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STRATEGY FOR IMPLEMENTING CIRCULAR ECONOMY IN WASTE MANAGEMENT IN THE COASTAL AREA OF LHOKNGA DISTRICT, ACEH BESAR REGENCY

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ABSTRACT

Waste management in the coastal area of Lhoknga District Aceh Besar Regency, still faces various challenges, both technical and non-technical. Waste is generally disposed of without segregation, openly burned, or directly discharged into the environment without adequate treatment. This study aims to analyze the existing conditions of solid waste management, map material flows within the waste management system, and formulate strategies for implementing a circular economy approach using SWOT analysis. The methods employed include field observations, waste generation measurements, and in-depth interviews with local residents. The results indicate that household activities are the dominant source of waste generation, with the largest composition consisting of organic waste, particularly coconut waste with a generation rate of 0.061 kg/person/day and food waste amounting to 0.072 kg/person/day. The application of the 9R principles by the community remains limited and is primarily confined to reuse, recycle, and recovery practices. Based on the SWOT analysis, the waste management strategy is positioned in Quadrant I, indicating a favorable condition characterized by strong internal capacities and significant external opportunities. The recommended strategies emphasize an aggressive growth approach through the establishment of Waste Collecting Points (WCPs), the development of educational tourism initiatives, and the strengthening of local partnerships. This approach integrates material flow analysis with strategic assessment at the local level and is expected to support sustainable coastal waste management based on circular economy principles.

Keywords : Circular economy, Coastal waste management, 9R, SWOT, Lhoknga Sub-district

ABSTRAK

Pengelolaan sampah di kawasan pesisir Kecamatan Lhoknga Kabupaten Aceh Besar masih menghadapi berbagai kendala baik dari aspek teknis maupun nonteknis. Sampah umumnya dibuang tanpa pemilahan, dibakar, atau dibuang langsung ke lingkungan tanpa pengolahan yang memadai. Penelitian ini bertujuan untuk menganalisis kondisi eksisting pengelolaan sampah, memetakan aliran material pengelolaan sampah, serta merumuskan strategi penerapan ekonomi sirkular menggunakan pendekatan analisis SWOT. Metode yang digunakan meliputi observasi lapangan, pengukuran timbulan sampah, dan wawancara mendalam dengan masyarakat. Hasil penelitian menunjukkan bahwa jenis sampah paling dominan berasal dari rumah tangga, dengan komposisi terbesar berupa sampah organik seperti kelapa yang memiliki

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timbulan sampah sebesar 0,061 kg/ orang/ hari dan sampah sisa makanan yang berjumlah 0,072 kg/orang/hari. Penerapan prinsip 9R oleh masyarakat masih terbatas pada aspek reuse, recycle, dan recovery. Berdasarkan analisis SWOT, strategi pengelolaan sampah berada pada Kuadran I yang menunjukkan posisi menguntungkan dengan kekuatan internal dan peluang eksternal yang tinggi. Strategi yang direkomendasikan berfokus pada pendekatan pertumbuhan agresif melalui pembangunan Waste Collecting Point (WCP), pengembangan wisata edukasi, serta penguatan kemitraan lokal. Pendekatan ini disusun dengan mengintegrasikan analisis aliran material dan penilaian strategis pada tingkat komunitas, sehingga diharapkan mampu mendukung pengelolaan sampah pesisir yang berkelanjutan berbasis ekonomi sirkular.

Kata kunci : *Ekonomi sirkular, Pengelolaan sampah pesisir, 9R, SWOT, Kecamatan Lhoknga*

Introduction

Waste management remains a complex environmental issue in many regions of Indonesia, including coastal areas. High levels of community and tourism activities have led to an increase in waste generation, while management capacity remains limited. This situation also occurs in the coastal area of Lhoknga Sub-district, Aceh Besar Regency, where most waste is disposed of without prior sorting, burned in open spaces, or directly dumped into the environment without proper treatment. These practices have resulted in environmental impacts including pollution, reduce aesthetic quality, and potential health risks to the local community.

According to data from the National Waste Management Information System (SIPSN, 2023), total waste generation in Aceh Besar Regency reached 148.09 tons per day in 2023, of which approximately 80% was organic waste. This condition highlights the need for a waste management system that not only focuses on collection and disposal but also promotes economic value creation and environmental sustainability.

One relevant approach to addressing these challenges is the circular economy. According to MacArthur (2013), the circular economy is an economic system or model that aims to maintain the value of products, materials, and resources within the economy for as long as possible, thereby preventing social and environmental degradation caused by the linear economic model. This concept emphasizes efforts to retain the value of resources, products, and materials through the implementation of the 9R strategies — Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (Bappenas, 2022). Unlike the linear economy, which focuses solely on production, consumption, and disposal, the circular economy highlights material recirculation and resource efficiency (Kirchher et al., 2017).

In the context of coastal waste management, implementaing the 9R principles has the potential to reduce waste volumes, create new employment opportunities, and strengthen locally based economic activities (Kristianto & Nadapdap, 2021). Several previous studies have shown that implementing a circular economy at the community level is effective in reducing waste generation while enhancing environmental awareness. However, to date, the application of this concept in coastal areas of Aceh remains limited and has not been systematically integrated (Setyawan et al., 2024). Although numerous studies have examined the application of the circular economy in solid waste management, most have focused on urban areas or have remained

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conceptual and policy-oriented. Research specifically addressing circular-economy–based waste management in coastal areas under tourism-related pressures remains limited. In addition, studies that integrate quantitative material flow analysis with the formulation of practical, locally applicable strategies are still scarce. Therefore, further research is needed that not only maps waste generation and material flows but also links them to contextual and implementable circular economy strategies that reflect the social, economic, and environmental conditions of coastal regions.

This study aims to analyze the existing conditions of solid waste management in the coastal area of Lhoknga District, identify material flows and the recycling potential within the waste management system, and formulate strategies for implementing a circular economy approach using SWOT analysis. The findings of this study are expected to serve as a reference for local governments and communities in developing sustainable, circular economy–based coastal waste management systems.

Methods

This study was conducted in Lhoknga District, Aceh Besar Regency, which covers an area of 87.95 km² and is located at 5°24′14.00″–5°31′55.00″ N latitude and 95°11′30.00″–95°19′40.00″ E longitude. Lhoknga District is bordered by Peukan Bada District to the north, Leupung District to the south, the Indian Ocean to the west, and Darul Imarah and Simpang Tiga districts to the east. The research specifically focused on the coastal area of Lhoknga District, encompassing Mon Ikeun, Meunasah Lambaro, and Meunasah Balee villages, with a total area of 36.99 km² and a population of 2.613 residents.

This study adopts a mixed-methods approach that integrates quantitative and qualitative methods. The quantitative approach is applied to analyze material flows within the waste management system, while the qualitative approach is employed to formulate circular economy implementation strategies through SWOT analysis.

To determine the existing condition of waste management, field observations were conducted in each of the study villages. The observations covered both technical aspects (such as waste storage, collection, transportation, and processing) and non-technical aspects (including institutional arrangements, financing, regulations, and community participation). The data obtained from the observations were then analyzed using a fishbone diagram (cause-and-effect diagram) to identify the root causes of the main problems in coastal waste management in Lhoknga district.

The Material Flow Analysis (MFA) was conducted based on data from measurements of waste generation and the composition of household and household-like waste in the three study villages. The sampling technique employed Stratified Random Sampling, which categorizes samples by household income level (high, medium, and low). This approach follows the Indonesian National Standard (SNI 19-3964-1994, 1994), on procedures for sampling and measuring the quantity and composition of municipal solid waste, which specifies that sampling was conducted for 8 consecutive days at the same locations. Waste composition was determined by weighing the total waste generation and sorting it into predefined material categories, including food waste, coconut waste, yard waste, paper, plastics (HDPE, LDPE, PET), textiles, metals, glass, rubber, and other residues. The measurement results

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were used to determine the proportion of each waste type and its recovery potential. After obtaining data on waste generation and composition from all study villages, several analyses were conducted to identify the characteristics of waste generation, including waste weight (kg), volume (m^3), generation rate (kg/L/person/day), composition, population projection, waste generation projection, and recovery factor (%).

To formulate strategies for implementing the circular economy, in-depth interviews were conducted with key informants including village officials, community leaders, business actors, and local residents involved in waste management. The selection of informants employed a purposive sampling technique combined with snowball sampling, in which initial respondents recommended other relevant participants. The interviews aimed to identify internal and external factors influencing coastal waste management within the circular economy framework. The qualitative data obtained were then analyzed using a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. Internal factors (strengths and weaknesses) and external factors (opportunities and threats) were organized into a SWOT matrix to determine the strategic position of waste management (Cipta & Hatamar, 2020). The results of this analysis were used to formulate alternative strategies for implementing the circular economy that are tailored to the socio-economic and environmental conditions of coastal communities in Lhoknga District.

Result and Discussion

1. Existing Condition of Waste Management

Field observations revealed that the waste management system in the coastal area of Lhoknga District, Aceh Besar Regency, has not been functioning optimally in both technical and non-technical aspects. Based on the fishbone analysis, four main factors were identified as influencing waste management issues in the coastal area, namely waste sources, waste management methods, human resources (HR), and facilities and infrastructure.

Figure 1. Open Dumping of Mixed Waste in the Coastal Area of Lhoknga District.

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Regarding waste source-related issues, the largest waste generation stems from household activities and culinary businesses in the coastal tourism area. The waste generated is dominated by food waste (0.072 kg/person/day) and coconut shell waste (0.061 kg/person/day). Meanwhile, the inorganic fraction is primarily composed of single-use LDPE plastics, with a generation rate of 0.008 kg/person/day. Increased tourism activities further contribute to the rise in inorganic waste generation, while source-based waste management remains suboptimal due to the absence of segregation practices.

Based on field conditions, waste management methods have not been well structured. Most residents continue to burn waste or dispose of it in open areas and along the coastal zone. Waste collection and transportation are not carried out regularly due to the absence of fixed schedules and dedicated personnel. Waste treatment efforts, such as composting and recycling, remain very limited and are conducted only on an incidental basis.

Figure 2. Solid Waste Scattered In Open Areas Of The Lhoknga Coastal Region.

From the perspective of human resources and policy, the main problems include limited public knowledge and participation in waste management, as well as weak coordination between local authorities and the community. Moreover, the absence of an organizational structure at the village level specifically responsible for waste management has led in unclear roles and responsibilities. Operational funding for waste management activities is also constrained, while Corporate Social Responsibility (CSR) programs from PT Solusi Bangun Andalas (SBA), which are expected to support environmental initiatives, have not been evenly distributed across all coastal villages in Lhoknga.

From the perspective of facilities and infrastructure, waste management in the coastal area of Lhoknga faces significant limitations in terms of supporting equipment and infrastructure. Although household-level waste containers are available, there is no segregation system between organic and inorganic waste. Furthermore, the subsystem for waste collection has not been established, resulting in

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irregular waste transportation. The area also lacks waste-processing machinery and collection vehicles, leaving most waste to be managed independently by residents. Additionally, Temporary Disposal Sites (TPS) are unevenly distributed across villages, hindering the effectiveness and comprehensiveness of waste management in the coastal region.

2. Material Flow Analysis of Waste Management

Based on Table 1, the types of waste in the coastal area of Lhoknga District consist of organic waste (coconut waste, food waste, and yard waste) and inorganic waste (PET, LDPE, and HDPE plastics, glass, paper, metals, and residual waste). The Recovery Factor (RF) is a parameter used to determine the percentage of each waste component that is potentially recoverable, with the remaining fraction classified as residual waste requiring final disposal or further treatment. A higher Recovery Factor (RF) value indicates greater potential for material recovery. The analysis shows that organic waste components, such as coconut waste, food waste, and yard waste, have an RF value of 80%, whereas inorganic waste components including PET plastics, paper, and metals have an RF value of 50%. Residual waste has no recovery potential and represents the final fraction requiring further management.

Table 1. Recovery Factor Value

No	Waste Composition	*Recovery Factor* (%)	Waste Generation Kg /d	Waste Generation L/d	Rf (T1)	RF (T2)
1	Organic Waste					
	Coconut Waste	80%	0,061	3,892	127,8	8.135,9
	Food Waste	80%	0,072	0,109	151,3	226,9
	Yard Waste	80%	0,006	0,030	12,3	63,7
2	Inorganic Waste					
	PET Plastic	50%	0,000	0,007	0,25	8,99
	LDPE Plastic	96%	0,008	0,122	21,08	304,8
	HDPE Plastik	90%	0,000	0,004	0,531	8,533
	Glass	65%	0,001	0,004	2,11	6,19
	Paper/Cardboard	50%	0,001	0,021	1,58	27,83
	Cans/Metal	50%	0,000	0,007	0,47	9,64
3	Residual Waste	0%	0,009	0,054	0	0

The results of the Material Flow Analysis (MFA) indicate that organic waste is processed through composting to produce compost fertilizer (R8 – Recycle and R9 – Recovery), while coconut waste is utilized to produce cocopeat and cocofiber (R6 – Remanufacture and R8 – Recycle). For the inorganic fraction, PET and LDPE plastics are shredded into plastic pellets, whereas HDPE is converted into new products (R6–R7–R8). Other materials, such as glass, paper, and metal, are compacted before being sold for recycling. The entire material flow process ultimately aligns with the R1 – Rethink principle, emphasizing that the success of waste management depends not only on technological interventions but also on

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behavioral change and public perception toward waste. A detailed schematic of the material flow in waste management is presented in Figure 3.

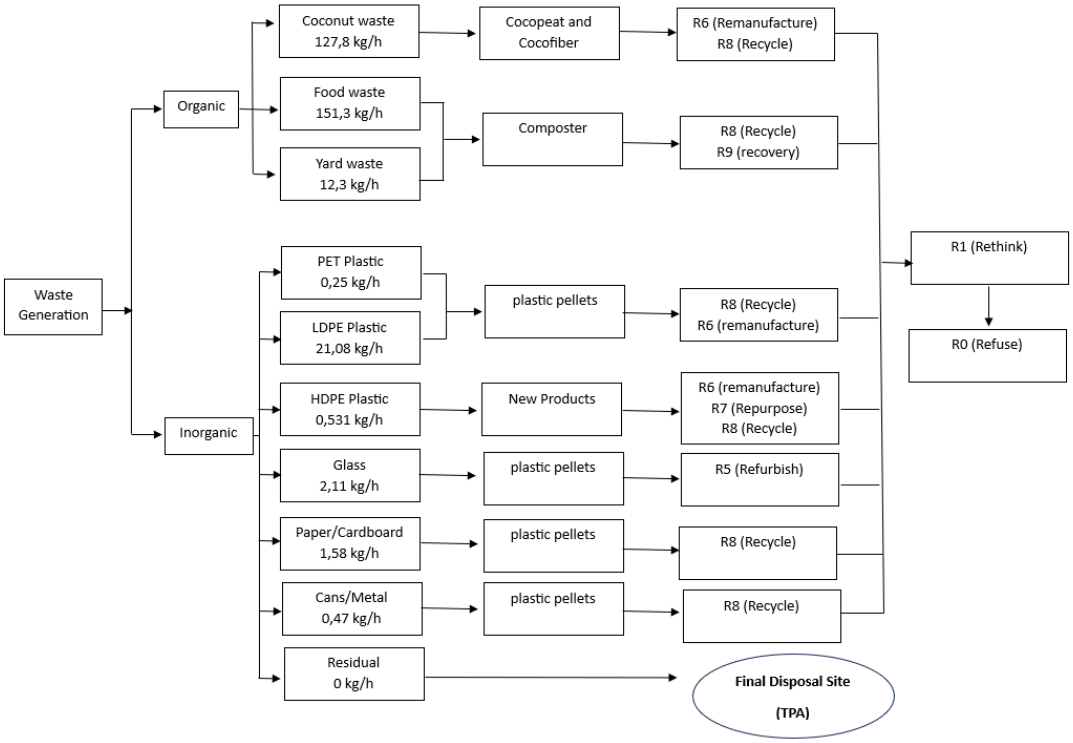

Figure 3. Material Flow Diagram of Waste Management

3. SWOT Analysis of Circular Economy Implementation

SWOT analysis was conducted to identify internal and external factors influencing the implementation of a circular economy in solid waste management in the coastal area of Lhoknga District. Each factor in the SWOT analysis was assigned a weight and a rating using a scale of 1–4 to assess its level of influence on the waste management system. The weight reflects the relative importance of each factor, while the rating indicates the extent to which the factor supports or constrains the implementation of a circular economy. The resulting weighted scores were then used to determine the strategic position coordinates (X- and Y-axes) within the SWOT quadrant diagram.

Table 2. Internal Variables of Waste Management

No	Internal Factors	Rating	Weight	Rating ×Weight
STRENGTHS				
1	Most of the community participates in collective activities such as gotong royong (R1)	3,8	5,47	20,786
2	Most residents have practiced waste segregation between organic and inorganic waste (R1)	2,6	3,73	9,698

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3	Many people have started to reuse materials or goods (R3)	2,7	3,88	10,476
4	A large portion of the community already has the initiative to repair, refurbish, and remanufacture items (R4, R5, R6)	2,5	3,59	8,975
5	Several community members take the initiative to repurpose and recycle materials (R7, R8)	3,0	4,31	12,93
6	Some residents are involved in composting practices (R9)	2,8	4,02	11,256
TOTAL				**74,121**
WEAKNESS				
1	Vendors still rely heavily on single-use plastic packaging (R0)	1,9	3,93	7,467
2	Awareness does not yet align with daily practice (people know but have not changed consumption patterns) (R1)	2,8	5,78	16.184
3	Not all residents possess the technical skills to repair, refurbish, and remanufacture items (R4, R5, R6)	2,6	5,37	13,962
4	Lack of strict regulations on single-use plastic restrictions and waste management	1,2	2,48	2,976
5	Limited equipment and facilities	2,6	5,37	13,962
6	Insufficient training on waste management	1,0	2,07	2,07
TOTAL				**56,621**

A SWOT matrix was applied to formulate preferred strategic scenarios because it enables the optimal exploitation of strengths and opportunities while minimizing identified weaknesses and threats in coastal waste management in Lhoknga. The formulation of primary preference scenarios combines variables with the highest and lowest scores. Table 3 presents the weighted preference scores for each variable, and Table 4 provides the evaluation of the weighted preference scenarios.

Table 3. Weight Scores of SWOT Factors

No	Strategy	Weightes Score
1	*Strengths* (S)	74,121
2	*Weakness* (W)	56,621
3	*Opportunities* (O)	88,081
4	*Threats* (T)	24,167

Table 4. Weight Scores of SWOT Strategic Combinations

No	Strategy	Weightes Score
1	*Strengths* (S)+ *Opportunities* (O)	74,121+88,081= 162,202
2	*Strenght* (S)+ Threats (T)	74,121+ 24,167= 98,288
3	*Weakness* (W)+ *Opportunities* (O)	56,621+ 88,081= 144,702
4	*Weakness* (W)+ *Threats* (T)	56,621+24,167= 80,788

Based on the calculation result, the estimated weighted preference value for the Strength-Opportunity (S-O) strategy is 162,202. This value is then applied to

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determine the preferred strategic approach for implementing the circular economy in coastal waste management within Lhoknga District.

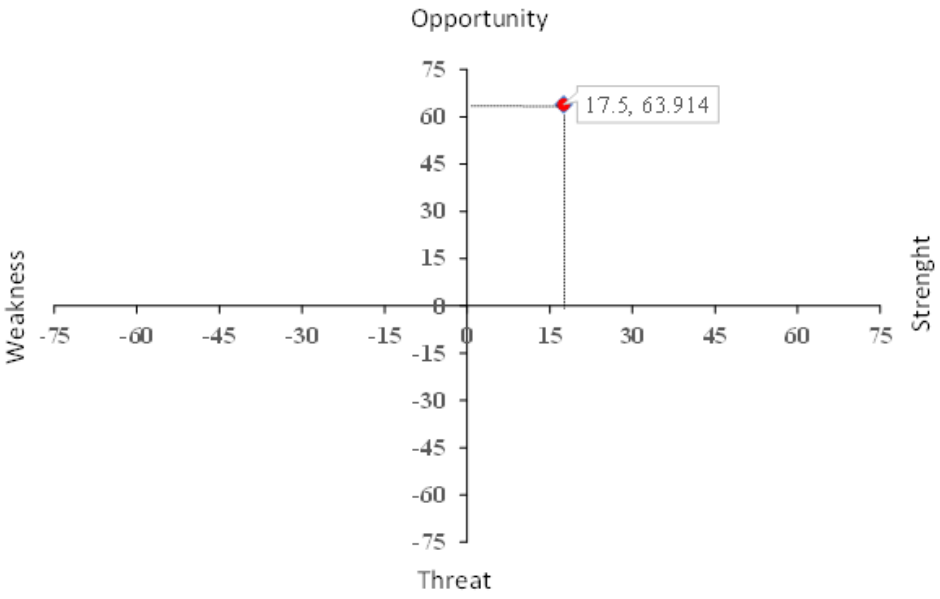

Figure 4. Quadrant SWOT

X Axis = Weight of Strenght- Weight of Weakness…….....(1)
= 74,121- 56,621
= 17,5
Y Axis = Weight of Opportunities –Weight of Threat …….....(2)
= 88,081- 24,167
= 63,914

The results of the analysis presented in Figure 2 show that waste management in the coastal area of Lhoknga District is positioned in Quadrant I, based on the calculated X and Y axis coordinates. This position represents a positive condition, characterized by both strong internal capabilities and significant external opportunities. It indicates that the coastal area has substantial potential to develop a circular economy–based waste management system.

The recommended strategy falls under the growth-oriented (aggressive) category, focusing on leveraging external opportunities through the strengthening of internal factors (Rimantho et al., 2022). This approach can be realized by optimizing the residual value of products and establishing local industrial symbiosis, where waste is processed into new raw materials through collaboration among businesses, communities, and institutions. Such strategies are directed toward supporting sustainable development through the gradual and adaptive implementation of circular economy programs aligned with the characteristics of coastal communities.

Based on the results of the SWOT analysis, the most relevant strategy to be implemented under these conditions is the Strengths–Opportunities (S–O) strategy. This strategy emphasizes the utilization of internal community strengths to capitalize

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on existing external opportunities. Its implementation can be realized through the development of Waste Collecting Points (WCPs) that actively involve community participation in collective waste management. Additionally, the development of educational tourism and handicraft products made from recycled materials can enhance local skills in the processes of reuse and recycling. Collaboration with external companies is also encouraged to strengthen the implementation of a locally driven circular economy. Furthermore, the waste collection fee system can be optimized through participation-based incentive schemes, aimed at increasing community awareness and engagement in sustainable waste management practices.

Through this strategy, the community is not only positioned as the executor of waste management activities but also as an integral part of the circular economy value chain. Educational and collaborative initiatives such as recycling training, compost processing, and innovation of waste-based products can create new economic opportunities for coastal residents. This approach also fosters stronger environmental awareness and enhances social solidarity among community members through collective actions in managing local resources. Consequently, waste management is perceived not merely as an environmental obligation but also as an instrument for improving the community's economic well-being.

Conclusion

Waste management in the coastal area of Lhoknga District, Aceh Besar Regency, has not yet operated optimally due to limited infrastructure, low public awareness, and the absence of waste management institutions at the village level. Results of the Material Flow Analysis (MFA) indicate that waste generation is dominated by organic waste and plastics, particularly food waste (151.3 kg/day), coconut shell waste (127.8 kg/day), and LDPE plastic (21.08 kg/day), which have considerable recovery potential, with Recovery Factor (RF) values of 80% for organic waste and 50% for inorganic waste. However, this potential has not been fully utilized due to the lack of waste segregation at the source.

Based on the Material Flow Analysis (MFA) results, the majority of waste generation is dominated by organic waste and plastics, which have high potential for recovery through reuse, recycling, and recovery activities. However, limited facilities and the lack of waste segregation practices among residents result in most waste still ending up as residuals.

SWOT analysis results indicate that waste management in the coastal area of Lhoknga District is positioned in Quadrant I (aggressive growth), suggesting that the potential for circular economy development is highly favorable. The recommended strategies include establishing Waste Collecting Points (WCPs) at the village level, developing educational tourism and recycling-based handicrafts, strengthening cross-sectoral partnerships, and implementing a participation-based waste retribution system. Implementation of these strategies is expected to reduce the volume of waste ending up as residuals by approximately 30–50%, increase the recovery of economically valuable materials, and potentially create new employment opportunities in the waste management and resource recovery sectors.

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