment, ensuring clean combustion with minimal environmental impact.

Despite these advancements, several challenges remain. The primary concern lies in residual waste management and the long-term operational sustainability of the various waste treatment technologies. Although initiatives such as PUSPA, PDU, BSF farming, peuyeumisasi/TOSS, and Ngopi Kancing represent notable strides in organic waste processing and recycling, residual waste volumes still demand attention, as evidenced by the necessity for incineration. While the Stungta incinerator is touted as an environmentally friendly solution, its efficacy depends on maintaining consistent operations, ensuring complete combustion, and sustaining low emissions. Furthermore, the continuity of input material—such as sufficient organic market waste for BSF, or a steady supply of manure for vermiculture—poses an additional operational challenge.

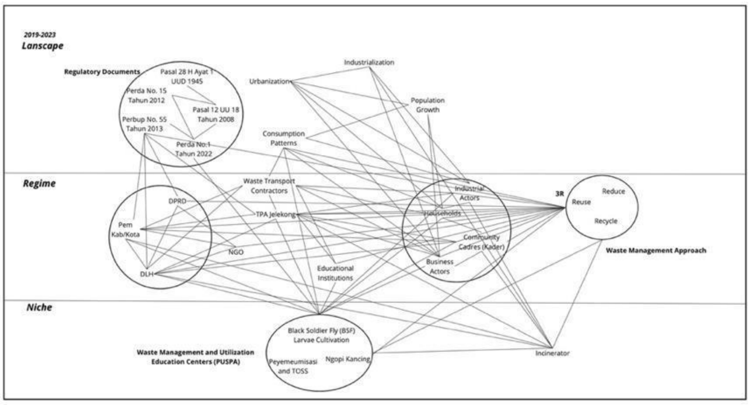

Figure 3. Nested hierarchy in Phase II
Source: Analysis results, 2025

c. Phase III (2023 – recent)

a) Landscape

The impacts of rapid population growth and industrialization on increasing waste volumes are clearly observable in Bandung Regency. In response, the local government has issued a series of regulations aimed not only at managing existing waste but also at promoting waste reduction at the source. During the administration of Regent Dadang M. Naser, key regulatory measures included Regional Regulation No. 15 of 2012 and Regent Regulation No. 55 of 2013, both of which sought to adapt to the emerging challenges of waste management. These initiatives were further strengthened under the leadership of Regent M. Dadang Supriatna through the issuance of Regional Regulation No. 1 of 2022, which emphasized community participation, technological innovation, and educational approaches such as the establishment of waste banks and the Waste Management and Utilization Education Center (PUSPA). This signaled a paradigmatic shift from a focus solely on waste handling to a more empowerment-oriented framework involving the community. On August 30, 2023, Regent H. M. Dadang Supriatna officially inaugurated the PUSPA facility, located in Jelekong Village, Baleendah District, Bandung Regency. The event was attended by the Head of the Bandung Regency Environmental Agency, Asep Kusumah. The inauguration marked a critical step in the local government's effort to promote an integrated and educational model of waste management. It also reinforced the role of public participation in supporting sustainable waste governance and advancing environmental literacy at the community level.

b) Regime

The core activities at PUSPA Jelekong encompass a range of sustainable waste management practices, emphasizing eco-friendly processing methods. These include waste separation, organic waste composting, and the application of bioconversion technology through the cultivation of Black Soldier Fly (BSF) larvae. In this bioconversion process, BSF eggs are placed on piles of organic waste such as food scraps, livestock manure, and agricultural residues. Upon hatching, the larvae consume and decompose up to 50% of the organic waste. Within approximately two weeks, mature larvae are harvested and utilized as a high-protein feed for livestock, while the remaining residue serves as compost or organic fertilizer with commercial value (Siddiqui et al., 2022).

In addition, PUSPA implements the peuyeumisasi method and the "Waste Processing at Source" (TOSS) program to convert waste into solid fuel in the form of briquettes. The peuyeumisasi process involves mixing waste with a bioactivator solution and fermenting it, akin to the traditional fermentation of peuyeum (cassava tape). This results in a denser, reduced mass, which is then further processed into briquettes using mechanical equipment—suitable as fuel for ovens and other combustion applications. Another innovative initiative, the Ngopi Kancing program, utilizes dairy cow manure to cultivate Lumbricus rubellus earthworms. The program constructs dedicated 25-square-meter vermiculture units where worms are raised alongside organic waste. After a three-month cycle, the worms are harvested as livestock feed, while the resulting vermicompost (kancing) is repurposed as high-quality organic fertilizer.

To address residual waste, i.e., waste that cannot be recycled, composted, or processed via maggot conversion, PUSPA employs incineration technology. The incinerator in use has a capacity of processing up to 2.8 tons of waste per day, thereby reducing dependence on landfill disposal and lowering waste transportation costs. The incineration unit, known as Stungta, represents a third-generation technology co-developed by PT Top Tekno Indo (Hejotekno) and PT Pindad (Persero). It features a dual-burner combustion system and is equipped with filters and smoke treatment mechanisms to ensure that the emissions released are safe for both human health and the environment.

c) Niche

The implementation of Refuse Derived Fuel (RDF) technology at the Waste Management and Utilization Education Center (PUSPA) Jelekong commenced operations in 2023 as part of Bandung Regency's commitment to sustainable waste management innovation. RDF technology is designed to process residual waste materials that are non-biodegradable and non-recyclable into environmentally friendly alternative fuels. At PUSPA Jelekong, the local government operates two RDF processing units, each with a capacity of 25 tons per day, resulting in a combined processing capacity of 50 tons per day. The RDF process involves several stages: waste sorting, shredding, drying, and compaction. The final product is a solid alternative fuel that can be utilized by cement industries or power generation facilities as a substitute for fossil fuels such as coal. The end product is an alternative fuel that can be utilized by the cement industry or energy plants, replacing fossil fuels such as coal, therefore promoting waste-to-energy recovery and economic benefits (Rotheut & Quicker, 2017; Yang et al., 2021). Despite the presence of RDF units capable of processing 25 tons of waste daily per unit (with a total of 100 tons across four units at various sites), the overall waste generation in Bandung Regency reaches approximately 1,300 tons per day. Following decentralized waste management efforts at the village level—reducing the waste to around 350 tons and with 100 tons processed via RDF, approximately 250 tons of waste remain unprocessed. This indicates that, while significant strides have been made, current RDF processing capacities are still insufficient to address the entire volume of waste, necessitating additional treatment strategies and infrastructure development.

In addition to its technological functions, PUSPA Jelekong serves as a center for education and community empowerment. A wide array of outreach activities, training sessions, and educational visits are conducted to raise public awareness of sustainable waste management practices. Community members—including housewives and youth—are actively engaged in compost production, maggot farming, and upcycling of waste materials into marketable crafts. Collaboration with the Ministry of Environment and Forestry (MoEF), educational institutions, and non-governmental organizations further enhances PUSPA's capacity to develop innovative waste treatment technologies and disseminate environmentally sound practices. Through this integrated approach, PUSPA Jelekong has evolved into more than just a waste treatment facility; it has become a catalyst for behavioral change and community empowerment in the environmental sector.

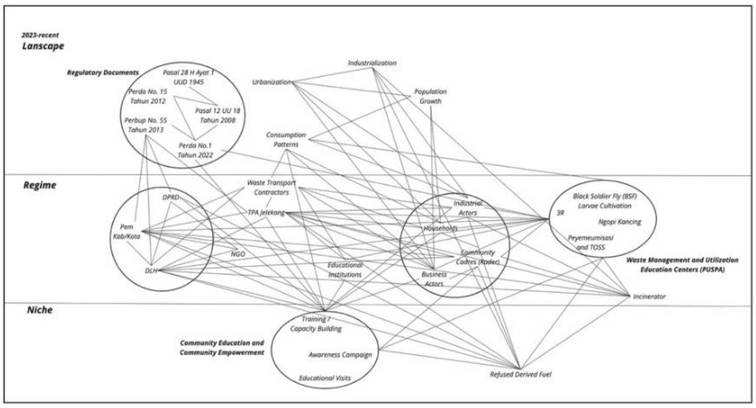

Figure 4. Nested hierarchy in Phase III

Source: Analysis results, 2025

2. Fit and Stretch

Table 1. Fit and Stretch Analysis

Technical Form/ Use Environment	Fit	Stretch
Fit	The Jelekong Final Disposal Site (TPA Jelekong) has undergone a functional transformation from a conventional landfill into an active waste treatment facility. Initially serving solely as a dumping ground, the site is now utilized for waste processing and recovery.	The facility adopts the 3R (Reduce, Reuse, Recycle) waste management principles, which involve the segregation of organic and inorganic waste at the source and the reuse of materials through locally available technologies. This includes manual composting, upcycling, and basic mechanical processing methods tailored to the community's capacity.
Stretch	TPA Jelekong has transitioned into PUSPA, whose role extends beyond waste management to include community education and empowerment. This transformation reflects a paradigm shift toward integrated and participatory approaches to environmental governance.	Through its Refuse Derived Fuel (RDF) technology, PUSPA is capable of processing up to 50 tons of residual waste per day, significantly reducing landfill dependency. In addition to technological interventions, PUSPA organizes awareness campaigns, capacity-building workshops, and educational visits to foster community engagement and promote innovative, sustainable waste management practices.

Source: Analysis results, 2025

The potential for utilizing both organic and inorganic waste within a circular economy framework has catalyzed innovation at the niche level, gradually transforming entrenched, conventional waste management practices that have long dominated the regime level.

According to data from the Environmental Agency (Dinas Lingkungan Hidup) of Bandung Regency, PUSPA Jelekong currently employs 102 operators and functions as a leading 3R (Reduce, Reuse, Recycle) recycling hub with a daily processing capacity of 10 tons. It also manages a waste bank with a capacity of 1 ton/day, organic waste bioconversion using black soldier fly larvae (maggots) with a capacity of 9 tons/day, cattle manure treatment, and inorganic waste processing through briquette fermentation "peuyeumisasi" with a substantial capacity of 75 tons/day. In practice, PUSPA Jelekong is able to handle an average of 7 m^3/day (equivalent to 2,856 kg/day) of emergency waste and approximately 400 kg/day of source-separated waste. Waste is collected from commercial areas such as Baleendah Market, Ciparay Market, and Uniba Campus as well as residential zones spanning nine neighborhood units (RW), reaching over 2,000 households. PUSPA Jelekong serves as a tangible embodiment of circular economy principles in community-based waste management through Refuse-Derived Fuel (RDF) and organic bioconversion technologies, aimed at achieving a zero-waste target.

Table 2. Waste Processing Report by UPT PPS 2023 Government

No	Loc	Waste Bank	Bioconv. Magot	RDF	Ngopi Nganci ng	Compost er	Residue
1	Puspa Jelekong	480 Ton	803,5 Ton	1860,5 Ton	6 Ton	14,4 Ton	512,6 Ton
2	TPS3R Citaliktik	108 Ton	66,2 Ton	449,7 Ton	-	-	278,6 Ton
3	TPS3R Pemda	4,8 Ton	11,4 Ton	367,8 Ton	-	-	-
4	TPS3R Jalak Harupat	4,5 Ton	-	10,2 Ton	-	201,2 Ton	-
5	TPS3R Eks TPA Babakan	1,6 Ton	-	23,6 Ton	3,6 Ton	-	-
	Total	**598,9 Ton**	**881,1 Ton**	**2711,8 Ton**	**9,6 Ton**	**215,7 Ton**	**791,2 Ton**

Source: Bandung Regency Environmental Service, 2024

Data from the 2023 TPS 3R (Waste Processing Site) performance report highlights PUSPA Jelekong as the highest-performing facility in Bandung Regency, with a total processing volume of 3,677 tons. This volume is managed through six diverse waste treatment pathways: 480 tons via the waste bank, 803.5 tons through maggot bioconversion, 1,860.5 tons converted into RDF, 14.4 tons processed using composting methods, 6 tons engaged through educational activities such as the "Ngopi Kancing" initiative, and 512.6 tons of residual waste managed through the waste bank system. These multifaceted processing mechanisms distinguish PUSPA Jelekong from other TPS 3R sites in the region such as TPS 3R Citaliktik, Pemda, and Jalak Harupat which do not yet offer the same comprehensive integration of treatment methods.

The innovation has been widely adopted, fundamentally transforming long-standing community practices in daily waste management. Residents have become more conscientious in sorting waste and have increasingly utilized processing technologies to produce compost, maggot-based bioconversion outputs, and recyclable materials. This behavioral shift has led to a more efficient and sustainable waste management system that supports the circular economy by maximizing resource reuse and significantly reducing environmental impact.

The transformation of the Jelekong Final Disposal Site (TPA) into the PUSPA Jelekong facility has yielded substantial benefits for communities in Bandung Regency and its surrounding areas. PUSPA serves as a community empowerment hub through a variety of educational activities, including training sessions, public awareness campaigns, and educational visits designed to enhance understanding of sustainable waste management practices. Local residents including women and youth are actively engaged in compost production, maggot cultivation, and the creation of economically valuable handicrafts from recycled materials. Institutional support from the Ministry of Environment and Forestry (MoEF), educational institutions, and non-governmental organizations has strengthened PUSPA's capacity to advance waste management technologies and broaden the implementation of environmentally responsible practices. Through this synergy, PUSPA Jelekong functions not only as a waste treatment facility but also as a catalyst for behavioral transformation and community empowerment in the environmental sector.

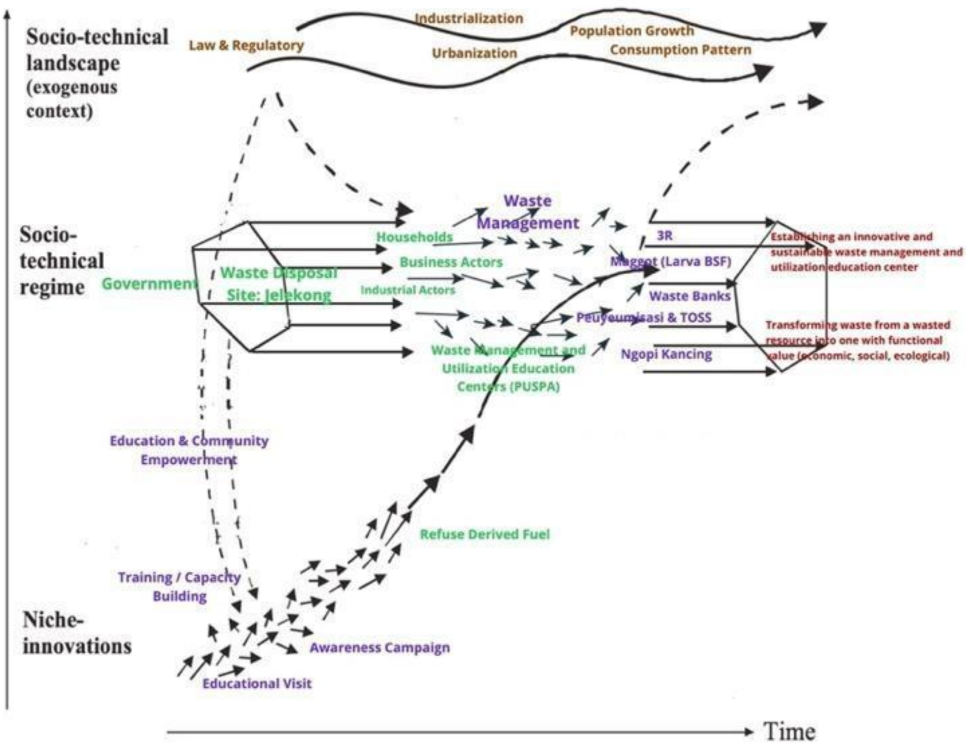

Figure 5. Socio-technical transition process
Source: Analysis results, 2025

E. CONCLUSIONS

Through the Multi-Level Perspective (MLP) analysis, it becomes evident that the waste management transition in Bandung Regency has evolved through a long-term, iterative process that continues to adapt in line with technological advancements. What was once the Jelekong Final Disposal Site (TPA), characterized by inadequate waste handling, has been transformed into PUSPA an integrated and innovative waste management facility. A particularly noteworthy aspect of this transition is the shift in how waste is valued. Waste, previously regarded as valueless refuse, has been redefined as an economic resource, thereby fostering the development of a circular economy within the local community. PUSPA not only focuses on technical waste processing but also emphasizes environmental education. The facility regularly conducts awareness campaigns, training programs, and educational visits to raise public consciousness regarding sustainable waste management. Applying the MLP framework reveals the relative stability of the landscape level while highlighting the tensions and negotiations generated by various actors as innovations evolve from niche practices into regime structures. Additionally, the MLP approach helps to identify critical factors influencing the transition process, such as institutional dynamics, societal engagement, and technological change. Ultimately, the case of PUSPA Jelekong illustrates how systemic transformation in waste governance can emerge through the interplay of socio-technical innovations and multi-level interactions.

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