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Supply Chain Performance Measurement and Determination of Improvement Priorities Using the Supply Chain Operations Reference – Digital Standard (SCOR DS) and Analytic Network Process (ANP) Methods (Case Study: Waste Management at Sendangsari)

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Abstract

Effective and efficient waste management remains a key challenge in supporting environmental sustainability at the regional level. This study was conducted at the Sendangsari Integrated Waste Management Site (TPST), located in Sleman, Yogyakarta. The aim of the research is to measure the performance of the waste processing supply chain and to determine the priority areas for improvement. The method used is the Supply Chain Operations Reference – Digital Standard (SCOR DS) approach to identify and categorize performance indicators based on six core processes: Plan, Order, Source, Transform, Fulfill, and Return. The Analytic Network Process (ANP) method is employed to assign weights to 18 Key Performance Indicators (KPIs) based on their level of influence and interrelation. These weights are then applied using the Objective Matrix (OMAX) method to calculate the performance scores for each indicator, which are subsequently classified using the Traffic Light System (TLS). The results show that TPST Sendangsari achieved an overall performance score of 7, with 9 KPIs falling in the green category, 7 in yellow, and 2 in red. These findings indicate that TPST Sendangsari requires further evaluation and improvement efforts, particularly for KPIs in the red and yellow categories, to enhance its overall performance.

Keywords: Supply Chain, SCOR Digital Standard, ANP, OMAX, TLS, Waste Management at Sendangsari, Performance, Waste Processing

INTRODUCTION

The waste problem in Indonesia, particularly in the Special Region of Yogyakarta (DIY), has become increasingly complex due to population growth and rising economic activity (Sayrani & Tamunu, 2020). Sleman Regency holds the highest population in the region, with 1.176.000 residents out of the total 3.667.406. This large population directly contributes to the increasing volume of waste generated on a daily basis. Waste generated from human, animal, and natural activities contribute significantly to the accumulation of waste in temporary disposal sites (TPS) and final disposal sites (TPA). The continuous population growth and increasingly diverse human activities have led to a substantial rise in waste volume, which when combined with limited land availability poses a significant challenge for waste management, particularly in urban areas (Purnama & Ciptomulyono, 2011).

According to Law No. 18 of 2008, waste is defined as solid or semi-solid residue resulting from natural processes or human activities, comprising both organic and inorganic materials. In 2023, Sleman's waste production reached 706–738 tons per day. Although it decreased to 330 tons per day in 2024, the volume remains significantly high. Approximately 60% of the waste is organic, which, if not properly managed, can lead to serious environmental pollution and public health issues (Prihantini et al., 2024). Before the closure of the Piyungan Final Disposal Site (TPA), Sleman Regency was the largest contributor of waste to the facility from January to June 2023. Following the operational restrictions imposed on the landfill, Sleman has faced significant challenges in managing its waste, as it relies on only two active Integrated Waste Processing Facilities (TPSTs): TPST Sendangsari and TPST Tamanmartani. These challenges are further exacerbated by high waste volumes driven by consumption patterns, combined with limited resources, constrained operational capacity, and persistent issues related to economic, social, and technological factors.

As one of the two active TPSTs in Sleman, TPST Sendangsari experiences various operational obstacles, including imbalanced waste collection, limited processing capacity, and inadequate facilities for storing Refuse-Derived Fuel (RDF). This study focuses on analyzing the waste supply chain flow at TPST Sendangsari, particularly the supply of waste from local collection depots.

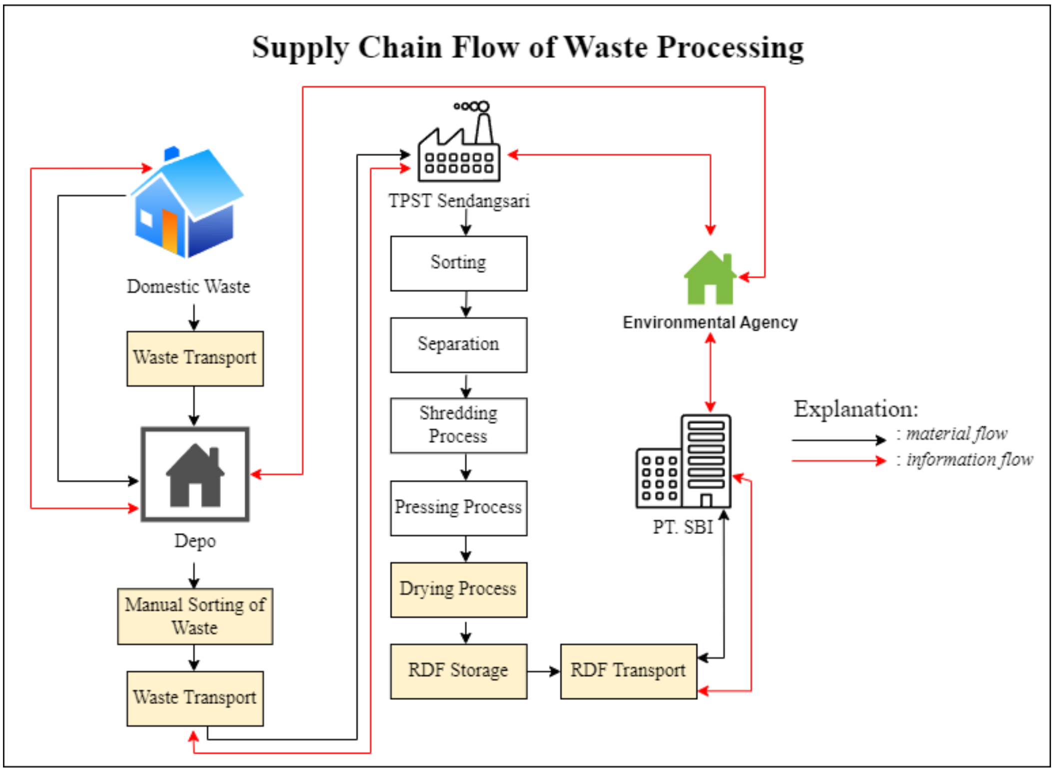

Figure 1. Supply Chain Flow of Waste Processing at TPST Sendangsari

Figure 1 illustrates the Supply Chain Flow of Waste Processing at TPST Sendangsari. The waste processing begins with centralized planning conducted by the Sleman Regency Environmental Agency (DLH). This is followed by the collection and preliminary sorting of household waste at individual depots, where waste is separated into organic and inorganic categories. The sorted waste is then transported to the TPST for further processing. However, throughout its operational period, TPST Sendangsari has not implemented a comprehensive performance assessment of its supply chain. Several stages within the process indicate potential inefficiencies, such as delays in transportation from households to depots due to limited vehicle availability and inconsistencies in delivery schedules from depots to the TPST. Additionally, suboptimal drying processes result in Refuse-Derived Fuel (RDF) with excessive moisture content, thereby reducing its quality. RDF storage is also limited to an area of only 200 m², while the average monthly volume of residue processed reaches approximately 723.5 tons.

The gap between the volume of RDF produced and the available storage capacity poses a risk of accumulation, which can be further exacerbated if deliveries to industrial partners, such as PT. Solusi Bangun Indonesia (SBI), are delayed due to coordination and logistical constraints. Based on these issues, further research is needed on the waste supply chain management process. Supply chain performance measurement is crucial for identifying areas that require improvement and enhancing operational effectiveness. There are three types of flows in the supply chain: the product flow, which moves downstream; the financial flow, which moves upstream; and the information flow, which moves bidirectionally between both ends of the supply chain (Yuliesti et al., 2020). The supply chain is a network of businesses working together, both directly and indirectly, to meet customer demand. Its primary operations include the procurement of raw materials, their transformation during production into semi-finished and finished goods, and the delivery of these finished goods to the end customer (Pujawan & Geraldin, 2009).

The Supply Chain Operation Reference Digital Standard (SCOR DS) approach is utilized in this study to comprehensively and systematically measure and evaluate supply chain performance at TPST Sendangsari. SCOR DS offers a standardized framework that encompasses various supply chain aspects, including plan, order, source, transform, fulfill, and return. In addition, this study employs the Analytic Network Process (ANP), Objective Matrix (OMAX), and Traffic Light System (TLS) methods to identify and prioritize areas for improvement within the supply chain. These methods are integrated with digital platforms, data analytics, and other enabling technologies to support the development of a more effective, efficient, and sustainable waste management system.

Supply Chain Management

Supply Chain Management (SCM) is an integrated process encompassing material procurement, product transformation, and distribution to customers, including purchasing and outsourcing to strengthen relationships across the chain, ultimately aiming to enhance overall productivity by optimizing time, location, and material flow (Jodlbauer et al., 2023). Its effective integration involves coordinating and managing all upstream and downstream product, service, financial, and information flows of core business processes between a focal company and its key suppliers and customers, thereby enabling timely product development, cost minimization, and flexible manufacturing operations (Näslund & Hulthen, 2012).

Performance in Supply Chain

To improve business performance, performance measurement is a standard procedure used to evaluate the effectiveness and efficiency of an action. It plays a critical role in tracking performance, enhancing motivation and communication, diagnosing problems, and assessing the potential and success of implemented management strategies (Anisa et al., 2022). Performance measurement in supply chains aims to reduce operational costs, ensure customer satisfaction, and maximize profitability for the company (Frederico et al., 2021).

Supply Chain Operation Reference Digital Standard (SCOR DS) Method

SCOR DS is a model that provides methodologies, diagnostic tools, and benchmarking to help businesses significantly and rapidly improve their supply chain operations. In addition to offering a framework that supports supply chain analysis at various levels and assists organizations in adopting industry-standard best practices and metrics, the SCOR DS model aims to enhance supply chain performance by integrating business processes, metrics, best practices, and technology into a coordinated structure. SCOR DS consists of six core processes: plan, order, source, transform, fulfill, and return (ASCM, 2022).

Integrated Waste Processing Site (TPST)

TPST is a waste management facility that combines temporary storage and final processing (Firmansyah & Mirwan, 2022). TPST also functions as a centralized waste processing site with main activities including further processing of sorted waste, separation and processing of urban waste components, and improvement of recycled product quality. Additionally, TPST plays a role in sorting, cleaning, and shipping recycled waste materials, with its functions determined by its involvement in waste management, the types of components processed, the waste shipped, and how the final products are packaged and stored (Sahwan, 2018).

METHODS

This case study at TPST Sendangsari, Sleman, aimed to evaluate its waste management supply chain performance and identify improvement priorities. The research employed four integrated methods: SCOR DS for supply chain mapping and assessment; ANP for comprehensive multi-criteria decision making, accounting for factor interdependencies and enabling qualitative analysis (Taherdoost & Madanchian, 2023) which determined weighted criteria and sub-criteria using a ratio scale (Perdana & Ambarwati, 2012), OMAX to calculate KPI-based performance scores (Prakoso, 2022), and TLS for categorizing performance levels to aid interpretation and identify improvement areas.

Data collection involved observations, interviews (for primary data), and questionnaires, supplemented by secondary data from TPST/DLH Sleman archives and relevant literature. The SCOR DS model structured waste management into six processes (Plan, Order, Source, Transform, Fulfill, Return), forming 18 validated KPIs grouped under Reliability and Responsiveness. ANP, implemented with Super Decision software, weighted these KPIs across three hierarchical levels (goal, criteria, sub-criteria) using pairwise comparisons and consistency evaluations. OMAX then calculated final performance scores, which were classified into green, yellow, or red categories via TLS, pinpointing KPIs requiring targeted improvements.

RESULT AND DISCUSSION

This section presents the performance measurement results of TPST Sendangsari's waste management supply chain, analyzed using SCOR DS, ANP, OMAX, and TLS methods to classify performance levels. The discussion then highlights key insights, performance gaps, and proposed improvement priorities aligned with the research objectives.

Pairwise Comparison Analysis of KPI

KPI pairwise comparison data were collected from an interview with the Head of TPST Sendangsari, who is also part of UPTD DLH Sleman's Waste Management Division. This respondent was selected due to their direct operational responsibility and comprehensive field knowledge. The interview results were then processed using Super Decision software.

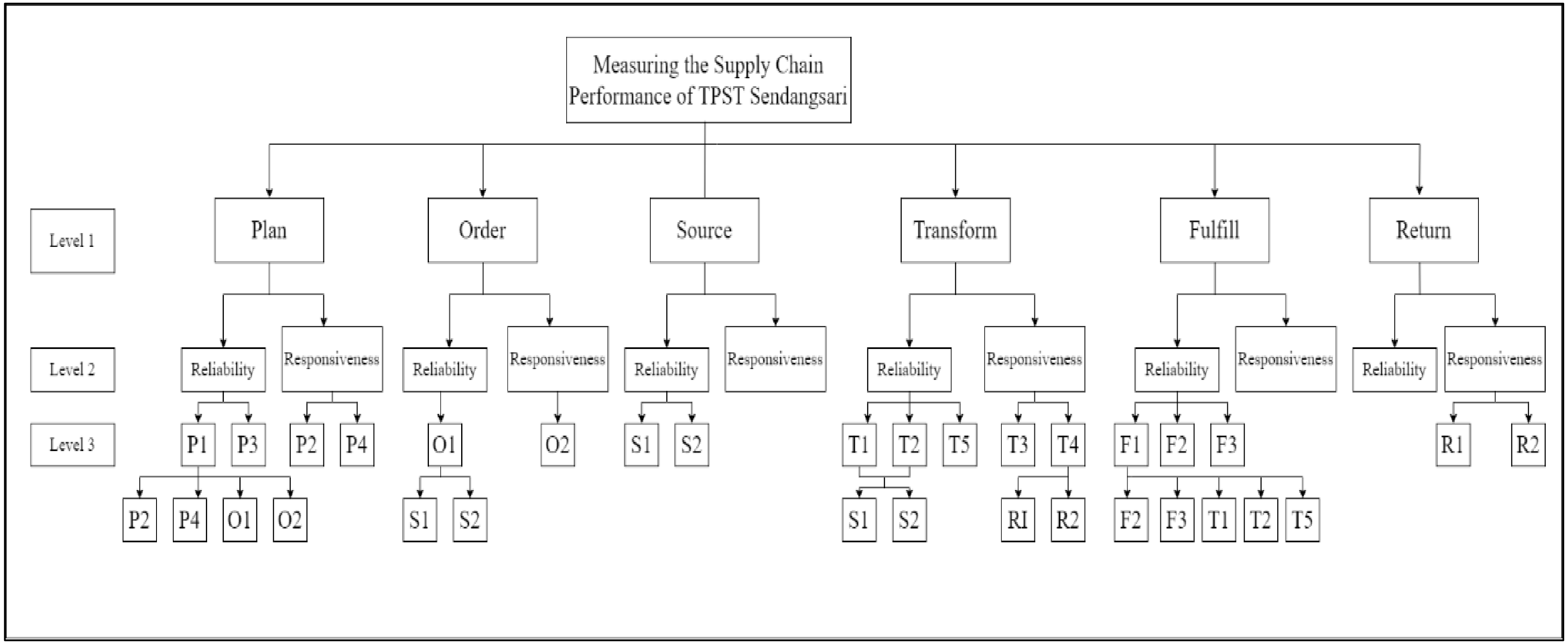

Figure 2. Hierarchical Structure

Figure 2 presents the hierarchical structure for supply chain performance measurement at TPST Sendangsari, developed based on the SCOR DS model, and illustrates that each waste management activity is interconnected within a dynamic and complex process. This SCOR DS based model was utilized to analyze and evaluate the overall supply chain performance of waste management activities at TPST Sendangsari. Following the interpretation of the ANP network, the subsequent step involved performing weighting based on interview data from the person in charge of TPST Sendangsari.

Table 1. Overall Weight Value

Perspective	Dimension	KPI	Perspective Weight	Dimension Weight	KPI Weight	Total Weight
Plan	Reliability	P1	0.12056	0.88889	0.67742	0.0726
		P3			0.32258	0.0346
	Responsiveness	P2		0.11111	0.63567	0.0085
		P4			0.36433	0.0049
Order	Reliability	O1	0.10831	0.66667	0.47853	0.0346
	Responsiveness	O2		0.33333	0.52147	0.0188
Source	Reliability	S1	0.1968	0.875	0.44464	0.0766
		S2			0.55536	0.0956
Transform	Reliability	T1	0.48179	0.88889	0.0476	0.0204
		T2			0.58815	0.2519
		T5			0.36425	0.156
	Responsiveness	T3		0.11111	0.56675	0.0303
		T4			0.43325	0.0232
Fulfill	Reliability	F1	0.04693	0.83333	0.17592	0.0069
		F2			0.10938	0.0043
		F3			0.7147	0.028
Return	Responsiveness	R1	0.04562	0.8	0.30295	0.0111
		R2			0.69705	0.0254

From Table 1, the perspective weights, dimension weights, and KPI weights were obtained from data processing using the Super Decision software with the SCOR DS matrix. The total weight calculation results from multiplying the perspective weight, dimension weight, and each KPI weight. This total weight value will be used to determine the overall Supply Chain performance of TPST Sendangsari.

Calculation Process Using the OMAX Method

Through the OMAX method, the value of each performance level is determined to identify the performance position of each indicator. The assessment results are then grouped into categories based on the TLS.

Table 2. OMAX Transform Calculation

KPI		T1	T2	T3	T4	T5
Performance		**95**	**1**	**99**	**8.3**	**140**
Level	**10**	100	1	100	100	70
	9	98.143	1.286	99.286	86.857	78.571
	8	96.286	1.571	98.571	73.714	87.143
	7	94.429	1.857	97.857	60.571	95.714
	6	92.571	2.143	97.143	47.429	104.286
	5	90.714	2.429	96.429	34.286	112.857
	4	88.857	2.714	95.714	21.143	121.429
	3	87	3	95	8	130
	2	74.667	35.333	83.333	5.333	120
	1	62.333	67.667	71.667	2.667	110
	0	50	100	60	0	100
Level		**7.3**	**10.0**	**9.0**	**3.0**	**1.78**
Weight		0.020385	0.25188	0.030339	0.023193	0.155993
Score		0.148811	3	0.273051	0.069579	0.277668

Based on Table 2, the results of the calculation using the OMAX method and the categorization based on TLS show that KPI T1 falls into the yellow zone with a score of 7.3. KPI T2 and T3 are categorized in the green zone with scores of 10 and 9, respectively. The red zone is assigned to KPI T4 and T5, with scores of 3 and 1.78. From these data, the highest score in the Transform process is achieved by KPI T2.

Supply Chain Performance Measurement Results

The next stage of this study conducts a comprehensive assessment of supply chain performance at TPST Sendangsari to evaluate the effectiveness and efficiency of its waste management system. Performance values are calculated by multiplying ANP weights, generated through Super Decision software, with performance scores obtained via the OMAX method. The final results, which integrate the ANP, OMAX, and TLS methods, are summarized in the following table.

Table 3. Results of Supply Chain Performance Measurement

No.	KPI Code	KPI Description	Result		
			Weight	Level	Value
1	P1	Percentage of waste collection and processing plans implemented according to schedule	0.072595	10.0	0.726
2	P3	The cost required to carry out the planning process; total planning costs related to waste collection and processing per unit volume.	0.034569	7.0	0.242
3	P2	Response time to adjust the processing plan in case of sudden changes in waste volume.	0.008515	10.0	0.0852
4	P4	Scheduling of meetings conducted by the Environmental Agency (DLH), depot, and TPST managers.	0.00488	5.3	0.0259
5	O1	Percentage of waste collection performed on time according to the planned schedule.	0.034553	6.5	0.2246
6	O2	Percentage of waste deliveries processed within the designated time frame.	0.018827	9.9	0.1864
7	S1	Percentage of procurement of waste transport equipment that meets specifications.	0.076567	6.5	0.4977
8	S2	Number of human resource trainings conducted in waste management.	0.095633	8.01	0.766
9	T1	Efficiency percentage of machine and equipment operational time in the waste processing system according to standards.	0.0204	7.3	0.1488
10	T2	Percentage of defective RDF products.	0.25188	10.0	3
11	T5	Measuring the fullness level of RDF storage capacity at the TPST.	0.156	1.78	0.2777
12	T3	Affects the level of public and consumer satisfaction with the products produced from organic and inorganic waste.	0.030339	9.0	0.2731

No.	KPI Code	KPI Description	Result		
			Weight	Level	Value
13	T4	Amount of residue processed into environmentally friendly fuel.	0.0232	3.0	0.0696
14	F1	Percentage of on-time delivery performance by the company.	0.00688	10.0	0.0688
15	F2	Time required to distribute products to consumers or users.	0.004278	10.0	0.0428
16	F3	Number of complaints from residents regarding waste management.	0.027951	6.28	0.1755
17	R1	Percentage of unprocessable waste returned to the community.	0.011056	6.5	0.0719
18	R2	Percentage of returned RDF products.	0.02544	10.0	0.2544
Total score of supply chain performance measurement					**7**

Based on the supply chain performance measurement presented in Table 3, it is shown that out of a total of 18 KPIs, 9 fall within the green zone category, 7 are categorized in the yellow zone, and 2 are in the red zone. The overall supply chain performance score is 7, which places it in the yellow zone category. This indicates that TPST Sendangsari is performing at a 'fair' level; however, its performance is not yet optimal or fully aligned with the intended targets. Therefore, evaluation and improvement efforts are necessary to enhance the overall effectiveness of the waste management supply chain performance.

CONCLUSION

This study aims to evaluate the performance of the waste management supply chain at TPST Sendangsari by employing the SCOR DS, ANP, OMAX, and TLS methods. The performance assessment resulted in an overall score of 7, indicating that the current management practices are relatively good, though not yet optimal. Of the 18 KPI analyzed, 2 fall within the red zone, 7 within the yellow zone, and 9 within the green zone. These findings reflect the presence of substantial opportunities for improvement across various operational dimensions.

Several improvement strategies have been proposed to address the underperforming indicators. These include the provision of RDF storage facilities and the implementation of a digital monitoring system, the addition of equipment and standard operating procedures for residue processing, the digitization of planning systems, and the enhancement of inter-agency coordination. In addition, technical recommendations were formulated to improve equipment efficiency, reduce odor-related complaints from the surrounding community, and increase public participation in waste sorting activities. These strategies are expected to enhance the efficiency, effectiveness, and sustainability of the waste management system at TPST Sendangsari.

Overall, the findings of this study underscore the importance of regular evaluation and continuous improvement within the waste management supply chain. The implementation of the proposed solutions may serve as a foundation for improving operational performance and provide a reference model for other TPST operating under similar conditions. Furthermore, this research opens the door for future methodological developments, particularly in optimizing facility layout (production layout) to improve space utilization and workflow efficiency in waste processing operations.

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