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Sustainable Layout Design Based on Integrated Systematic Layout Planning and TOPSIS: A Case Study

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ABSTRACT

This research applies the concept of sustainable layout in the manufacturing industry by incorporating social, environmental, and economic aspects in the production process. The main objective of this research is to design a sustainable layout for the plastic packaging manufacturing industry. The approach utilizes the TOPSIS method to select an Activity Relation Chart (ARC) integrated with a systematic Layout Planning procedure. A case study is presented on an industry that produces plastic packaging in Indonesia. The results show that the proposed sustainable layout design significantly reduces the material handling distance compared to the initial layout. These results confirm that the Systematic Layout Planning approach and TOPSIS method have great potential in designing layouts that integrate sustainable principles effectively in manufacturing environments.

1. Introduction

In today's world, protecting and improving the environment is a critical challenge amidst rampant pollution and resource depletion [1]. In the manufacturing sector, the need to design safer factories and reduce pollution impacts has become an important issue to be resolved [2-4]. This concept is known as "sustainability," which implies a responsibility to safeguard the needs of future generations by managing current resources [5]. The success of a sustainable approach involves three essential pillars: economy, environment, and society [6]. Among the efforts to realize sustainable manufacturing, the role of layout design is crucial. Designing a factory layout involves making long-term decisions, with changes potentially resulting in high adjustment costs [7]. However, a good layout long-term impacts industrial performance, even reducing waste and addressing environmental concerns.

Layout design significantly affects the efficiency of the production line, which is a significant factor in productivity [8]. An optimized layout arrangement is critical to ensuring smooth production [9]. The concept of effective layout focuses on the optimal utilization of production floor space to improve space quality and reduce material movement costs [10]. However, layout inaccuracies are often the cause of inefficient movement [11]. In designing a layout, all influential factors must be carefully taken into account [12]. In implementing a sustainable layout in the manufacturing industry,

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economic, environmental, and social aspects must be well integrated [13]. Based on these considerations, a sustainable approach is needed in designing the company's layout. It aims to create a sustainable industry that is efficient in terms of production and supports economic, environmental, and social aspects in a balanced manner. Thus, a sustainable layout is important in realizing a sustainable and productive industry.

Previous studies have proposed approaches to planning sustainable plant layouts. One of them is a framework that aims to improve the sustainability of factory systems through optimal layout design [14]. Other research focuses on developing sustainable layout design, specifically in the context of steel buildings, emphasizing the importance of considering energy consumption to optimize cost efficiency in the construction industry [15]. Researchers have developed a new heuristic approach to designing sustainable plant layouts, considering various sustainability factors [16]. Furthermore, some research focuses on dynamic facility layout planning as a sustainability strategy to minimize material handling costs, facility rearrangement, number of material handling devices, and budget constraints [17]. These are all crucial steps in realizing more sustainable and efficient plant layout planning.

In addition, studies involving the application of Systematic Layout Planning (SLP) in layout design have also been conducted. Previous case studies have indicated the practical significance of using SLP in improving productivity and space utilization in production units [18]. In this context, SLP has been successfully applied to various industrial sectors, including manufacturing and textiles, to redesign the layout of facilities based on the flow of production processes and optimize the utilization of existing resources [19, 20]. This approach is also recognized for its alignment with lean manufacturing principles and waste reduction efforts [9]. As such, SLP has proven to be a valuable tool in the industry for optimizing facility layouts and improving operational efficiency.

Although several studies have examined the application of SLP, one of the gaps is the limited in-depth exploration of the integration of sustainability concepts in the SLP methodology. In addition, attention to sustainability aspects in layout design with SLP procedures must be investigated. In sustainable layout design with SLP procedures, selecting an appropriate Activity Relation Chart (ARC) is very important because it can reflect the process flow and interaction of activities, identifying potential reductions in material movement distances and optimizing the use of resources. A more sustainable layout design can be planned by considering sustainability in the ARC. Therefore, proper selection of ARC can support the implementation of lean principles and reduce waste in line with the goal of sustainable layout design. Based on this description, this research combines the SLP method with Topsis to complete the sustainable layout design. This research tries to use the Topsis method to evaluate the selection of ARC alternatives with consideration of sustainability aspects. ARC is a procedure for assessing the proximity of facilities based on the degree of activity relationship [21, 22]. The use of the Topsis method in evaluating available ARCs from a sustainability perspective was inspired by research conducted by Durmusoglu [23]. The Topsis procedure has also been successfully applied to various industrial problems [24, 25].

The integration of SLP and Topsis procedures is also applied to industrial plastic packaging industries in Indonesia. So, this research makes a real contribution from two aspects: science and practical contribution. This research proposes an integration procedure that combines the SLP method with Topsis to solve sustainable layout design. This approach enables the effective use of both methods to produce layout solutions that are operationally efficient and consider sustainable aspects. This research applies the SLP-Topsis integration procedure in a real case in an industry that produces plastic packaging. Using this approach, the facility layout in the industry was re-planned with

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sustainable factors in mind. The results of this study are expected to provide practical guidance for similar industries in sustainably optimizing their layouts.

2. Methods

2.1 Proposed Method

This research proposes combining SLP and Topsis methods in designing a sustainable layout. In designing a sustainable layout with SLP and Topsis, the Topsis method is used to select the best ARC based on sustainable aspect criteria. The stages of designing a sustainable layout with SLP and Topsis are presented in Fig. 1.

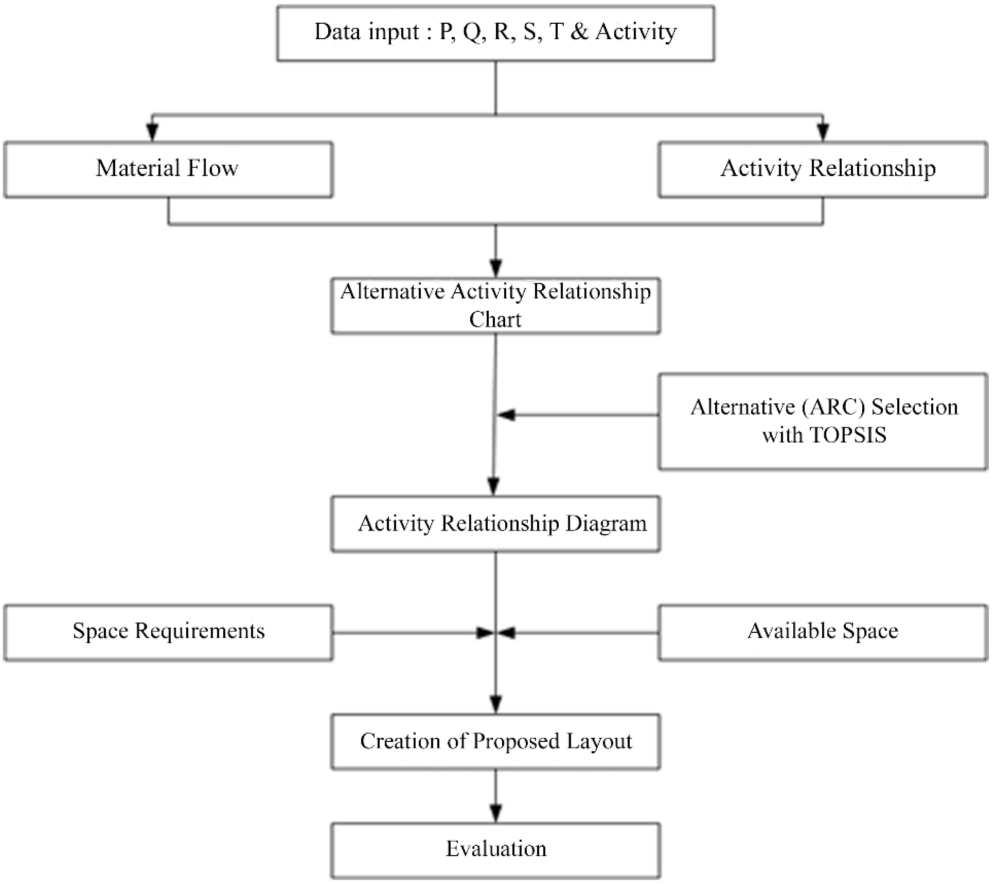

Fig. 1. Stages of SLP and Topsis

The SLP stage begins with data analysis of product (P), quantity (Q), routing (R), supporting (S), and time (T) in all production activities. The next stage is to identify material flow and create activity relations. Material flow identification can use an Operation Process Chart or Flow Chart. This stage aims to facilitate researchers in understanding some of the company's production processes, as well as knowing the movement or flow of materials that occur from raw materials to finished products [26].

The next step is to create several alternative ARCs. The value of the degree of closeness to the ARC is presented in Table 1. Each ARC alternative is assessed based on the Topsis procedure based on the ARC assessment criteria based on sustainability aspects. Each criterion of sustainability aspect in the ARC assessment is assessed based on a scale of 1 (very bad) - 5 (very good). Furthermore, each ARC (i) selection step in each criterion (j) is recorded as x_{ij}. After that, the scoring matrix is normalized using Equation

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(1). The next stage involves calculating the decision matrix weights for each criterion j, described in Equation (2). The criteria weight scale ranges from 1 (not important) to 5 (very important). The following process is determining the positive and negative ideal solutions described in Equations (3) and (4). The scoring for positive and negative ideal solutions considers the benefit criteria, with A^+ being based on the highest y_{ij} value.

Conversely, in the case of the cost criterion, A^- is calculated based on the lowest y_{ij} value. The value of A^- for the benefit criterion is determined from the lowest y_{ij} value, but in the case of the cost criterion, A^+ is taken from the largest y_{ij} value. The difference between each ARC's positive and negative ideal solution values is calculated through Equations (5) and (6). In the end, the preference value for each ARC is determined. At this stage, the preference of each ARC is calculated based on the ARC's positive and negative ideal solution distance. This preference value is used to rank the ARCs in rank order (C^+), according to Equation (7). Thus, the selected ARC is determined based on the highest C^+ value.

Table 1. Degree of proximity value

Value	Proximity
A	Absolutely necessary to bring a closer
E	Very important to be close
I	Important to be close
O	Sufficient / Ordinary
U	Not important
X	Not desire to be close

$$r_{ij} = \frac{xij}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \quad \text{with i = 1, 2, 3, . . . , m; and j = 1, 2, 3, . , , n} \tag{1}$$

$$v_{ij} = w_i r_{ij} \tag{2}$$

$$A^+ = (y_1^+, y_2^+, \dots \dots .\, y_n^+) \tag{3}$$

$$A^- = (y_1^-, y_2^-, \dots \dots .\, y_n^-) \tag{4}$$

$$S_i^+ = \sqrt{\textstyle\sum_j^n = 1\ \left(v_{ij} - v_j^+\right)^2} \tag{5}$$

$$S_i^- = \sqrt{\textstyle\sum_j^n = 1\ \left(v_{ij} - v_j^-\right)^2} \tag{6}$$

$$C_i^+ = \frac{S_i^-}{(S_i^- + S_I^+)}\ , 0 \le C_i^+ \le 1 \tag{7}$$

Based on the selected ARC, the next step is to create an Activity Relationship Diagram (ARD). The proposed new sustainable layout is based on ARC, ARD, which considers the space requirements and the available area. The last stage is evaluating the proposed sustainable layout by considering the distance of material transfer.

2.2 Data and Case Study

The research data is based on a case study of Indonesia's plastic packaging production industry. The area required in the production process is presented in Table 2. The production flow diagram is shown in Fig. 2. Furthermore, 3 experts were involved in designing ARC alternatives, determining ARC assessment criteria, and assessing each ARC. The ARC results of 3 alternatives are presented in Fig. 3, with proximity reasons presented in Table 3.

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Table 2. Production process area

Department	Code
Raw Material Warehouse	A
Dept. Printing	B
Dept. Drying	C
Dept. Cutting	D
Dept. Sealing	E
Dept. Finishing	F
Dept. Packaging	G
Plastic waste bin	H
Finished Product Warehouse	I

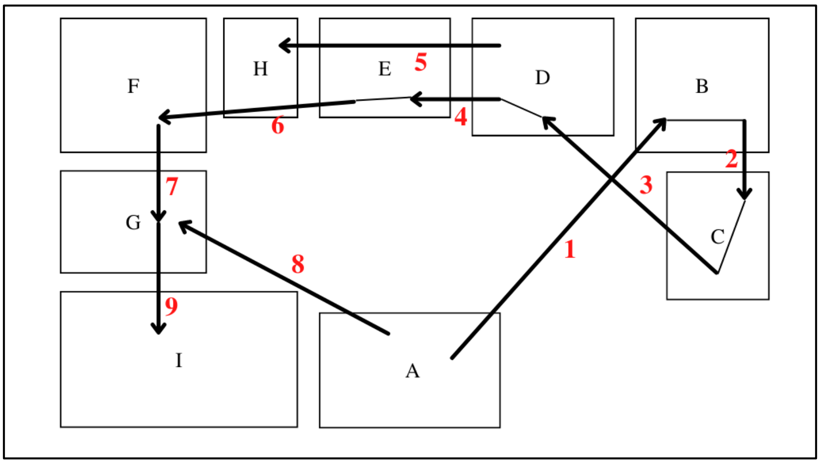

Fig. 2. Production flowchart

Table 3 Reason for proximity

Reason Codes	Reason Description
1	Shared use of documents.
2	Using the same workforce.
3	Using the same space area.
4	The degree of personnel contact is frequent
5	The degree of document contact is often done
6	Work flow sequence
7	Carrying out the same work activities
8	Using the same work equipment
9	Possibility of unpleasant odors, noise, etc.

Furthermore, 3 criteria were set by experts to assess ARC based on sustainable layout criteria, namely Manufacturing Efficiency (C1), Environmental Considerations (C2), and Safety (C3). The Manufacturing Efficiency (C1) criterion represents the economic dimension of the sustainability pillar. Meanwhile, Environmental Considerations (C2) and Safety (C3) represent the environmental and social dimensions of the sustainability pillar, respectively. The assessment of each ARC alternative on the criteria can be seen in Table 4. Meanwhile, the area of each production department can be seen in Table 5. In addition, Table 6 show Importance value of each criterion.

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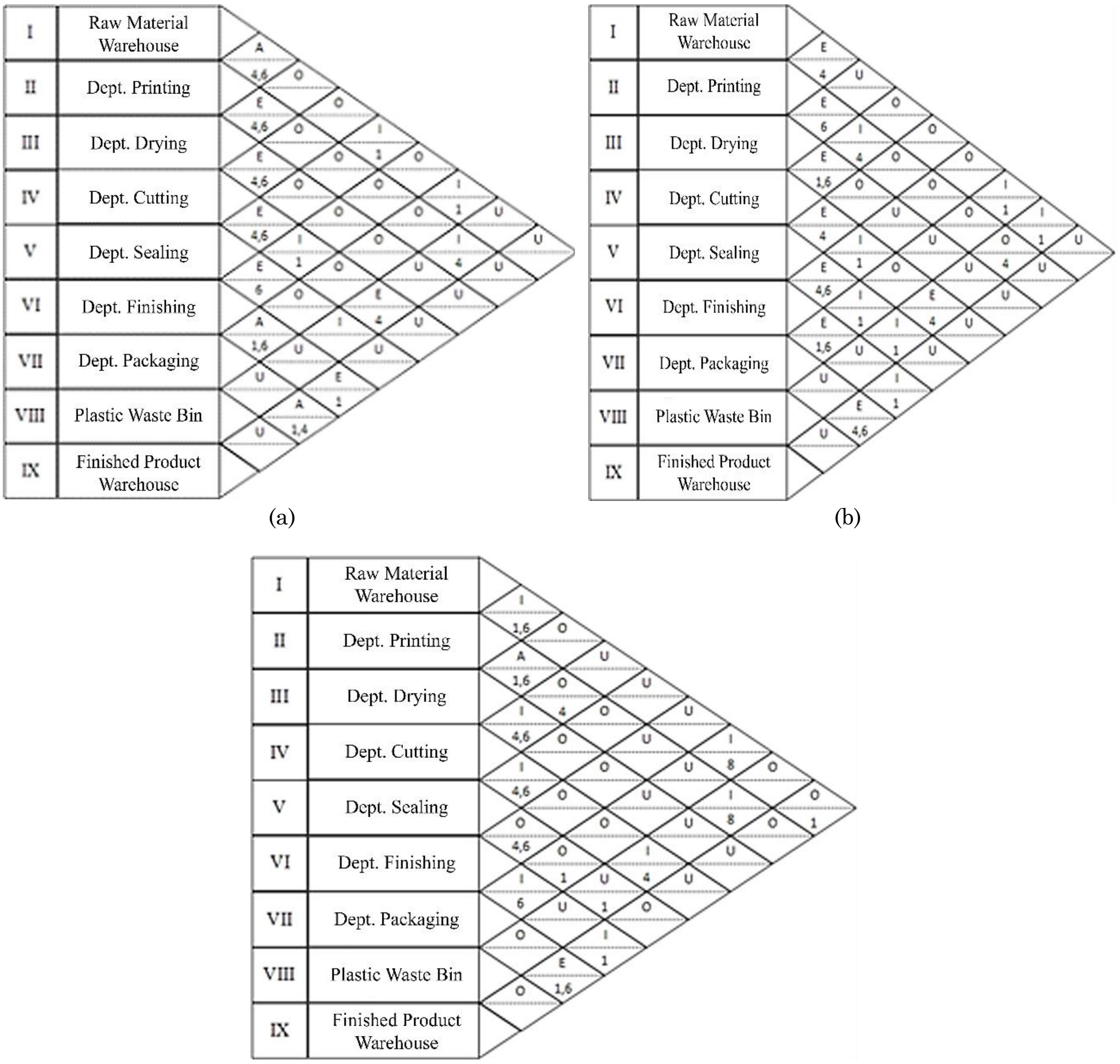

(a) (b) (c)

Fig. 3. (a) ARC Alternative 1, (b) ARC Alternative 2, and (c). ARC Alternative 3

Table 4. Assessment of each ARC alternative on criteria

Criteria	Alternative Assessments		
	ARC 1	ARC 2	ARC 3
Manufacturing Efficiency (C1)	5	4	3
Environmental Considerations (C2)	4	3	4
Safety (C3)	5	4	4

3. Results and Discussion

3.1 Proposed Sustainable Layout

The results show that the Manufacturing Efficiency criterion (C1) which represents the economic dimension has the highest level of importance followed by the Environmental

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Consideration criterion (C2) which represents the environmental dimension and Safety (C3) which represents the social dimension.

Manufacturing Efficiency Considerations (C1) ranked highest in importance, emphasizing the urgency of economic aspects in sustainable layout design. Efficiency in the manufacturing process not only helps reduce production costs but also has the potential to increase overall productivity [27]. Many businesses have started to take important steps towards sustainable manufacturing [28]. Sustainable manufacturing is the creation of products manufactured through economical and environmentally friendly processes that minimize negative environmental impacts while conserving energy and natural resources. Sustainable manufacturing also improves the safety of employees, communities, and products [29].

Table 5. Area of each department

No.	Room / Department	Code	Lenght (m)	Width (m)	Area (m^2)
1	Raw Material Warehouse	A	5	3	15
2	Dept. Printing	B	4	3,5	14
3	Dept. Drying	C	3	4	12
4	Dept. Cutting	D	4	3	12
5	Dept. Sealing	E	3	2	6
6	Dept. Finishing	F	3	4,5	13,5
7	Dept. Packaging	G	4	3,5	14
8	Plastic waste bin	H	1	2	2
9	Finished Product Warehouse	I	5	4	20
		Total			108,5

Environmental Considerations (C2) ranked second, reflecting awareness of the environmental impact of each step in the production process. Careful assessment of factors such as energy use, waste management, and selection of sustainable raw materials is increasingly becoming crucial [30]. Unlimited use of natural resources without regard to sustainability is harmful to the world [31]. Emphasizing environmentally conscious manufacturing and product recovery is a crucial strategy to reduce waste and minimize negative environmental impacts. Last but not least, Safety Considerations (C3) which reflect a commitment to social aspects in layout design are equally important. Focusing on occupational safety, ergonomics, and comfort for workers creates an environment that supports collective well-being [32]. Overall, the findings emphasize the need for a solid balance between economic, environmental, and social considerations to design sustainable layouts with a holistically positive impact.

Table 6. Importance value of each criterion

No.	Criteria	Importance value
1	Manufacturing Efficiency (C1)	5
2	Environmental Considerations (C2)	4
3	Safety (C3)	3

The results of the ARC assessment with the TOPSIS method are shown in Fig. 4. These results show that ARC 1 has the highest preference value, so it can be selected for a sustainable layout. The results of the ARC selection are used to load the ARD shown in Fig. 5. Finally, the proposed sustainable layout based on SLP and Topsis is presented in Fig. 6.

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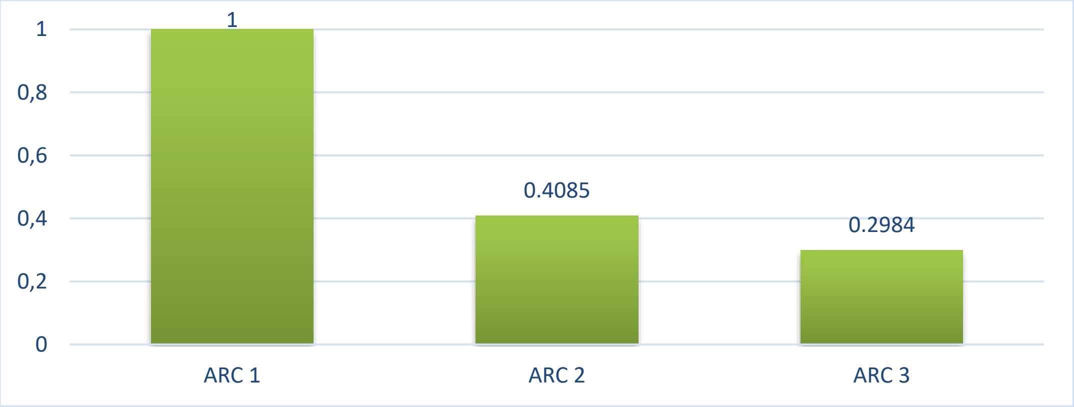

Fig. 4. Results of ARC assessment with TOPSIS method

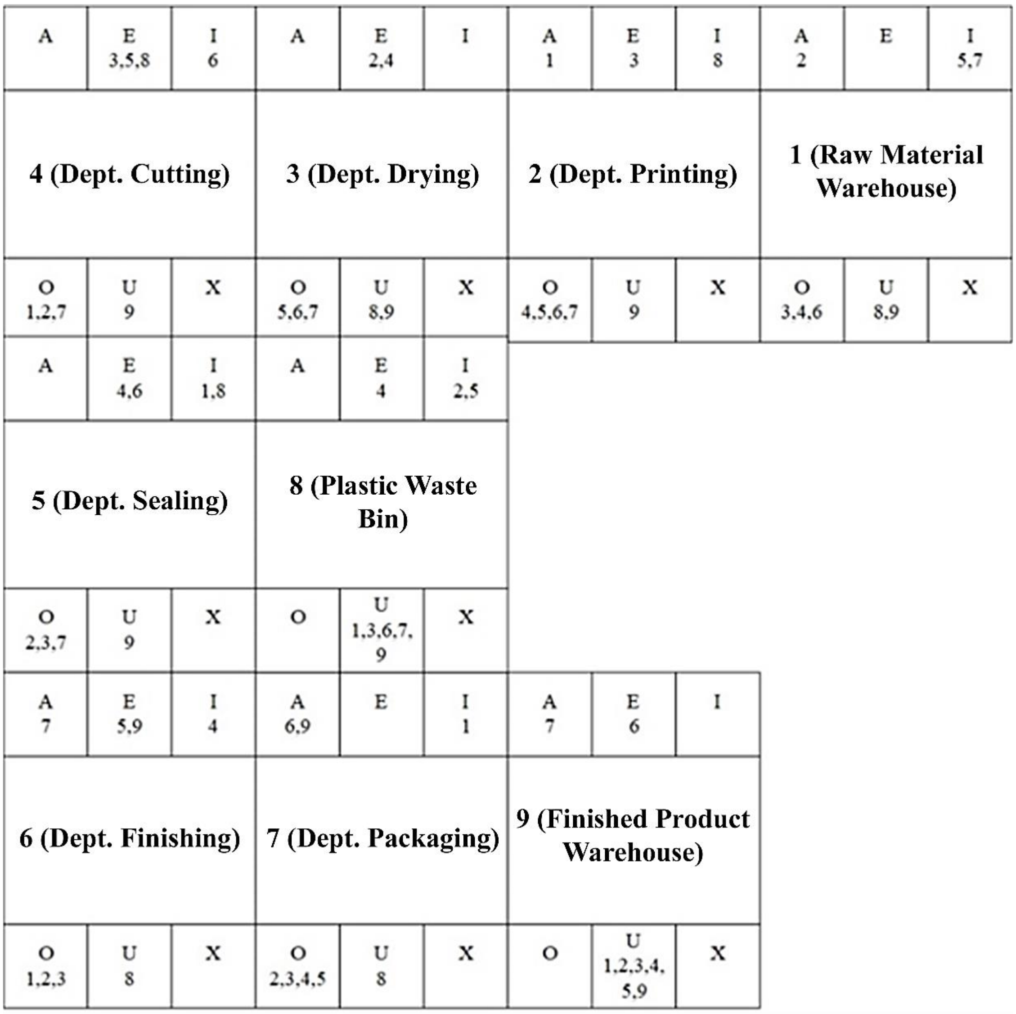

Fig. 5. ARD based on selected ARC

Based on the results described in Table 7 which compares the initial layout and the proposed sustainable layout, there is a significant difference in distance traveled. In the initial layout, the distance traveled reached 5407.5 meters in one week. Meanwhile, the proposed sustainable layout decreased the miles moved to 4672.5 meters in one week.

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These results highlight that the proposed sustainable layout can reduce the total displacement distance required in the company's operations.

The decreased distance traveled also indicates that the proposed sustainable layout can optimize the efficiency of space usage and facility placement. Furthermore, by reducing the distance traveled, the proposed sustainable layout can potentially reduce material handling costs and the time required for moving goods and materials. In other words, the use of the proposed sustainable layout can have a positive impact on the company's economic factors. These results underscore the importance of a sustainable approach in designing company layouts. In addition to optimizing operational efficiency, the proposed sustainable layout reflects a commitment to reducing environmental impacts and making wiser use of resources. Overall, the findings provide concrete evidence that the proposed sustainable layout has the potential to provide multiple benefits, namely in terms of operational efficiency and improved environmental sustainability of the company.

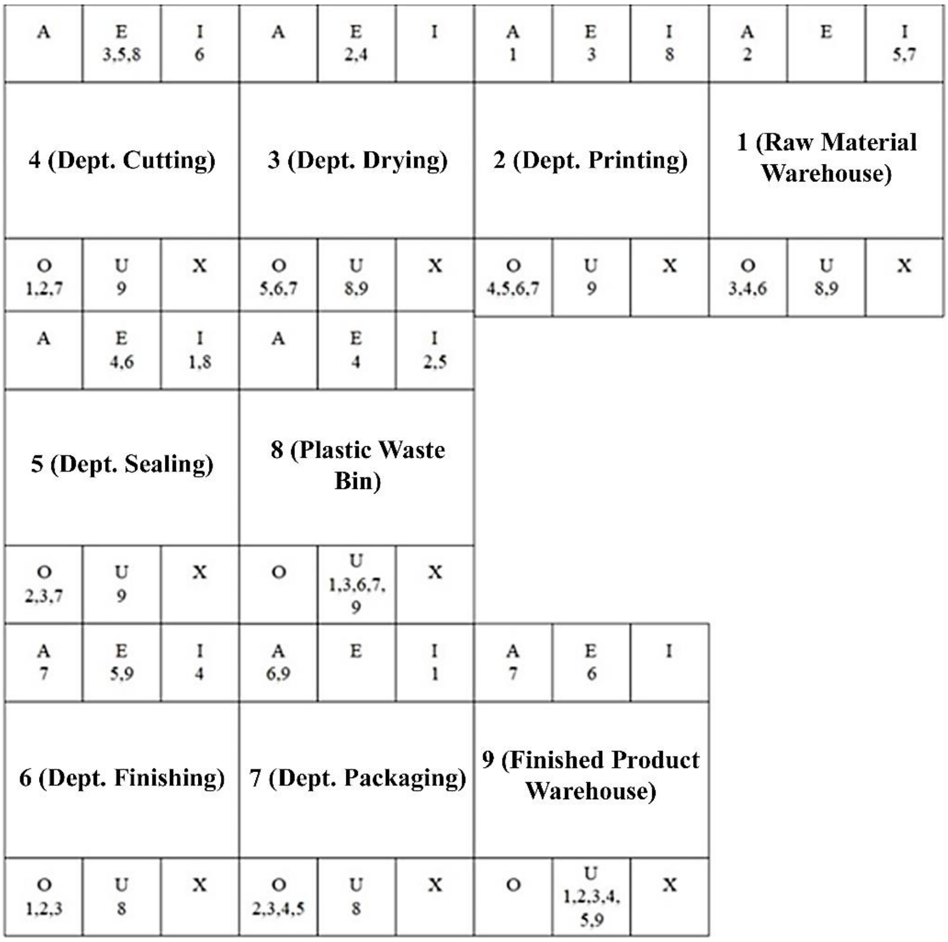

Fig. 6. Proposed sustainable layout

Table 7. Comparison of initial and proposed layouts

	Initial Layout	Sustainable layout proposed	Difference
Interdepartmental Total	40.25 meter	35.75 meter	4.5 meter
Total distance traveled for material movement	5407.5 meters/week	4672.5 meters/week	735 meters/week

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3.2 Research Implications

The findings of this study have significant implications for designing and developing sustainable layouts for manufacturing environments. Integrating the SLP with the Topsis method demonstrates a holistic and structured approach to designing more efficient and sustainable layouts. This method combines aspects of layout planning with more careful decision-making, resulting in a more appropriate and optimized solution. The proposed procedure that combines the SLP method with Topsis as a tool for ARC selection in sustainable layout design has several significant advantages. This approach combines the systematic aspects of the SLP method with the capabilities of Topsis in more in-depth preference-based decision-making. This combination provides a comprehensive approach to layout design, ensuring that decisions are based on accurate analysis and broader considerations. Using Topsis in ARC selection allows for a more precise assessment of the various sustainable layout alternatives. This helps identify and prioritize solutions closest to the ideal solution, thus minimizing the risk of suboptimal decisions. The integration of this method also makes it possible to accommodate various factors relevant to the economic, environmental, and social dimensions in the ARC assessment. As such, this procedure enables the selection of layouts that are not only operationally efficient but also positively impact the environment and worker welfare.

The importance of Manufacturing Efficiency (C1), which has the most significant weight, shows that economic aspects play a crucial role in designing sustainable layouts. Efficiency in production processes and resource use is critical to achieving overall sustainability goals. Therefore, organizations need to prioritize investments and changes to improve their operational efficiency, focusing on reducing production costs and increasing productivity. The finding that the proposed layout can reduce material handling distances is clear evidence that a sustainable approach to layout design can directly reduce operational costs and optimize resource use. The reduction in material handling distances not only impacts the efficiency of the production process but also has the potential to reduce energy consumption and greenhouse gas emissions associated with material movement.

4. Conclusion

In the conclusion of this scientific article, the main objective has been successfully achieved by designing a sustainable proposal to improve the company's layout. The results show that an approach that combines Systematic Layout Planning and TOPSIS as an ARC evaluation tool can produce a more optimal sustainable layout arrangement characterized by a reduction in material handling distances that are more efficient. Nevertheless, this research also has limitations regarding criteria selection in ARC selection. Therefore, future research is recommended to consider using more complex and comprehensive criteria in designing sustainable layouts. In addition, it is essential to note that this study did not consider the relationship between criteria. Therefore, future research is expected to consider the possible interconnections between the criteria in the ARC selection process to produce more accurate and sustainable recommendations for designing better layouts.

Declarations

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References

[1] M. Song, Y. Chen, and Q. An, "Spatial econometric analysis of factors influencing regional energy efficiency in China," *Environmental Science and Pollution Research,* vol. 25, no. 14, pp. 13745-13759, 2018. https://doi.org/10.1007/s11356-018-1574-5.

[2] R. Kumar, S. P. Singh, and K. Lamba, "Sustainable robust layout using Big Data approach: A key towards industry 4.0," *Journal of Cleaner Production,* vol. 204, pp. 643-659, 2018. https://doi.org/10.1016/j.jclepro.2018.08.327.

[3] A. Mubin, D. M. Utama, and R. C. Nusantara, "Manufacturing Sustainability Assessment Comprising Physical and Mental Workload: An Integrated Modified SVSM and AHP Approach," *Process Integration and Optimization for Sustainability,* vol. 7, no. 1, pp. 407-417, 2023. https://doi.org/10.1007/s41660-022-00300-z.

[4] D. M. Utama, N. Ardiyanti, and A. A. Putri, "A new hybrid method for manufacturing sustainability performance assessment: a case study in furniture industry," *Production & Manufacturing Research,* vol. 10, no. 1, pp. 760-783, 2022. https://doi.org/10.1080/21693277.2022.2141366.

[5] A. Tayal, A. Solanki, and S. P. Singh, "Integrated frame work for identifying sustainable manufacturing layouts based on big data, machine learning, meta-heuristic and data envelopment analysis," *Sustainable Cities and Society,* vol. 62, p. 102383, 2020. https://doi.org/10.1016/j.scs.2020.102383.

[6] R.-D. Chang, J. Zuo, Z.-Y. Zhao, G. Zillante, X.-L. Gan, and V. Soebarto, "Evolving theories of sustainability and firms: History, future directions and implications for renewable energy research," *Renewable and Sustainable Energy Reviews,* vol. 72, pp. 48-56, 2017. https://doi.org/10.1016/j.rser.2017.01.029.

[7] S. P. Singh and V. K. Singh, "An improved heuristic approach for multi-objective facility layout problem," *International Journal of Production Research,* vol. 48, no. 4, pp. 1171-1194, 2010. https://doi.org/10.1080/00207540802534731.

[8] M. Kikolski and C.-H. Ko, "Facility layout design – review of current research directions," *Engineering Management in Production and Services,* vol. 10, no. 3, pp. 70-79, 3918. https://doi.org/doi:10.2478/emj-2018-0018.

[9] S. A. Ali Naqvi, M. Fahad, M. Atir, M. Zubair, and M. M. Shehzad, "Productivity improvement of a manufacturing facility using systematic layout planning," *Cogent Engineering,* vol. 3, no. 1, p. 1207296, 2016. https://doi.org/10.1080/23311916.2016.1207296.

[10] B. Suhardi, E. Juwita, and R. D. Astuti, "Facility layout improvement in sewing department with Systematic Layout planning and ergonomics approach," *Cogent Engineering,* vol. 6, no. 1, p. 1597412, 2019. https://doi.org/10.1080/23311916.2019.1597412.

[11] A. R. S. C. Rodriguez and P. V. D. Oliveira, "An extension of systematic layout planning by using fuzzy AHP and fuzzy VIKOR methods: a case study," *European Journal of Industrial Engineering,* vol. 16, no. 1, pp. 1-30, 2021. https://doi.org/10.1504/EJIE.2022.119368.

[12] Q. Lin and D. Wang, "Facility Layout Planning with SHELL and Fuzzy AHP Method Based on Human Reliability for Operating Theatre," *Journal of Healthcare Engineering,* vol. 2019, p. 8563528, 2019. https://doi.org/10.1155/2019/8563528.

[13] V. E. de Oliveira Gomes, D. J. De Barba, J. de Oliveira Gomes, K.-H. Grote, and C. Beyer, "Sustainable Layout Planning Requirements by Integration of Discrete Event Simulation Analysis (DES) with Life Cycle Assessment (LCA)," in *Advances*

Please cite this article as: Dresanala, M., Kusuma Dewi, S., & Utama, D. M. (2023). Sustainable Layout Design Based on Integrated Systematic Layout Planning and TOPSIS: A Case Study. Jurnal Teknik Industri, 24(1), 51–64. https://doi.org/10.22219/JTIUMM.Vol24.No1.51-64

in Production Management Systems. Competitive Manufacturing for Innovative Products and Services, Berlin, Heidelberg, 2013, pp. 232-239: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-40361-3_30.

[14] M. Süße, S. Ihlenfeldt, and M. Putz, "Framework for increasing sustainability of factory systems by generative layout design," *Procedia CIRP,* vol. 105, pp. 345-350, 2022. https://doi.org/10.1016/j.procir.2022.02.057.

[15] A. M. Elsayed, H. H. Elanwar, M. Marzouk, and S. S. Safar, "Sustainable layout design of steel buildings through embodied energy and costs optimization," *Cleaner Engineering and Technology,* vol. 5, p. 100308, 2021. https://doi.org/10.1016/j.clet.2021.100308.

[16] N. N. Nordin, R. Ab Razak, and G. Marthandan, "A Unique Strategy for Improving Facility Layout: An Introduction of The Origin Algorithm," *Sustainability*, vol. 15, no. 14. 2020. https://doi.org/10.3390/su151411022.

[17] P. Pérez-Gosende, J. Mula, and M. Díaz-Madroñero, "Overview of Dynamic Facility Layout Planning as a Sustainability Strategy," *Sustainability*, vol. 12, no. 19. 2020. https://doi.org/10.3390/su12198277.

[18] O. Sutari and S. U. Rao, "Development of plant layout using systematic layout planning (SLP) to maximize production–A case study," *International Journal of Mechanical and Production Engineering,* vol. 2, no. 8, pp. 63-66, 2014.

[19] A. T. Haryanto, M. Hisjam, and W. K. Yew, "Redesign of Facilities Layout Using Systematic Layout Planning (SLP) on Manufacturing Company: A Case Study," *IOP Conference Series: Materials Science and Engineering,* vol. 1096, no. 1, p. 012026, 2021. https://doi.org/10.1088/1757-899X/1096/1/012026.

[20] A. P. Lista, G. L. Tortorella, M. Bouzon, S. Mostafa, and D. Romero, "Lean layout design: a case study applied to the textile industry," *Production,* vol. 31, 2021. https://doi.org/10.1590/0103-6513.20210090.

[21] A. Wahid, "Application Of Track Balance And Re-Layout Proposed Using Heuristic Methods And Activity Relationship Chart In The Integrating Process: A Case Study in PT HAI," *JKIE (Journal Knowledge Industrial Engineering),* vol. 8, no. 3, pp. 215-223, 2021. https://doi.org/10.35891/jkie.v8i3.2754.

[22] F. Dweiri, "Fuzzy development of crisp activity relationship charts for facilities layout," *Computers & Industrial Engineering,* vol. 36, no. 1, pp. 1-16, 1999. https://doi.org/10.1016/S0360-8352(98)00102-8.

[23] Z. D. U. Durmusoglu, "A TOPSIS-based approach for sustainable layout design: activity relation chart evaluation," *Kybernetes,* vol. 47, no. 10, pp. 2012-2024, 2018. https://doi.org/10.1108/K-02-2018-0056.

[24] D. M. Utama, "AHP and TOPSIS Integration for Green Supplier Selection: A Case Study in Indonesia," *Journal of Physics: Conference Series,* vol. 1845, no. 1, p. 012015, 2021. https://doi.org/10.1088/1742-6596/1845/1/012015.

[25] D. M. Utama, R. P. Parameswari, and A. Mubin, "Evaluation and Performance Analysis using ANP and TOPSIS Algorithm," *Journal of Physics: Conference Series,* vol. 2394, no. 1, p. 012005, 2022. https://doi.org/10.1088/1742-6596/2394/1/012005.

[26] T. Yang, C. T. Su, and Y. R. Hsu, "Systematic layout planning: a study on semiconductor wafer fabrication facilities," *International Journal of Operations & Production Management,* vol. 20, no. 11, pp. 1359-1371, 2000. https://doi.org/10.1108/01443570010348299.

[27] M. d. R. Cabrita, J. P. Domingues, and J. Requeijo, "Application of Lean Six-Sigma methodology to reducing production costs: case study of a Portuguese bolts manufacturer," *International Journal of Management Science and Engineering*

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Management, vol. 11, no. 4, pp. 222-230, 2016. https://doi.org/10.1080/17509653.2015.1094755.

[28] C. G. Machado, M. P. Winroth, and E. H. D. Ribeiro da Silva, "Sustainable manufacturing in Industry 4.0: an emerging research agenda," *International Journal of Production Research,* vol. 58, no. 5, pp. 1462-1484, 2020. https://doi.org/10.1080/00207543.2019.1652777.

[29] D. Y. Pimenov *et al.*, "Resource saving by optimization and machining environments for sustainable manufacturing: A review and future prospects," *Renewable and Sustainable Energy Reviews,* vol. 166, p. 112660, 2022. https://doi.org/10.1016/j.rser.2022.112660.

[30] I. D. Paul, G. P. Bhole, and J. R. Chaudhari, "A Review on Green Manufacturing: It's Important, Methodology and its Application," *Procedia Materials Science,* vol. 6, pp. 1644-1649, 2014. https://doi.org/10.1016/j.mspro.2014.07.149.

[31] T. Ibn-Mohammed *et al.*, "A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies," *Resources, Conservation and Recycling,* vol. 164, p. 105169, 2021. https://doi.org/10.1016/j.resconrec.2020.105169.

[32] L. Sadeghi, J.-Y. Dantan, A. Siadat, and J. Marsot, "Design for human safety in manufacturing systems: applications of design theories, methodologies, tools and techniques," *Journal of Engineering Design,* vol. 27, no. 12, pp. 844-877, 2016. https://doi.org/10.1080/09544828.2016.1235262.

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