



Multi-Stakeholder Synergy in Waste Management Toward a Clean and Sustainable North Sumatra

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ABSTRACT

Waste management in North Sumatra faces complex challenges encompassing technical, legal, institutional, and community behavior aspects. The increase in waste generation, unbalanced with adequate management capacity, impacts environmental quality and public health, thus requiring a sustainable, collaboration-based approach. This research analyzes the legal framework and policy implementation of waste management in North Sumatra through Stakeholder Analysis, exploring the roles, interests, and authorities of local governments, educational institutions, the private sector, and communities in the waste management system. This normative legal research with a limited empirical approach examines national and regional regulations, provincial and district/city policies, as well as field practices. The findings indicate that the legal substance provides an adequate normative basis, but policy effectiveness is hindered by weak institutional structures, limited infrastructure, and inconsistent law enforcement, which reduce public compliance and participation. Multi-stakeholder synergy serves as the key to enhancing effectiveness through policy innovations, institutional capacity building, and changes in community behavior. Strengthening the waste management model oriented toward source reduction, reuse, and environmentally friendly final disposal requires integration of legal substance, institutional structures, and community legal culture. The success of a clean and sustainable North Sumatra depends on consistent cross-sector collaboration within a framework of shared responsibility.

Keywords: Waste Management, North Sumatra, Stakeholder Analysis, Multi-Stakeholder Synergy, Sustainability

ABSTRAK

Pengelolaan sampah di Sumatera Utara menghadapi tantangan kompleks yang meliputi aspek teknis, hukum, kelembagaan, dan perilaku masyarakat. Peningkatan timbulan sampah yang tidak seimbang dengan kapasitas pengelolaan memengaruhi kualitas lingkungan dan kesehatan publik, sehingga memerlukan pendekatan berkelanjutan berbasis kolaborasi. Penelitian ini menganalisis kerangka hukum dan implementasi kebijakan pengelolaan sampah di Sumatera Utara melalui Analisis Stakeholder, dengan mengeksplorasi peran, kepentingan, serta kewenangan pemerintah daerah, institusi pendidikan, sektor swasta, dan masyarakat dalam sistem pengelolaan sampah. Penelitian hukum normatif dengan pendekatan empiris terbatas ini mengkaji peraturan perundang-undangan nasional dan daerah, kebijakan provinsi serta kabupaten/kota, serta praktik lapangan. Hasilnya menunjukkan bahwa substansi hukum telah menyediakan dasar normatif memadai, tetapi efektivitas kebijakan terhambat oleh lemahnya struktur kelembagaan, keterbatasan infrastruktur, dan inkonsistensi penegakan hukum,



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yang menurunkan kepatuhan serta partisipasi publik. Sinergi multipihak antar-stakeholder menjadi kunci utama untuk meningkatkan efektivitas melalui inovasi kebijakan, penguatan kapasitas kelembagaan, dan perubahan perilaku masyarakat. Penguatan model pengelolaan sampah berorientasi pengurangan di sumber, pemanfaatan kembali, serta pengelolaan akhir ramah lingkungan mensyaratkan keterpaduan substansi hukum, struktur kelembagaan, dan budaya hukum masyarakat. Keberhasilan Sumatera Utara yang bersih dan berkelanjutan bergantung pada kolaborasi lintas sektor yang konsisten dalam kerangka tanggung jawab bersama.

Kata kunci: Pengelolaan Sampah, Sumatera Utara, Analisis Stakeholder, Sinergi Multipihak, Keberlanjutan

1. Introduction

The waste problem in North Sumatra is not merely a matter of urban aesthetics but also a reflection of complex social and economic dynamics and the implementation of environmental laws. North Sumatra is among the provinces with the highest waste generation in Indonesia. Data shows that total waste generation reached $\pm 1,827,494.37$ tons in 2023, making it one of the largest contributors to national waste, with the city of Medan as the main contributor at $\pm 645,661.28$ tons of the total. This phenomenon forces stakeholders to focus not only on the volume of waste generated, but also on the challenges of processing, availability of facilities, community behavior, and the implementation of existing regulations. The context of waste management in North Sumatra must be understood as an integral part of sustainable development, as well as a reflection of the effectiveness of environmental law at the regional level.¹

The term “waste” generally refers to residual materials from human activities that no longer have any value and must be managed properly so as not to cause health impacts and environmental damage. In Indonesian regulations, such as Government Regulation No. 81 of 2012 concerning the Management of Household Waste and Household-like Waste, it is defined that household waste includes all waste materials from domestic activities that are not classified as special waste, such as hazardous waste. The lack of clarity in the community's understanding of what is categorized as waste and how to manage it immediately is often the root cause of indiscriminate disposal practices, even when collection facilities are available.²

The phenomenon of increasing waste generation in North Sumatra can be explained by socio-economic interactions and the production and consumption behavior of urban communities. Rapid urbanization, increased consumption of plastic packaging, and weaknesses in sorting systems in households or public facilities have increased the amount of waste that must be managed. Data from the Medan City Environment Agency (DLH) shows an average waste generation of $\pm 2,000$ tons/day, but transportation and management facilities are only capable of handling around ± 800 tons/day, while the remaining 1,000 tons have the potential to pollute the physical environment. This imbalance between waste generation and service capacity reflects weaknesses in governance, including in terms of law enforcement and multi-stakeholder commitment.³

Table 1 Waste Generation and Management Capacity in North Sumatra Province, 2023

Region	Total Generation (Ton/Year)	Daily Generation (Ton/Day)	Management Capacity (Ton/Day)	Unmanaged Waste (Ton/Day)
North Sumatra Province	$\pm 1,827,494.37$	$\pm 5,006$	–	–
Medan City	$\pm 645,661.28$	$\pm 2,000$	± 800	$\pm 1,200$
Other Regencies/Cities (aggregated estimate)	$\pm 1,181,833.09$	$\pm 3,006$	–	–

Source: North Sumatra Provincial Environment Agency and Medan City Environment Agency (2023), processed.

¹ NN. M. U. Munthe, M. Nanda, S. N. Aisyah, R. Hasibuan, T. Wulandari, R. Pohan, & N. I. Nasution, (2025). Analysis of waste management at the PON event at the Multipurpose Astaka Medan Pancing Sport Center. HEARTY, 13(4), 1001–1008.

² R. F. Pawitra Sari, (2023). Integrated waste management system based on green building assessment principles at Jakarta International Stadium. Journal of Civil and Environmental Engineering, 1–12

³ Antara, Medan City Government: Waste management is not only the responsibility of the government, accessed from https://sumut.antaranews.com/berita/598593/pemkot-medan-pengelolaan-sampah-bukan-hanya-tanggung-jawab-pemerintah?utm_source.com

The lack of adequate management not only affects aesthetics, but also results in various socio-environmental consequences. Improperly managed waste can contaminate soil and water, become a breeding ground for disease-carrying pests, and even worsen air quality, especially if burned in open areas. Traces of microplastic pollution in rivers and waterways are one indication of the impact of plastic-based waste seeping into ecosystems. According to contamination data in North Sumatra, the province has one of the highest levels of microplastic exposure in surface water. When plastic waste enters water bodies, aquatic ecosystems and the livelihoods of coastal communities are disrupted, expanding the socio-ecological impact of waste problems.⁴

The North Sumatra Provincial Government, through the Environment and Forestry Agency, has formulated various programs and policies to address these challenges. These include the development of transportation facilities, public education on sorting waste at home, and collaboration with the private sector to promote recycling and the processing of waste into energy or alternative fuels. Not only that, the provincial government has issued policies such as Governor Regulation No. 30 of 2025 concerning Source-Based Waste Management, which regulates the implementation of waste management from the source, and Governor Instruction No. 2 of 2025 concerning the Plastic Waste Reduction Movement in office environments. This policy demonstrates a normative commitment to providing a regional legal framework for reducing waste generation.⁵

Table 2 Waste Management Programs and Implementation Status in North Sumatra (2023–2025)

Waste Management Program	Legal Basis	Implementation Status	Main Challenges
Source-based waste management	Governor Regulation No. 30 of 2025	Initial stage / pilot	Low household-level sorting
Plastic waste reduction movement	Governor Instruction No. 2 of 2025	Ongoing in government institutions	Uneven adoption in informal sector
Community Waste Banks & Integrated Waste Processing Sites (TPST)	Regency/City Regional Regulation	Partial implementation	Limited facilities & human resources
Incentives for private sector recycling	Provincial Policy	Planning	Legal drafting & financing
Public education on waste sorting	Provincial Environment Agency Program	Ongoing / sustainable	Suboptimal community participation

Source: North Sumatra Provincial Environment and Forestry Agency (2024–2025)

However, legal challenges are not limited to the existence of regulations, but also their implementation at the grassroots level. Empirical research in Medan, for example, found that despite the existence of legal basis for waste management and sanctions against littering (such as local regulations), the practice remains rampant due to inconsistent law enforcement and low social sensitivity to these regulations. Cases of littering reveal a gap between written legal norms and actual behavior, which requires multi-stakeholder synergy, including law enforcement officials, local governments, and the community, to provide a deterrent effect as well as environmental legal education. Multi-stakeholder synergy efforts can also be seen in the involvement of local communities and community groups, such as scavengers, environmental communities, educational institutions, and the private sector in integrated management models. Pilot projects on plastic waste management and community efforts to turn waste into economic value are part of a collaborative approach that combines social, economic, and legal aspects. This synergy is important because waste management cannot rely on just one party; it requires the active role of the public, the business sector, law enforcement agencies, and the government in order to implement the principles of the circular economy.⁶

⁴ A. J. Gita Prajati, (2019). Analysis of sociodemographic and socioeconomic factors on urban waste generation in Sumatra Island. *Journal of Civil and Environmental Engineering*, 1

⁵ D. Nainggolan, A. Agusmidah, & D. Harianto, (2025). Implementation of laws in imposing sanctions on littering on roads for environmental sustainability using the theory of living law: Research. *Journal of Community Service and Educational Research*, 4(2), 12675–12682.

⁶ M.Marlina, M. Mulyadi, A. Syahrin, & E. S. Harahap, (2024). Imposition of additional penalties on corporations that commit environmental crimes (study of decision Number 349/Pid.B/LH/2019/PN.Plw). *Locus Journal of Academic Literature Review*, 3(1).

The expansion of the role of educational institutions in sustainable waste management is evident through the Integrated Waste Management Facility (TPST) initiative developed by the University of North Sumatra in collaboration with the Provincial Government of North Sumatra. This TPST is not just an ordinary waste management facility, but has been designed as an integrated innovation and research center involving cross-faculty collaboration. This facility combines technologies such as pyrolysis to convert plastic into fuel, organic composting, and maggot cultivation to address organic waste while creating economic value from it. In practice, the TPST functions as a living laboratory for lecturers and students to study human behavior towards waste, develop efficient processing models, and test source separation approaches. This concept is in line with the objectives of the Sustainable Development Goals (SDGs) and the campus's efforts towards a zero-waste lifestyle, where waste is not only managed but also becomes a resource with economic and social value.

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However, the growth of initiatives such as the North Sumatra University TPST presents its own challenges when viewed from the perspective of institutions and broader inter-agency synergy at the provincial and district/city levels. Although there is a strong legal basis and political support for strengthening the integrated waste management model, there is still a clear gap between policy on paper and its implementation in the public sphere. For example, the call to convert open waste management systems to sanitary landfills in all regencies/cities in North Sumatra by 2026 demonstrates regulatory ambition, but the realization of inter-sectoral coordination remains a significant obstacle that could affect the smoothness of the transition. Inconsistencies in the level of understanding, operational capacity, and legal monitoring often hinder implementation, both at the local government and community levels. Furthermore, the effectiveness of policy implementation depends on strong synergy between the government, law enforcement, academics, the business sector, and the community itself, which still requires more systematic collaborative mechanisms.⁸

In practice, the formation of multi-stakeholder synergies must go beyond normative rhetoric and enter into concrete steps that combine legal, economic, technological, and socio-cultural aspects. One of the non-technical aspects that often becomes an obstacle is citizen participation and the effective imposition of sanctions for violations of waste management regulations, including indiscriminate disposal or violations of sorting at the source. Without the active involvement of the community as legal subjects who understand and comply with environmental regulations, and without law enforcement institutions capable of providing a deterrent effect, major policy directions such as the target of eliminating open disposal will be difficult to achieve. This is where environmental education, legal education, and cross-sector collaboration become key instruments for strengthening the capacity of communities and local governments to manage waste sustainably, so that the law is not just a static document but also a daily practice that has a significant impact in the field.⁹

Waste management towards a clean and sustainable North Sumatra cannot be separated from the region's ability to integrate legal policies with management practices in the field. Reality shows that the waste problem is not solely due to increased waste generation, but also caused by weak consistency in the implementation of regulations, limited infrastructure, and low public awareness of the law. Various regulations have been formulated, both at the national and regional levels, but their effectiveness is highly dependent on coordination between parties, ranging from provincial governments, district/city governments, the private sector, to the community as subjects of environmental law. When waste management is still understood as a purely technical matter, aspects of law enforcement, supervision, and collective responsibility tend to be neglected, making it difficult to achieve the goal of a clean and healthy environment in a sustainable manner.¹⁰

The future direction of waste management in North Sumatra requires a paradigm shift from a collect-transport-dispose system to source reduction and reuse-based management. This approach positions the law not only as a regulatory tool, but also as an instrument of social engineering that encourages behavioral change and public participation. Multi-stakeholder synergy is key, as successful sustainable waste management can

⁷ University of North Sumatra. (2023). USU and North Sumatra Provincial Government inaugurate integrated waste management facility. Retrieved from <https://www.usu.ac.id/id/berita/usu-bersama-pemprov-sumut-resmikan-tempat-pengolahan-sampah-terpadu>

⁸ University of North Sumatra. (2023). Processing waste, fostering hope: USU TPST builds a zero waste movement from campus. Retrieved from <https://www.usu.ac.id/id/berita/mengolah-sampah-menumbuhkan-harapan-tpst-usu-bangun-gerakan-zero-waste-dari-kampus>

⁹ Rokan, M. P., Natsir, M., Asnawi, M. I., Rambe, M. I., & Tarigan, V. C. E. (2025). Integration of Green Procurement In Procurement Contracts: Strategies for Realizing Sustainable Procurement with impact in Indonesia. *Lex Generalis Law Journal*, 6(11)

¹⁰ J. T. Situmorang. (2022). The role of subdistrict heads in addressing waste problems in Medan Baru Subdistrict, Medan City, North Sumatra Province (Doctoral dissertation, Institute of Domestic Governance). Slamet, J. S. (2011). *Kesehatan Lingkungan*. Yogyakarta: Gadjah Mada University Press.

only be achieved through clear role sharing, institutional strengthening, and effective accountability mechanisms. Thus, the effort to realize a clean and sustainable North Sumatra is not merely an administrative target, but a legal and social process that requires long-term commitment from all stakeholders.

The complexity of waste management issues in North Sumatra stems not only from technical and regulatory aspects, but also from the relationships between stakeholders who have different roles, interests, and authorities. Local governments, communities, academics, the private sector, and law enforcement agencies interact within the same policy space, but are not yet fully integrated effectively. This condition shows that waste management issues cannot be understood in a sectoral manner, but require an analytical approach that is capable of mapping the roles, interests, and powers of each actor. Based on these considerations, this study uses Stakeholder Analysis as a method to examine the dynamics of roles and build synergy between parties in sustainable waste management in North Sumatra.

2. Research Method

The research method used in this study is normative legal research with a conceptual and legislative approach, which is combined with an empirical approach to strengthen contextual analysis.¹¹ The study focuses on examining legal norms governing waste management, both at the national and regional levels in North Sumatra, including legislation, local government policies, and official documents related to sustainable waste management.¹² Primary, secondary, and tertiary legal materials were analyzed qualitatively to examine the compatibility between regulatory objectives and implementation practices in the field, particularly in the context of multi-stakeholder synergy. An empirical approach was taken through document studies and secondary data searches from relevant agencies to understand the dynamics of policy implementation and the obstacles encountered, enabling this study to provide a comprehensive picture of the effectiveness of waste management towards a clean and sustainable North Sumatra.

3. Result and Discussion

3.1. Legal Framework for Waste Management in North Sumatra

Given the reality of increasing waste generation, the legal framework for waste management in Indonesia has been designed to regulate this issue in a systematic and sustainable manner. Law No. 18 of 2008 on Waste Management is the main foundation that shifts the old paradigm of waste management from simply disposing and transporting waste to an approach of reduction and treatment. This norm emphasizes that waste is no longer positioned as residue that must be disposed of, but rather as an object of management that requires shared responsibility between the state, local governments, and the community. This principle is reflected in Article 3 of Law No. 18 of 2008, which emphasizes environmentally conscious and sustainable waste management as part of protecting citizens' rights to a good and healthy environment.¹³

This legal framework was then reinforced by Law No. 32 of 2009 on Environmental Protection and Management, which positions waste management as an integral part of efforts to prevent pollution and environmental damage. Article 1 paragraph 2 of Law No. 32 of 2009 emphasizes that environmental protection includes systematic and integrated actions to preserve environmental functions, including controlling pollution caused by waste and garbage. This framework shows that waste management is not only a technical matter of cleanliness, but also a legal instrument to maintain ecological balance and sustainable development. Thus, every regional policy related to waste should be in line with the principles of precaution, participation, and state responsibility as mandated in environmental laws.

More technical regulations related to the management of household waste and similar types of waste are regulated through Government Regulation No. 81 of 2012. This regulation provides operational details regarding the obligations of local governments in implementing waste reduction and management, including regulations on sorting, collection, transportation, and final processing. Article 12 of Government Regulation No. 81 of 2012 explicitly requires local governments to establish regional policies and strategies for waste management that are oriented towards reduction at source. This provision emphasizes that regions should not only act as implementers of central government policies, but also as key actors in formulating management models that are appropriate to the characteristics of their regions and communities.¹⁴

¹¹ Sugiyono. (2020). *Quantitative, Qualitative, and R&D Research Methods*. Bandung: Alfabeta.

¹² Z. Ali, (2019), *Legal Research Methods*, Jakarta: Sinar Grafika.

¹³ A. Afriansyah, A. T. S. Kusumo, A. Sitamala, & F. M. Kinanti, (2023). State practice of Asian Countries in International Law: Indonesia. *Asian Yearbook of International Law*, 29, 211–220.

¹⁴ P. Manalu, F. S. Tarigan, E. Girsang, & C. N. Ginting, (2022). Barriers to the Implementation of Household Waste Management Policies in Binjai City. *Indonesian Journal of Environmental Health*, 21(3), 285–292.

The North Sumatra Provincial Government has established a source-based waste management policy in response to the limited capacity of final processing sites. This policy aims to strengthen the role of district/city governments as the spearhead of waste management, while encouraging community and business involvement. This regional legal framework is important because North Sumatra has diverse geographical and demographic characteristics, requiring policy flexibility that remains within the corridor of national law.

In waste management in North Sumatra, local governments occupy the position of key stakeholders because they have formal power and legal authority in policy formulation, infrastructure provision, and environmental law enforcement. The provincial and district/city governments act as the main decision makers that determine the direction of waste management policy through the formulation of regional regulations, governor regulations, and technical programs implemented by regional agencies such as the Environmental Agency.

The distribution of authority between provincial and district/city governments in waste management demonstrates the complex dynamics of administrative law. Provincial governments play a role in coordination, guidance, and supervision, while district/city governments are directly responsible for the operational management of waste in their respective areas. This scheme is in line with the principle of decentralization as stipulated in Law Number 23 of 2014 concerning Regional Government, which provides space for regions to regulate environmental affairs in accordance with local needs. However, in practice, this division of authority often faces coordination obstacles, especially when provincial policies have not been fully internalized in technical policies at the district/city level.¹⁵

Another issue that has arisen is the weak integration between legal norms on waste management and law enforcement mechanisms in the regions. Although various regional regulations contain provisions on administrative and criminal sanctions for waste management violations, their implementation tends to be sporadic. Article 29 of Law No. 18 of 2008 actually prohibits the indiscriminate disposal of waste, but enforcement of this provision is highly dependent on the commitment of local governments and law enforcement officials. The lack of firmness in applying sanctions has resulted in a low deterrent effect and the continuation of environmentally unfriendly behavior by the community.¹⁶

Within the framework of modern law, waste management is also viewed as an instrument of social engineering to shape public awareness and legal compliance. The law does not only function repressively through sanctions, but also persuasively through the regulation of public participation. Article 28 of Law No. 18 of 2008 opens up space for the role of the community and the business world in waste management, whether through reduction, reuse, or recycling activities. This norm shows that waste management law contains a participatory dimension that requires multi-stakeholder synergy, not the dominance of a single actor. The dimension of sustainability in the legal framework of waste management is also reflected in the encouragement of environmentally friendly technology and safe final management. The transition from an open disposal system to sanitary landfills is a minimum standard that must be achieved by local governments. This policy is not only technical in nature but also has legal implications as it relates to the state's obligation to prevent environmental pollution. When final management does not meet environmental standards, the potential for violations of the right to a healthy environment as guaranteed by Article 65 of Law No. 32 of 2009 becomes highly relevant.¹⁷

When analyzed using Lawrence M. Friedman's legal system theory, the role of local government in waste management in North Sumatra falls within the realm of legal structure, namely institutions and officials that function to execute, implement, and enforce legal norms. This legal structure includes the provincial and district/city governments, the Environmental Agency as the technical implementer, local law enforcement officials, and supervisory agencies with administrative authority. The existence of this legal structure is a key prerequisite for the concrete realization of waste management norms formulated in legislation in local government and public service practices.

Within this framework, local governments have a strategic position because they hold formal authority to formulate policies, provide waste management infrastructure, and implement monitoring and law enforcement mechanisms. The main motive of local governments in waste management is basically oriented towards the public interest, which includes protecting the environment, improving public health, and meeting

¹⁵ E. Z. Siregar, N. M. Harahap, N. Hasibuan, A. B. Harahap, A. H. Ritonga, & M. E. U. Harahap, (2023). Utilization of household waste in Bargoutopong Village, Batang Angkola District, South Tapanuli Regency, North Sumatra Province. *Kifah: Journal of Community Service*, 2(2), 149–160

¹⁶ J. S. Slamet, (2011) *Environmental Health*. Yogyakarta: Gadjah Mada University Press.

¹⁷ D. Anggriani, B. Purba, I. J. Saragih, S. Aisyah, & W. Anzani, (2024). Analysis of the Effects of Household Waste on Environmental Pollution in the City of Medan. *EKOMA: Journal of Economics, Management, Accounting*, 4(1), 187–192

sustainable development targets. In addition, waste management is also related to the constitutional responsibility of local governments to guarantee the community's right to a good and healthy environment, as mandated in environmental legislation.

Compared to East Java Province, waste management in North Sumatra shows differences in terms of policy integration and institutional innovation. East Java has promoted the strengthening of waste banks, the development of Integrated Waste Processing Sites (TPST), and the optimization of collaboration schemes between local governments and communities through a circular economy approach. Some regencies/cities in East Java even integrate waste management with SME empowerment programs and poverty reduction initiatives, allowing environmental and social dimensions to progress hand in hand. Meanwhile, in North Sumatra, although the normative framework is in place and aligned with national regulations, the implementation of source-based policies still faces challenges related to technical capacity, limited budgets, and inter-regional coordination. This comparison indicates that the effectiveness of the legal structure is not determined solely by the completeness of regulations, but also by policy innovation and consistent implementation at the local level.¹⁸

A comparison can also be made with Surabaya, which is known for successfully reducing waste volume through household-level sorting, the optimization of TPS 3R, and relatively consistent enforcement of regional regulations. This success is supported by progressive local leadership, adequate infrastructure, and public participation that has been internalized into the community's legal culture.¹⁹ Analyzed through Lawrence M. Friedman's legal system theory, Surabaya demonstrates a balance between legal structure, legal substance, and legal culture. In contrast, in North Sumatra, while the legal structure has been established, the legal culture and enforcement effectiveness still require strengthening to achieve a fully integrated synergy. This inter-regional comparison underscores that the main challenge in waste management is not merely the legal norms themselves, but the consolidation of institutions and the sustainable transformation of community legal behavior.

3.2. Policy Implementation and Challenges in Waste Management in the Region

The implementation of waste management policies in North Sumatra shows a significant gap between legal norms and reality on the ground. Various regulations have stipulated the obligations of local governments in managing waste sustainably, but actual achievements still do not fully reflect the stated objectives. The increasing amount of waste is not matched by an adequate waste management system, especially at the district/city level. This condition shows that legal policies have not been fully translated into effective administrative and technical actions, so that environmental impacts continue to occur even though normative instruments are available. Infrastructure limitations are a major challenge in the implementation of waste management policies in the regions. Many district/city governments still rely on open-air landfills that do not meet environmental standards. In fact, Government Regulation No. 81 of 2012 has encouraged waste management through reduction at the source and environmentally friendly final treatment. When transportation facilities, sorting facilities, and processing technology are not yet adequately available, these policies tend to remain at the planning stage without any real impact on reducing pollution.²⁰

Implementation issues are also closely related to the institutional capacity of local governments. The organizational structure for waste management in several regions still faces limitations in terms of human resources, budget, and technical competence. As a result, the functions of planning, supervision, and evaluation of waste management are not running optimally. In fact, Law No. 23 of 2014 on Regional Government emphasizes that environmental issues, including waste management, are mandatory matters that must be prioritized by local governments. This institutional unpreparedness weakens the effectiveness of established policies. The gap between legal norms and practice is also evident in the weakness of the monitoring and sustainable monitoring systems. Waste management should be monitored regularly to ensure compliance with environmental standards and legal provisions. However, in many regions, the monitoring mechanism is still reactive and not data-driven. The lack of monitoring means that violations, such as indiscriminate waste disposal or substandard landfill management, often escape strict legal action. This situation creates the perception that waste management laws do not have strong enforcement power.²¹

¹⁸ Antara Jatim, East Java is committed to managing waste based on a circular economy model, accessed from <https://megapolitan.antaranews.com/berita>

¹⁹ Antara Jatim, The Surabaya City Government targets 500 waste sorting sites, accessed from https://jatim.antaranews.com/berita/914457/pemkot-surabaya-targetkan-500-tempat-pemilihan-sampah?utm_source.com

²⁰ T.Rahmadi, (2011), *Environmental Law in Indonesia*. Jakarta: Rajawali Pers.

²¹ Koesnadi Hardjasoemantri. (2018). *Environmental Law*. Yogyakarta: Andi.

Law enforcement is a crucial challenge in the implementation of waste management policies. Although Law No. 18 of 2008 regulates prohibitions and sanctions for waste management violations, its implementation at the regional level is still inconsistent. Administrative and criminal sanctions are rarely applied to the fullest extent, so they do not deter violators. This lack of firmness has resulted in low compliance by the community and businesses with the waste management obligations stipulated in local regulations. Low community participation also complicates the implementation of waste management policies. Although the law has opened up space for public involvement, the community's understanding of legal obligations and the environmental impact of waste is still limited. Without continuous education and a structured persuasive approach, policies on waste sorting at the source and reducing plastic use are difficult to implement on a large scale. This situation shows that policy implementation requires a combination of legal, social, and cultural approaches to bring about gradual behavioral change.²²

Coordination between parties at the regional level often lacks synergy. Waste management involves various actors, ranging from environmental agencies, public works agencies, law enforcement officials, to village and sub-district governments. When coordination is not well established, policies that should be integrated end up being implemented partially. As a result, responsibility for waste management becomes unclear and authorities pass the buck to each other, which ultimately harms the interests of the environment and the community. Implementation challenges also arise from limited funding for waste management in the regions. Regional budgets often do not prioritize the waste sector proportionally, even though it has a significant impact on health and the environment.²³ In fact, sustainable waste management policies require long-term investment in infrastructure, technology, and human resource capacity building. When budgetary support is minimal, legal policies lack the material support to be implemented effectively. These conditions show that the success of waste management policy implementation is not only determined by the completeness of regulations, but also by political and administrative commitment at the regional level. Good laws without consistent implementation will only result in symbolic norms without real change. Therefore, strengthening governance, transparency, and accountability are important elements for policy implementation.²⁴

3.3. Multi-stakeholder Synergy in Sustainable Waste Management

Sustainable waste management in North Sumatra cannot rely solely on the role of the government, given the complexity of issues involving social, economic, environmental, and legal aspects simultaneously. The limited capacity of local governments, both in terms of budget and infrastructure, makes cross-sector collaboration an inevitable necessity. The national legal framework through Law No. 18 of 2008 explicitly opens up space for the involvement of various parties in waste management, signifying that environmental management is a collective responsibility that must be carried out jointly.²⁵ The government's role in multi-stakeholder synergy remains central as a regulator and policy coordinator. Provincial and district/city governments are responsible for setting policy directions, providing a legal framework, and ensuring consistent oversight and law enforcement mechanisms. However, in a collaborative context, the government is no longer positioned as a dominant actor working alone, but rather as a facilitator that bridges the interests of various stakeholders. This approach is in line with the principles of good governance, which emphasize participation, accountability, and transparency in the management of public affairs.²⁶

Educational institutions play a strategic role in strengthening multi-stakeholder synergy through their functions of education, research, and community service. The involvement of universities in waste management not only contributes to technological innovation and management models, but also to the formation of legal and environmental awareness in the community. Through applied research and community service programs, educational institutions are able to bridge the gap between policy concepts and practices in

²² Bram, (2014). *Environmental Law*. Bekasi: Gramata Publishing.

²³ A. Charitou, R. N. Aga-Spyridopoulou, Z. Mylona, R. Beck, F. McLellan, & A. M. Addamo, (2021). Investigating the Knowledge and Attitude of The Greek Public Towards Marine Plastic Pollution and the EU Single-Use Plastics Directive. *Marine Pollution Bulletin*, 166, 112182.

²⁴ D. Dermawan, L. Lahming, & M. A. S. Mandra, (2018). Study of waste management strategies. *UNM Environmental Journals*, 1(3), 86–90.

²⁵ J. Abdussamad, F. P. Tui, F. Mohamad, & S. Dunggio, (2022). Implementation of waste management policies through the waste bank program at the Bone Bolango Regency Environmental Agency. *Publik: Journal of Human Resource Management, Administration and Public Services*, 9(4), 850–868.

²⁶ V. Yogiesti, S. Hariyani, & F. R. Sutikno, (2010). Community-based integrated waste management in Kediri City. *Journal of Urban and Regional Planning*, 2(2), 95–102.

the field, while providing a scientific basis for the formulation of more adaptive and contextual policies.²⁷ The contribution of the private sector and the business world in sustainable waste management is becoming increasingly relevant with the development of the circular economy concept. Businesses are not only seen as waste producers, but also as part of the solution through the application of the principle of extended producer responsibility. The involvement of the business world in reducing the use of single-use packaging, managing production waste, and investing in recycling technology shows that economic interests can be aligned with environmental protection. This approach is also supported by national policies that encourage the active role of the private sector in environmental management.²⁸

The contribution of the private sector and the business world in sustainable waste management is becoming increasingly relevant as the concept of the circular economy develops. Businesses are no longer seen solely as waste producers, but also as part of the solution through the application of the principle of extended producer responsibility. The involvement of the business world in reducing the use of single-use packaging, managing production waste, and investing in recycling technology shows that economic interests can be aligned with environmental protection. This approach is also supported by national policies that encourage the active role of the private sector in environmental management.

Community groups are key actors in ensuring the sustainability of waste management at the grassroots level. Without active community participation, waste management policies are likely to fail to achieve their objectives, even if they are supported by adequate regulations and infrastructure. Community involvement in waste sorting, reducing plastic use, and social monitoring of environmental violations reflects the application of the principle of shared responsibility. From an environmental law perspective, public participation is an important element that ensures the legitimacy and effectiveness of policies. This condition reaffirms that the issue of waste management cannot be understood solely from the completeness of legal norms, but needs to be analyzed through how the law is implemented and accepted in practice.

Multistakeholder synergy also plays a role in encouraging waste management innovations that are more adaptive to local conditions. Collaboration between the government, academics, and communities can produce locally-based management models that are more easily accepted by the community. Such innovations not only reduce the burden on final disposal sites, but also open up new economic opportunities through value-added waste processing. When innovation is supported by a clear legal framework, its sustainability can be ensured in a more systemic manner. From a legal perspective, multi-stakeholder synergy serves as a mechanism to strengthen policy implementation. The involvement of various actors enables mutual control and oversight, so that policy implementation does not depend entirely on the capacity of government officials. In this context, the law no longer stands as a coercive instrument, but as a coordinative tool that regulates relationships between parties in achieving common goals. This approach is relevant to overcoming weak law enforcement, which is often an obstacle to waste management in the regions²⁹

In addition to legal structures, challenges in implementing waste management policies are also related to aspects of the legal culture of society. In Friedman's perspective, legal culture reflects the attitudes, values, and level of public awareness of the law. Low public participation, weak compliance with waste sorting obligations, and the persistence of the habit of littering indicate that legal norms have not been fully internalized in social behavior. Without strengthening legal culture through education and participatory approaches, waste management policies will be difficult to implement effectively. The success of multi-stakeholder synergy is greatly influenced by the clarity of the roles and responsibilities of each actor. Without a clear division of roles, collaboration has the potential to cause overlapping authorities or even conflicts of interest. Therefore, waste management policies need to be designed inclusively by establishing clear and measurable coordination mechanisms. The regional legal framework has an important role in ensuring that multi-stakeholder synergy runs within a definite and accountable legal corridor.³⁰

The main challenge in building multi-stakeholder synergy is the difference in interests and levels of commitment among actors. The government tends to focus on regulatory compliance, while the private sector

²⁷ M. Maskun, R. Mohamad Khalid, R. Ratnawati, M. Mutawalli Mukhlis, W. Anggara, & R. N. R. Ramli. (2024). Strengthening Indonesia's Waste Management Laws: Compliance with Public Health and Marine Conservation Norms. *Substantive Justice International Journal of Law*, 7(2), 142–166.

²⁸ D. A. Kurniawan, & A. Z. Santoso, (2020). Waste management in the Sepatan area of Tangerang Regency. *ADI Community Service Journal*, 1(1), 31-36.

²⁹ B. R. Simbolon, P. Pin, & T. Y. Gulo. (2023). Implementation of Medan Mayor Regulation No. 18 of 2021 on the Delegation of Waste Management to Subdistricts (Case Study in Medan Sunggal Subdistrict). *Meta Hukum Journal*, 2(1), 176–185.

³⁰ A. F. Rahmawati, & F. D. Syamsu, (2021.). Analysis of sustainable waste management in urban areas in Indonesia. *Binagogik Journal*, 8(1), 1–12.

considers economic efficiency, and the community acts based on practical daily needs. This is where the law functions as a balancing instrument that harmonizes these interests so that they remain within the framework of environmental protection and sustainability.³¹ When the law is able to play this role effectively, multi-stakeholder synergy can develop in a more solid and sustainable manner. Thus, the failure to implement waste management policies in the regions is not solely due to regulatory weaknesses, but also to the failure of the legal system as a whole. Weak legal structures and legal culture have caused waste management laws to remain at the normative level. Within the framework of Lawrence M. Friedman's theory, improving waste management requires strengthening implementing institutions as well as changing public legal awareness in a sustainable manner.³²

3.4. Strengthening Waste Management Models Towards a Clean and Sustainable North Sumatra

Strengthening waste management models in North Sumatra needs to start with a change in policy orientation that prioritizes waste reduction at the source. Until now, the dominant approach has been based on transportation and final disposal, resulting in an increasing environmental burden as waste continues to accumulate. In fact, Law No. 18 of 2008 explicitly places waste reduction as the first step in a sustainable management system. This approach requires the active involvement of households, businesses, and public institutions in limiting waste production from daily activities, rather than simply leaving it to the government as the final manager.³³

From the perspective of Lawrence M. Friedman's legal system theory, this change in policy orientation is closely related to the legal substance, namely the norms, principles, and policies that govern the direction of waste management. The emphasis on waste reduction at the source indicates an effort to renew the legal substance to be more preventive and sustainability-oriented. Responsive legal substance is an important foundation for waste management models to be not only reactive, but also capable of reducing waste generation from the outset.³⁴

Reuse and recycling are the next important elements in strengthening the waste management model. Waste that still has value should not end up directly in final processing sites, but rather be processed through a system that allows economic value and social benefits to emerge. Strengthening waste banks, community-based processing facilities, and supporting the recycling industry are concrete steps that can extend the life cycle of materials. From an environmental law perspective, this approach is in line with the principles of resource efficiency and pollution prevention, as mandated in Law No. 32 of 2009 concerning Environmental Protection and Management.³⁵

The final management aspect continues to hold a strategic position in a comprehensive waste management system. The transition to environmentally friendly final management, such as sanitary landfills, is an urgent need for districts/cities in North Sumatra. Open disposal systems not only risk contaminating soil and water, but also have the potential to violate the community's right to a healthy environment. Strengthening the end management model requires legal certainty, clear technical standards, and continuous monitoring so that processing facilities do not cause new impacts on the surrounding environment.

The integration of legal aspects is key to ensuring the sustainability of the waste management model. Existing regulations need to be translated into consistent and easily implemented operational policies at the regional level. Local regulations and governor policies must be able to bridge national norms with local needs, so that there are no legal vacuums or overlapping authorities. Within Friedman's theoretical framework, the effectiveness of legal substance is highly dependent on the support of a legal structure that implements it consistently and in a coordinated manner.³⁶

The regulation of waste management does not stop at Law No. 18 of 2008 and Law No. 32 of 2009, but has been further elaborated into regional policies, such as the North Sumatra Provincial Regulation on

³¹ T. Okhtafianny & R. Ariani. (2023). Analysis of the Implementation of Waste Management Policies in Payakumbuh City. *Journal of Economics, Business, Management, and Accounting (JEBMA)*, 3(2), 537–550.

³² E. Firdausi, (2024). Implementation of sustainable waste management: A case study of the Waste Bank in Kotabaru Village, Yogyakarta City. *Journal of Ecology, Society and Science*, 5(1), 60–65.

³³ B. Swerda, (2012). *Waste Bank (Theoretical Study and Application)*. Yogyakarta: Pustaka Rimaha.

³⁴ M. Dewanti, E. P. Purnomo, & L. Salsabila, (2020). Analysis of the Effectiveness of Waste Banks as an Alternative to Waste Management in Achieving a Smart City in Kulon Progo Regency. *Publisia: Journal of Public Administration*, 5(1).

³⁵ R. Aqmalia, A. Z. Anwary, & A. Jalpi, (2020). The Relationship Between Behavioral Domains and Waste Management at Balitbangda Balangan. *Journal of Public Health*, 3

³⁶ D. Nurmayadi, & A. R. Hendardi, (2020). Waste management using the Behavior Mapping Approach. *Jaz*, 3, 45–52.

Waste Management and various regency/city regulations that govern operational technicalities, financing, public participation, and administrative sanctions. At the city level, for example, Medan City has Medan City Regulation No. 6 of 2015 on Waste Management, which stipulates obligations for waste sorting, the role of the community, responsibilities of business actors, and mechanisms for waste service fees.³⁷ The existence of these regulations demonstrates that, normatively, multi-stakeholder synergy has been institutionalized in regional law, including provisions on partnerships with the private sector and community empowerment through waste banks. Thus, the analysis does not only focus on the concept of participation, but can also be directed toward evaluating the effectiveness of these regional norms in practice.³⁸

Analysis of these regional legal products can focus on the extent to which provisions regarding public participation, producer responsibility, and administrative sanctions are actually implemented. Regional regulations generally include obligations for communities to sort waste at the source and prohibitions against littering, accompanied by sanctions. However, challenges often arise due to weak supervision and inconsistent law enforcement by local authorities. This highlights the importance of examining the interrelation between the legal substance in regional regulations, the legal structure (implementing agencies such as the Environmental Service), and the legal culture of the community, as proposed by Lawrence M. Friedman. By incorporating analysis of regional legal products concretely, the discussion on multi-stakeholder synergy becomes more comprehensive, as it addresses not only the conceptual level but also the implementation and evaluative dimensions of policies at the local level.

From Lawrence M. Friedman's perspective, community participation reflects the aspect of legal culture, which encompasses attitudes, values, and behaviors of society toward the law. Without a supportive legal culture, the legal substance and institutional structure will not function effectively. Therefore, strengthening legal awareness, environmental education, and habitual pro-environmental behavior becomes a crucial element in building a sustainable waste management model. The integration of legal substance, institutional structure, and community legal culture opens the space for developing a more adaptive and contextual waste management model.³⁹ Each region in North Sumatra has distinct social and geographical characteristics, so the management model cannot be rigidly standardized. A flexible approach that still operates within the legal corridor allows for sustainable local innovations to emerge. With a fully functioning legal system, as described by Lawrence M. Friedman, the strengthening of the waste management model is expected to contribute to achieving a clean and sustainable North Sumatra.

4. Conclusion

Waste management in North Sumatra has a fairly strong legal foundation at both the national and regional levels; however, its implementation has not been optimal. Limitations in institutional capacity, infrastructure, and consistency in law enforcement have created a gap between legal norms and practices on the ground. Multi-stakeholder synergy is key to the success of sustainable waste management. Regional governments act as regulators and supervisors, educational institutions support through research and education, the private sector contributes through technological innovation and circular economy practices, while the community serves as the primary actor in waste sorting and social monitoring. This collaboration produces an adaptive, contextual, and sustainable waste management model, in which regulations, institutional capacity, technology, and public participation work synergistically. Strengthening coordination among actors, fostering a participatory legal culture, and implementing source-based practices form the foundation for North Sumatra to achieve effective and environmentally friendly waste management.

Reference

- Abdussamad, J., Tui, F. P., Mohamad, F., & Dunggio, S. (2022). Implementation of waste management policies through the waste bank program at the Bone Bolango Regency Environmental Agency. *Publik: Journal of Human Resource Management, Administration and Public Services*, 9(4), 850–868.
- Afriansyah, A., Kusumo, A. T. S., Sitamala, A., & Kinanti, F. M. (2023). State practice of Asian countries in international law: Indonesia. *Asian Yearbook of International Law*, 29, 211–220.

³⁷U. Mustaghfiroh, L. K. Ni'mah, A. Sundusiyah, H. A. Addahlawi, & A. F. Hidayatullah. (2024). Implementation of the Principles of Good Environmental Governance in Waste Management in Indonesia. *Bina Hukum Lingkungan*, 4(2), 279–291.

³⁸A. L., Daffa Athallah, M. Hamdi, & M. Rahmah. (2024). Determinant Factors of Successful Implementation of Waste Management Policies in Semarang City. *Journal of Government Policy*, 7(2), 43–60.

³⁹F. Amir, A. S. Miru, & E. Sabara, (2025). Urban household behavior in Indonesia: Drivers of zero waste participation. arXiv preprint arXiv:2505.17864.

- Akib, M. (2014). *Environmental Law from a Global and National Perspective*. Jakarta: PT Raja Grafindo Persada.
- Ali, Z. (2019). *Legal Research Methods*. Jakarta: Sinar Grafika.
- Amir, F., Miru, A. S., & Sabara, E. (2025). Urban household behavior in Indonesia: Drivers of zero waste participation. *arXiv preprint arXiv:2505.17864*.
- Anggriani, D., Purba, B., Saragih, I. J., Aisyah, S., & Anzani, W. (2024). Analysis of the Effects of Household Waste on Environmental Pollution in the City of Medan. *EKOMA: Journal of Economics, Management, Accounting*, 4(1), 187–192.
- Anies. (2015). *Environment-Based Diseases*. Yogyakarta: Ar-Ruzz Media.
- Antara Jatim, East Java is committed to managing waste based on a circular economy model, accessed from <https://megapolitan.antaranews.com/berita>
- Antara Jatim, The Surabaya City Government targets 500 waste sorting sites, accessed from https://jatim.antaranews.com/berita/914457/pemkot-surabaya-targetkan-500-tempat-pemilihan-sampah?utm_source.com
- Antara. (2023). Medan City Government: Waste management is not only the responsibility of the government. Retrieved from https://sumut.antaranews.com/berita/598593/pemkot-medan-pengelolaan-sampah-bukan-hanya-tanggung-jawab-pemerintah?utm_source.com
- Aqmalia, R., Anwary, A. Z., & Jalpi, A. (2020). The relationship between behavioral domains and waste management at Balitbangda Balangan. *Journal of Public Health*, 30.
- Bram. (2014). *Environmental Law*. Bekasi: Gramata Publishing.
- Charitou, A., Aga-Spyridopoulou, R. N., Mylona, Z., Beck, R., McLellan, F., & Addamo, A. M. (2021). Investigating the Knowledge and Attitude of The Greek Public Towards Marine Plastic Pollution and the EU Single-Use Plastics Directive. *Marine Pollution Bulletin*, 166, 112182.
- Daffa Athallah, A. L., Hamdi, M., & Rahmah, M. (2024). Determinant factors for the successful implementation of waste management policies in Semarang City. *Journal of Government Policy*, 7(2), 43–60.
- Damanhuri, E., & Padi, T. (2016). *Integrated waste management*. Bandung: Environmental Engineering, Bandung Institute of Technology.
- Dermawan, D., Lahming, L., & Mandra, M. A. S. (2018). Study of waste management strategies. *UNM Environmental Journals*, 1(3), 86–90.
- Dewanti, M., Purnomo, E. P., & Salsabila, L. (2020). Analysis of the Effectiveness of Waste Banks as an Alternative to Waste Management in Achieving a Smart City in Kulon Progo Regency. *Publisia: Journal of Public Administration*, 5(1).
- Fadhillah, F. (2018). *The Right to a Good and Healthy Environment in the Context of Air Quality in Jakarta*. Jakarta: Indonesia Center for Environmental Law.
- Firdausi, E. (2024). Implementation of sustainable waste management: A case study of the Waste Bank in Kotabaru Village, Yogyakarta City. *Journal of Ecology, Society and Science*, 5(1), 60–65.
- Hardjasoemantri, K. (2018). *Environmental Law*. Yogyakarta: Andi.
- Hasibuan, M. R., & Siagian, S. P. (2023). Implementation of waste management policies through the waste bank program (a study of the Permata Hati-DLH Waste Bank in Medan City). *Journal of Governance Opinion*, 8(2), 62–67.
- Kurniawan, D. A., & Santoso, A. Z. (2020). Waste management in the Sepatan area of Tangerang Regency. *ADI Community Service Journal*, 1(1), 31–36.
- Manalu, P., Tarigan, F. S., Girsang, E., & Ginting, C. N. (2022). Barriers to the Implementation of Household Waste Management Policies in Binjai City. *Indonesian Journal of Environmental Health*, 21(3), 285–292.
- Marlina, M., Mulyadi, M., Syahrin, A., & Harahap, E. S. (2024). Imposition of additional penalties on corporations that commit environmental crimes (study of decision Number 349/Pid.B/LH/2019/PN.Plw). *Locus Journal of Academic Literature Review*, 3(1).
- Maskun, M., Mohamad Khalid, R., Ratnawati, R., Mutawalli Mukhlis, M., Anggara, W., & Ramli, R. N. R. (2024). Strengthening Indonesia's Waste Management Laws: Compliance with Public Health and Marine Conservation Norms. *Substantive Justice International Journal of Law*, 7(2), 142–166.
- Munthe, N. M. U., Nanda, M., Aisyah, S. N., Hasibuan, R., Wulandari, T., Pohan, R., & Nasution, N. I. (2025). Analysis of waste management at the PON event at the Multipurpose Astaka Medan Pancing Sport Center. *HEARTY*, 13(4), 1001–1008.

- Mustaghfiroh, U., Ni'mah, L. K., Sundusiyah, A., Addahlawi, H. A., & Hidayatullah, A. F. (2024). Implementation of the principles of good environmental governance in waste management in Indonesia. *Bina Hukum Lingkungan*, 4(2), 279–291.
- Nainggolan, D., Agusmidah, A., & Harianto, D. (2025). Implementation of law in imposing sanctions on littering on roads for environmental sustainability using the theory of living law: Research. *Journal of Community Service and Educational Research*, 4(2), 12675–12682.
- Nurmayadi, D., & Hendaradi, A. R. (2020). Waste Management Using the Behavior Mapping Approach. *Jaz*, 3, 45–52.
- Okhtafianny, T., & Ariani, R. (2023). Analysis of waste management policy implementation in Payakumbuh City. *Journal of Economics, Business, Management, and Accounting (JEBMA)*, 3(2), 537–550.
- Pawitra Sari, R. F. (2023). Integrated Waste Management System with Green Building Assessment Principles at Jakarta International Stadium. *Journal of Civil and Environmental Engineering*, 1–12.
- Prajati, A. J. G. (2019). Analysis of sociodemographic and socioeconomic factors on urban waste generation in Sumatra Island. *Journal of Civil and Environmental Engineering*, 13.
- Rahmadi, T. (2011). *Environmental Law in Indonesia*. Jakarta: Rajawali Pers.
- Rahmawati, A. F., & Syamsu, F. D. (2021). Analysis of sustainable waste management in urban areas in Indonesia. *Binagogik Journal*, 8(1), 1–12.
- Rokan, M. P., Natsir, M., Asnawi, M. I., Rambe, M. I., & Tarigan, V. C. E. (2025). Integration of green procurement in procurement contracts: Strategies for realizing sustainable procurement with impact in Indonesia. *Lex Generalis Law Journal*, 6(11).
- Simbolon, B. R., Pin, P., & Gulo, T. Y. (2023). Implementation of Medan Mayor Regulation No. 18 of 2021 concerning the delegation of waste management to sub-districts: A case study in Medan Sunggal Subdistrict. *Meta Law Journal*, 2(1), 176–185.
- Siregar, E. Z., Harahap, N. M., Hasibuan, N., Harahap, A. B., Ritonga, A. H., & Harahap, M. E. U. (2023). Utilization of household waste in Bargot Topong Village, Batang Angkola District, South Tapanuli Regency, North Sumatra Province. *Kifah: Journal of Community Service*, 2(2), 149–160.
- Situmorang, J. T. (2022). The role of subdistrict heads in addressing waste problems in Medan Baru Subdistrict, Medan City, North Sumatra Province (Doctoral dissertation, Institute of Domestic Governance).
- Slamet, J. S. (2011). *Kesehatan Lingkungan*. Yogyakarta: Gadjah Mada University Press.
- Sugiyono. (2020). *Quantitative, qualitative, and R&D research methods*. Bandung: Alfabeta.
- Swesda, B. (2012). *Waste Bank (Theoretical Study and Application)*. Yogyakarta: Pustaka Rimaha.
- University of North Sumatra. (2023). Processing waste, fostering hope: USU TPST builds a zero waste movement from campus. Retrieved from <https://www.usu.ac.id/id/berita/mengolah-sampah-menumbuhkan-harapan-tpst-usu-bangun-gerakan-zero-waste-dari-kampus>
- University of North Sumatra. (2023). USU and North Sumatra Provincial Government inaugurate integrated waste management facility. Retrieved from <https://www.usu.ac.id/id/berita/usu-bersama-pemprov-sumut-resmikan-tempat-pengolahan-sampah-terpadu>
- Yogiesti, V., Hariyani, S., & Sutikno, F. R. (2010). Community-based integrated waste management in Kediri City. *Journal of Urban and Regional Planning*, 2(2), 95–102.