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Layout Design of Copra Factory Facilities in Small and Medium Industry Centers Using Systematic Layout Planning Method

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ABSTRACT

This research was conducted on the layout of copra processing facilities. Copra is one of the products to be produced by the Small and Medium Industry Center in the Meranti Islands. The purpose of designing the layout of this copra factory facility is to provide a proposal in the form of a copra processing facility layout with the shortest material handling distance. The methods used in this study are Systematic Layout Planning (SLP) and Arena Simulation. The result of the SLP method is in the form of alternative layout proposals, which will be checked with a simulation model. This Arena simulation is carried out to see whether the production process of the resulting layout is good or not by implementing it into a conceptual model in the Arena software, which is then tested to see the disruptions that exist in the production process, such as the accumulation of raw materials at one of the stations (bottleneck). Based on data processing results, one alternative layout was selected with a material handling distance of 26.33 m from 3 existing alternatives. This selection is based on the smallest material handling distance obtained. Furthermore, testing the layout with the Arena software simulation model found that there was a disruption in the production process in the form of a buildup of raw materials at the smoking and drying station caused by the manual drying process using the scorching heat of the sun so that it takes 4-5 days for the drying process.

Keywords: Layout, Copra, Systematic Layout Planning, Arena Simulation

INTRODUCTION

The Meranti Islands Regency Government plans to build an adequate industrial area for coconut fruit processing, and the Meranti Islands Regency Government has prepared a place of ± 6 Ha, which will later be used as a small and medium industrial center to process the coconut. In this case, the Meranti Islands Regency Government needs a layout design for each processing industry to be built. The Center for Small and Medium Industries (SIKM) coconut processing that will be built in Meranti Islands Regency will later process coconuts into several derivative products such as virgin coconut oil, cocoa milk, copra, nata de coco, hydro coco, coco fiber, and coconut shell briquettes. The construction of this industrial center will undoubtedly be built in an area with the most significant coconut production on Meranti Island, and this is done to facilitate this processing center in obtaining raw materials in the form of coconuts. According to data from the Central Statistics Agency, Rangsang Island is the largest producer of coconuts in the Meranti Islands.

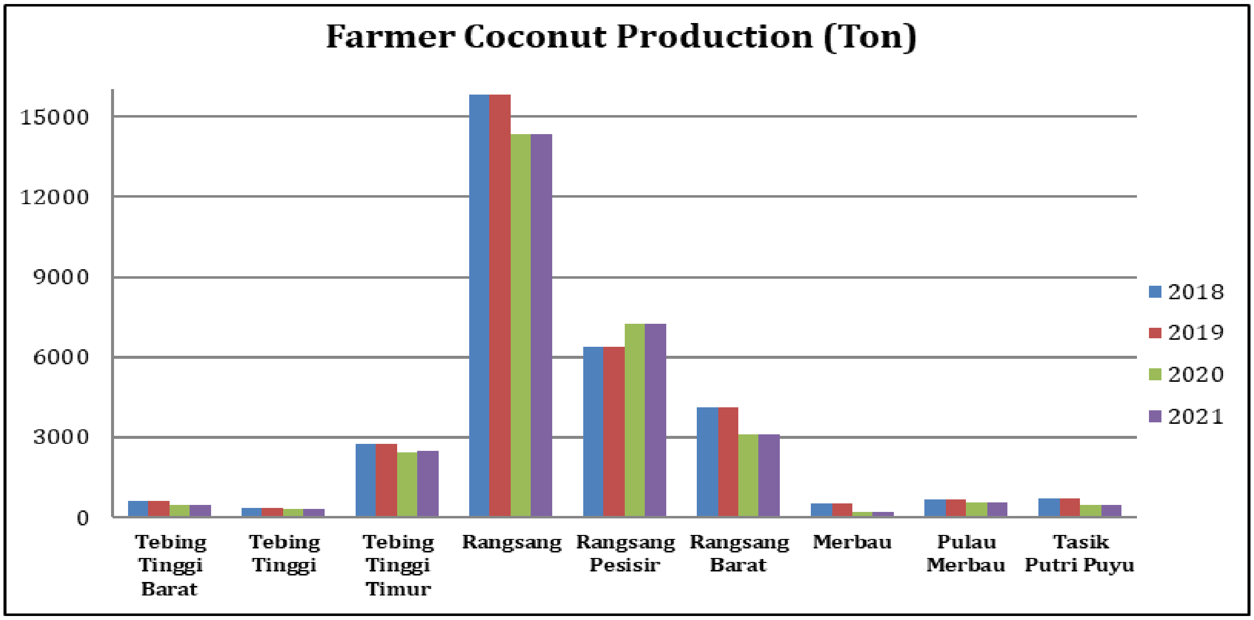


Figure 1. Production Graph of Meranti Islands Coconut Plantation

Figure 1 shows the production of coconut plantations in the Meranti Islands from 2018-2021. The total production of coconut plantations in the Meranti Islands 2018 was 31,914 tons. In 2019, it was 31,915 tons. In 2020, it was 29,190 tons, and in 2021 it was 29,260 tons. Of the several existing regions, Rangsang Island is the most significant contributor of coconuts to the Meranti Islands. Rangsang Island is divided into three districts: Rangsang, Rangsang Pesisir, and Rangsang Barat.

The coconut Small and Medium Industry Center (SIKM) construction aims to absorb the results of coconut plantations in the Meranti Islands, especially on Rangsang Island. This center will process all parts of the coconut fruit, from coir, shell, and meat to water. It will be processed into several products that are very economically valuable, one of which is copra or dried coconut meat. So far, most coconuts are sold in whole form without processing first. This is because many people or farmers still do not have the facilities to process coconuts into derivative products. So, the selling price obtained is not too high compared to after being processed into derivative products.

Copra is. The people of Indonesia cultivate many processed coconut products. This product is usually used to manufacture coconut oil [1]. Copra is produced from dried coconut meat. The drying process of coconut meat is usually done manually using the help of direct sunlight, ovening, or smoking. Copra is one of the most promising coconut derivative products for people in the Meranti Islands if they want to process it because it has great profit potential with a production process that is not too complicated and does not require too many machines in the processing process [2]. This is based on data from the Central Statistics Agency on exports of Indonesian copra products, reaching 107,487,136 tons in 2020. The total export value of copra is second in terms of the number of exports after coconut oil and cooking oil. In addition, based on data from the Riau Provincial Plantation Office in 2021, the average price of dried copra in Riau Province is around IDR 6,432.08 per kg at the farmer level and the price of granulated coconut is around IDR 3,410.46 per piece at the farmer level. To process coconut meat into copra requires several processes and requires a production facility, so a good facility layout design is needed for processing coconut meat into copra to get maximum production results.

This research was conducted to discuss the design of the layout of coconut meat processing plant facilities into copra using the Systematic Layout Planning (SLP) method. Then, the results obtained will be simulated in Arena software [3]. This research is expected to produce a proposed layout that can maximize the production of coconut processing into copra with a small material handling distance [4]. A facility layout design is needed to produce coconut meat in Copra. In this case, the Systematic Layout Planning method and Arena software simulation will design the layout required for an industry processing coconut meat into copra [5]. This method was chosen because, according to [6], Systematic layout planning methods can identify the facilities needed on a plant or Activity Relationship Chart (ARC) and determine it. The proximity relationship between these facilities is based on the value of the level of proximity. [7] states that the Systematic Layout Planning (SLP) method is used to obtain a more efficient flow of various problems in manufacturing, assembly, warehousing, transportation, support services, and other related activities of offices, rooms, or factories. The use of the Systematic Layout Planning algorithm pays attention to the order throughout. Process and related to the operations performed [8][9].

METHOD

Data Collection

Data collection in this study was carried out using the literature study method. Literature studies are conducted to collect information about data that can support this study. The data needed in this study are as follows [10][11]:

1. Land
2. Production Capacity
3. Production process
4. Average Production Time

Data Processing

The data obtained is used as supporting data in planning the layout of copra factory facilities at the Center for Small and Medium Industries (SIKM) Coconut Processing in Meranti Islands Regency using the Systematic Layout Planning (SLP) method and Arena Simulation [12]–[21].

Working Map

Work maps describe activities or processing processes systematically from the initial stage to the end and contain the sequence of work procedures in the production process and information on machines used in the copra production process [22].

1. Operation Process Map

The operation process map systematically illustrates the steps of the copra manufacturing process from the initial stage to the end, starting from still in the form of coconut meat raw materials to copra. In addition, the operation process map also contains work sequence procedures for processing coconut into copra and machines that will be used in the production process.

2. Routing Sheet

Routing Sheet is a sheet that contains information to explain or describe in detail about work activities in the production process of coconut meat into copra. The Routing Sheet will display information about Copra raw materials and production flows in the form of work activities that raw materials go through to become products, the length of the work process of each work activity, and the machinery and equipment used during Copra making [23].

3. Multi Product Process Chart (MPPC)

MPPC is a map that contains information about the facilities on the production floor of copra making and communication about the work on each part of the product at each station in the process of making copra [24].

4. Manpower Needs Planning

The calculation of labor in this study was carried out to know the amount of work needed at each workstation in the copra processing facility. Several supporting data are needed before calculating labor needs, such as the number of working hours per day, cycle time, normal time, and standard or standard time, calculated using work sampling using the Westinghouse method [25].

5. Planning Space Requirements and Independent Work Stations

Every company must have the necessary workforce to support the smooth running of production activities in the internal and external environment. Therefore, in this case, planning human resource needs and space needs is needed by a company to achieve company efficiency and effectiveness [26].

6. Activity Linkage Planning

In making a proposal layout using the Systematic Layout Planning method, it is necessary to plan the linkage of activities.

7. Selected Allocation Diagram Area

After completing the material handling process on each proposed alternative layout, the selection of the most optimal Area Allocation Diagram (AAD) from several existing alternatives is carried out. The alternative to be chosen is the alternative that has the smallest total distance value [27].

8. Material Handling Proposal (FTC)

The calculation of the proposed material handling is a calculation of several alternative layouts that will be made. The material handling distance calculation results in the distance that raw materials will pass until they become products. In the analysis of material handling, there is a value from the chart distance based on the proposed layout.

9. Simulation with Arena Software

The design results in the form of a proposed alternative layout that has the most minor material handling distance calculation results will be simulated in the Software Arena to identify the presence or absence of bottlenecks on the production floor and to see how effective and efficient the layout is to be used in processing coconut into copra in small and medium industrial centers in the Meranti Islands. The method section is written with a length of 15 – 20% of the size of the article contains the research design, data collection techniques and, data sources, and methods of data analysis.

RESULTS

Self-Service Workstation Planning

Independent workstation planning is needed to streamline the production process flow, and six workstations are designed, from the coconut peeling process to sorting and packing copra. Planning of a self-contained workstation at a copra processing facility is shown from Figure 2 to Figure 7.

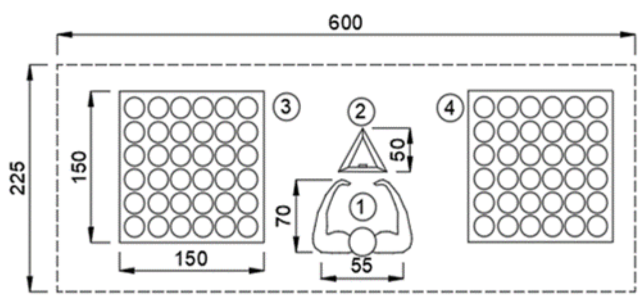


Figure 2. Coconut Stripping Workstation

Image Caption 2 (cm):
1= Coconut Peeler Operator
2= Coconut Peeler Machine / Tool
3= Initial Raw Material
4= Final Raw Material

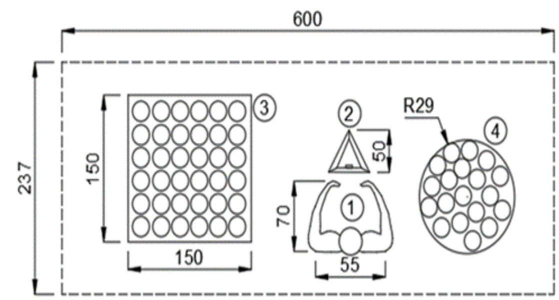


Figure 3. Coconut Cleavage Work Station

Image Caption 3 (cm):
1= Coconut Peeler Operator
2= Coconut Splitting Machine / Tool
3= Initial Raw Material
4= Final Raw Material

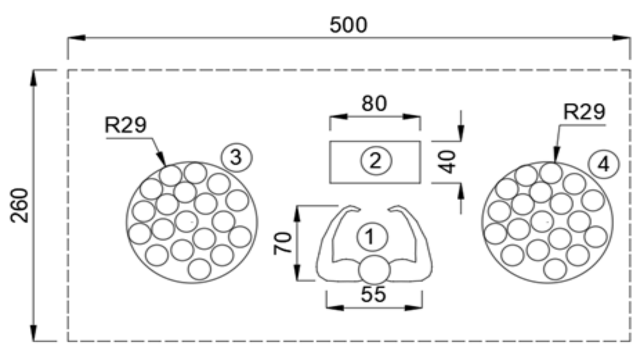


Figure 4. Coconut Washing Workstation

Image Caption 4 (cm):
1= Coconut Peeler Operator
2= Water Tub
3= Initial Raw Material
4= Final Raw Material

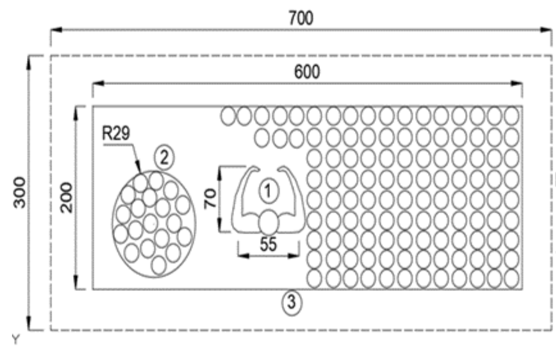


Figure 5. Coconut Smoking and Drying Workstation

Image Caption 5 (cm):
1= Coconut Drying Operator
2= Stacking of raw materials
3= Sun-drying Area

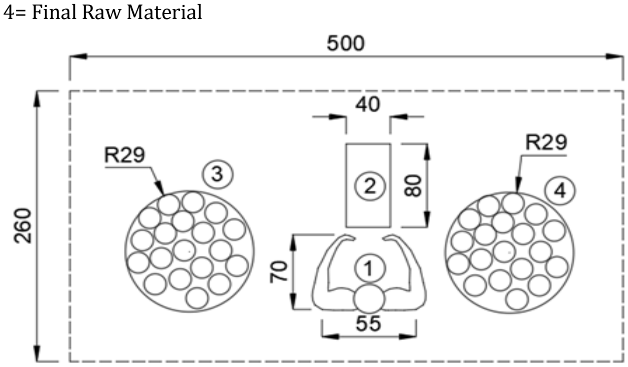


Figure 6. Coconut Scrapping Workstation

Image Caption 6 (cm):
1= Coconut Gouging Operator
2= Coconut Gouging Place
3= Initial Raw Material
4= Final Raw Material

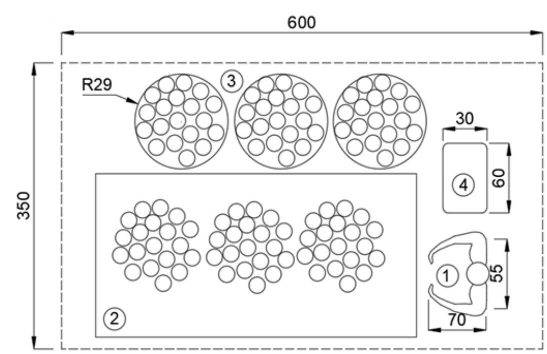
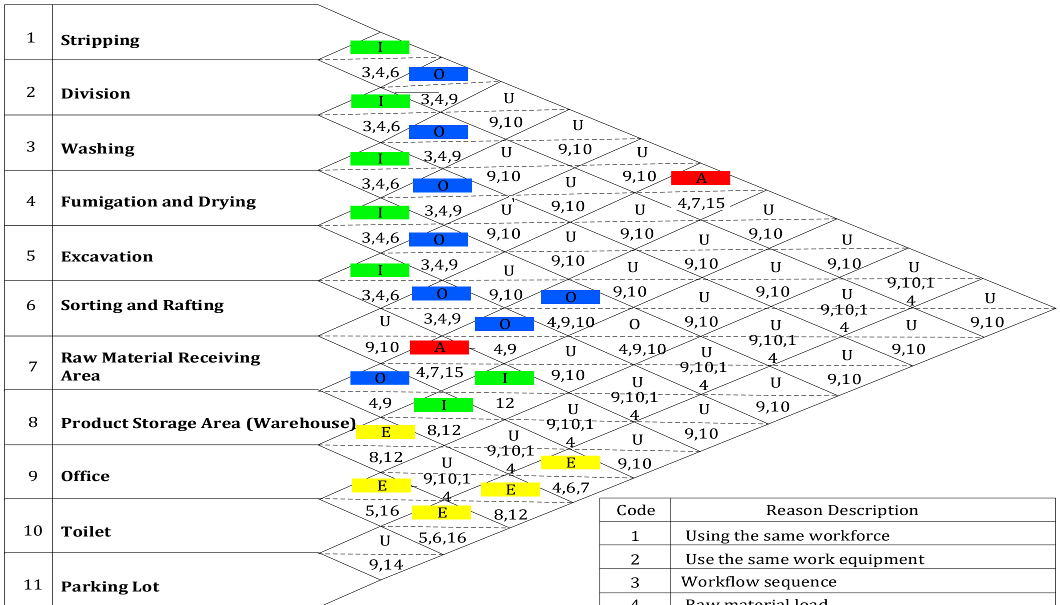


Figure 7. Copra Sorting and Packing Workstation

Image Caption 7 (cm):
1= Copra Sorting Operator
2= Cobra before sorting
3= Copra after sorting
4= Copra Packing Area

Inter-activity linkage planning

This activity linkage planning includes planning an Activity Relationship Chart (ARC), Activity Relationship Diagram (ARD), and Area Allocation Diagram (AAD). The ARC Design is shown in Figure 8.



Value	Closeness
A	Absolutely Necessary
E	Very Necessary
I	Need
O	Normal/No Problem
U	No Need
X	Undersirable

Code	Reason Description
1	Using the same workforce
2	Use the same work equipment
3	Workflow sequence
4	Raw material load
5	Essential facilities for work
6	Minimizing work time speeding
7	Up the production process
8	Simplify transactions
9	No releated
10	No wanted
11	Normal itinerary
12	Surveillance facility
13	Using the same room
14	Dirty, noise, dust, odor
15	Facilitate movement of goods
16	Transfer officers

Figure 8. Overall Activity Relationship Chart

Planning Activity Relationship Diagram (ARD)

There are three alternative proposed Activity Relationship Diagrams (ARD) shown in Figure 9 to Figure 11.

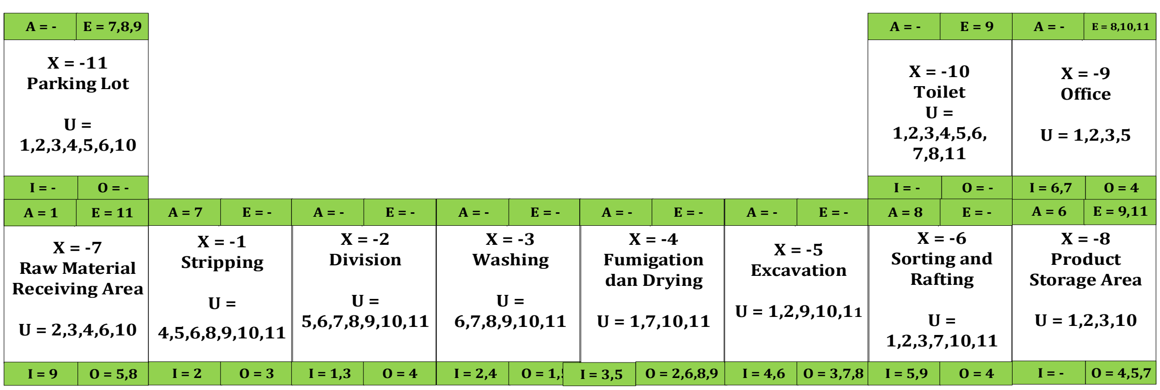


Figure 9. ARD Straight Flow Pattern

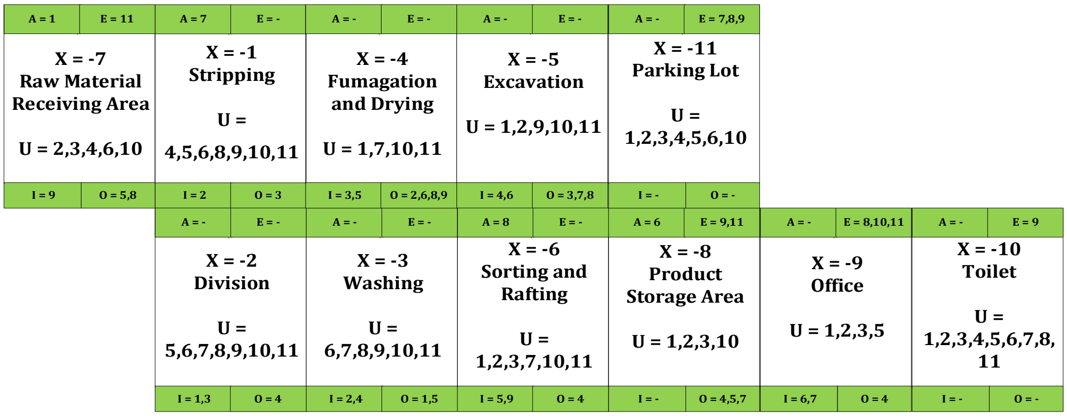


Figure 10. ARD Zig Zag Flow Pattern

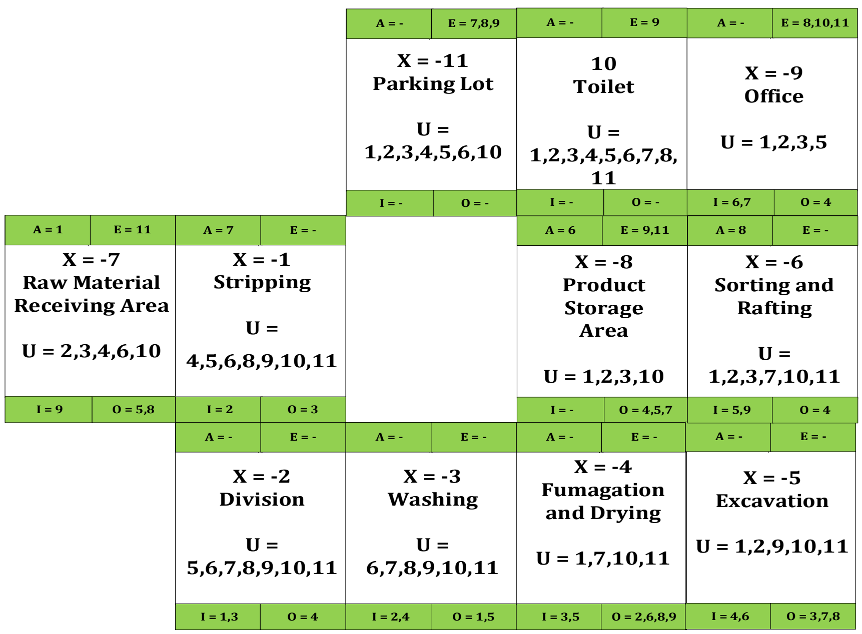


Figure 11. ARD U Flow Pattern

Area Planning Allocation Diagram (AAD)

AAD planning is a continuation of ARD; in this planning, the template on ARD is set in the form of blocks with actual size. In this AAD planning, a measure of the distance of movement of raw materials between stations is directly carried out in each flow pattern formed in the ARD. From the comparison results, the proposal of alternative layout 2 with a zig-zag flow pattern was selected to be applied to the layout of the copra factory in the center of small and medium industries to be built in the Meranti Islands Regency. The comparative results of the distance of movement of raw materials between stations from each formed flow pattern can be seen in Table 1.

Table 1. Comparison of Raw Material Displacement Distance

No	Facilities/Stations	Distance Between Production Facilities (meters)		
		Straight Pattern	Zigzag Pattern	U pattern
1	Raw Material Acceptance – Stripping	2.40	2.41	2.40

2	Stripping – Cleavage	6	2.31	4.59
3	Cleavage – Washing	5.51	5.50	5.51
4	Washing – Fumigation and Sun-drying	6	2.97	5.99
5	Fumigation and Sun-drying – Drying	6	6	6
6	Sorting – Sorting and Cloaking	5.50	3.09	4.36
7	Sorting and wading – product storage	2.99	4.05	2.80
	Total	34.4	**26.33**	31.65

From the comparison between alternatives, alternative II was selected with the shortest raw material transfer distance with a total length of 26.33 m. The Final Layout Design is shown in Figure 12.

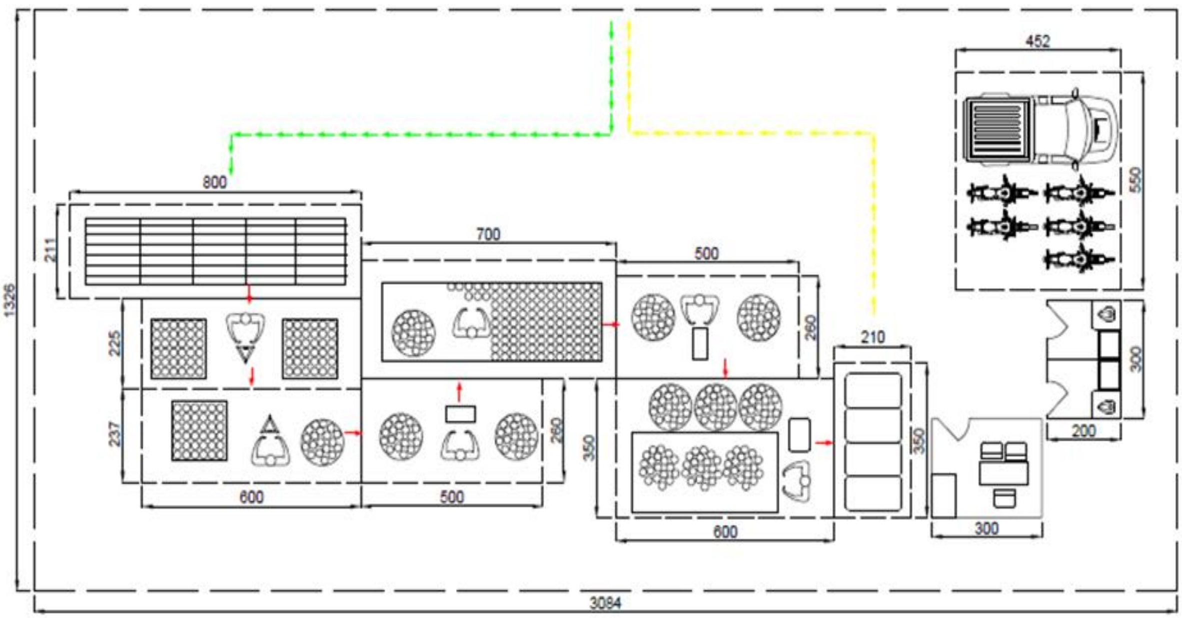


Figure 12. Copra Production Design Layout

Calculating Material Handling Distance

Material handling or moving materials from one station to another to reduce the distance of displacement. In the production process, Copra does not use mathematical handling equipment. All movement of goods is done manually by workers. The results of the Material Handling calculation are shown in Table 2.

Table 2. Total Material Handling Distance

Station	MH	Frequency	Displacement Distance(m)	Mileage(m)	% Of Handling Distance
A-B	Manual	5	2.41	12.05	9.15
B-C	Manual	5	2.31	11.55	8.77
C-D	Manual	5	5.50	27.5	20.89
D-E	Manual	5	2.97	14.85	11.28
E-F	Manual	5	6	30	22.79
F-G	Manual	5	3.09	15.45	11.74
G-H	Arco	5	4.05	20.25	15.38
		Total		**131.65**	**100**

Layout Simulation using Arena

The module input creates an entity compiling objects to develop a conceptual model of the copra manufacturing production process.

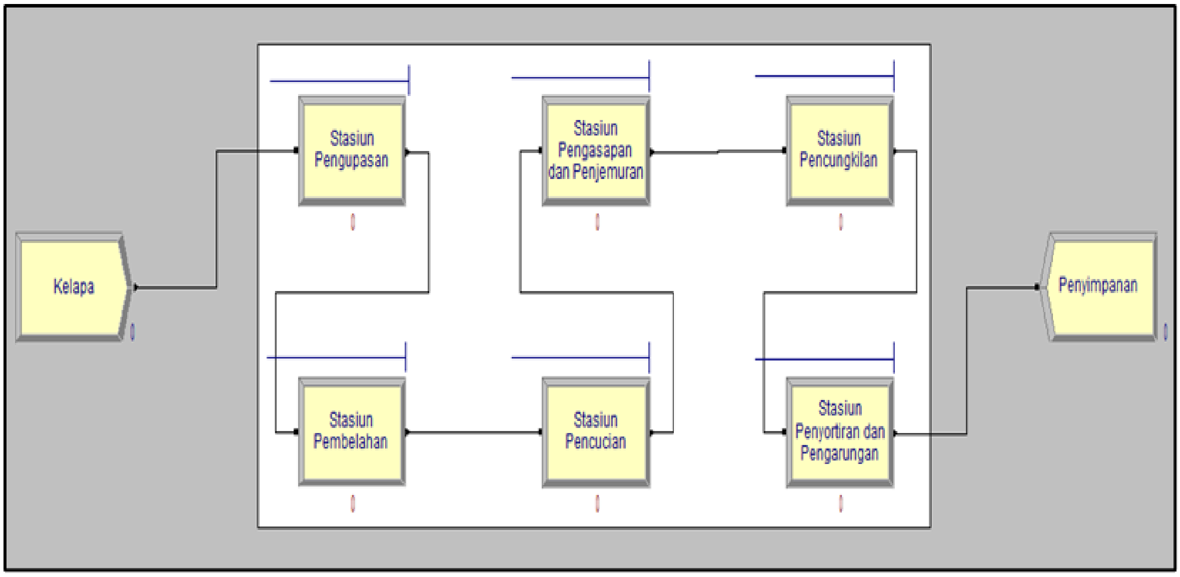


Figure 13. Conceptual Model Layout
(*Display in Indonesian)

In the experiment, the number of replication is filled with the number 5, then replication length 7 is the total amount of productive work time in one day, and hours per day 8 is the number of active working hours per day.

Table 3. Total Time Conceptual Model Proposal

Replication	Total Time
1	3.4129
2	3.4424
3	3.4202
4	3.4603
5	3.4035
6	3.4271
Average	3.42786
Standard Deviation	0.02069

The results of Table 3 above can be known as the standard deviation value of 0.02069, and then the calculation continues to find half width with an α value of 5%, then the value of t (0.025: 4) is 2.7764 and the importance of Zα / 2 is 1.96.

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Entity 1.NumberIn	2500.0	.00000	2500.0	2500.0	6
Entity 1.NumberOut	64.166	.42850	64.000	65.000	6
Resource 1.NumberSeized	2500.0	.00000	2500.0	2500.0	6
Resource 1.ScheduledUtilization	.59881	.00160	.59723	.60086	6
Resource 2.NumberSeized	2500.0	.00000	2500.0	2500.0	6
Resource 2.ScheduledUtilization	.34722	.00175	.34559	.34998	6
Resource 3.NumberSeized	2500.0	.00000	2500.0	2500.0	6
Resource 3.ScheduledUtilization	.59770	.00165	.59512	.59949	6
Resource 4.NumberSeized	65.166	.42850	65.000	66.000	6
Resource 4.ScheduledUtilization	.99939	5.4957E-05	.99931	.99944	6
Resource 5.NumberSeized	64.166	.42850	64.000	65.000	6
Resource 5.ScheduledUtilization	.01004	1.9196E-04	.00971	.01021	6
Resource 6.NumberSeized	64.166	.42850	64.000	65.000	6
Resource 6.ScheduledUtilization	.02531	2.2145E-04	.02513	.02570	6
System.NumberOut	64.166	.42850	64.000	65.000	6

Simulation run time: 2.50 minutes.
Simulation run complete.

Figure 14. Average Results of Proposed Layout Simulation Model

Average results of data from the proposed layout simulation model. It can be known that the number in or raw material entered as many as 2,500 coconuts and obtained the number of coconuts that were successfully produced or the minimum number out of 64 grains and a maximum of 65 coconuts. The unbalanced number of digits in and number out occurs due to a buildup (bottleneck) because many products are still working (WIP) at the smoking and drying station. This is due to the processing time required, which is ± 4-5 days.

DISCUSSION

In simulating the layout, the modules that have been determined will be arranged according to the flow of production activities. After the module becomes a conceptual model, a model check is carried out to find out whether the model that has been created has errors or not [19]. The check model stage is a simulation model verification stage where actual system activities can be applied directly in models with appropriate information input in basic system activities, namely the flow of production activities that will later be used in copra processing facilities [13]. Furthermore, the verified model will go through the setup run stage first before being tried, and this aims to regulate the number of initial replications that will be tested on the model, the number of initial replicas in the model, namely five repetitions with replication length seven and hours per day eight obtained from the number of operational hours and effective working hours per day [20]. Run model of 5 replications performed will provide total time information from the model, which will then be searched for standard deviation to determine the minimum number of copies [8]. After calculation, it is known that the minimum number of replications for the conceptual model run of the proposed copra processing layout is at least three replications. From the simulation results that have been carried out on the proposed alternative layout 2, it is known that there are bottlenecks at the smoking and drying stations. This is because the drying process is still done manually, relying only on the sun's scorching heat and taking at least four days [18].

In data processing that has been done with manual calculations obtained, the required replication is three, and validation in the output of the proposed alternative layout 2 with the desired assumption output range "μ" 1 - "μ" 2 is not at an interval-valued at 0 then the decision is H0 rejected [26]. In other words, the simulation model that has been created is invalid because it is not yet suitable or has not approached the actual production system [12]. This can happen because there are differences in the input distribution of production process time, where the fumigation and drying stations use input time of 4 -5 days in seconds [28].

The results of this study are in line with [29] the title Simulation of the Truck service system model in the fertilizer loading process using arena software to optimize service facilities (Case Study: Multipurpose Warehouse (GMG) of PT Petrokimia Gresik). From the initial 15 trial replications, the minimum number of replicas needed was calculated as many as 13 duplicates. This study tested two alternative proposed models in the Arena simulation. The results of this study are also in line with [30] title, Proposed Floor Layout for the Furniture Industry Production Using Systematic Layout Planning and Arena Simulation. From this study, the results of the number of alternative layouts were two alternatives. Five replications were obtained in the initial experiment for the Arena model simulation. That number had met the minimum number of copies, which was 2—this study compared the output results between alternatives 1 and 2 in terms of material transfer distance and displacement time.

CONCLUSION

Three alternative layout proposals can be applied to copra processing plants, and each layout has a different type of flow pattern, such as straight-line flow pattern, zig-zag flow pattern, and U flow pattern. Calculating the distance of material movement from each obtained the space for the proposed alternative layout 1 of 34.4 m, the proposed alternative layout 2 of 26.33 m, and the proposed alternative layout 3 of 31.65 m. Among the three alternative layout proposals, alternative layout proposal 2 with a zig-zag flow pattern has the shortest material transfer distance and will be applied to copra processing plants. After calculating the material handling in the proposed alternative layout 2, the total displacement distance traveled was 131.65 m. The proposed alternative layout two was tested using Arena simulation as a conceptual model. From the test results, it can be concluded that the design has worked well, but there is still a buildup of raw materials at the smoking and drying stations. The advertisement occurs due to the length of the smoking and drying process, which takes 4-5 days.

REFERENCES

[1] X. Hu, “E-commerce warehouse layout optimization: systematic layout planning using a genetic algorithm,” *Electron. Commer. Res.*, vol. 23, no. 1, pp. 97–114, 2023, doi: 10.1007/s10660-021-09521-9.

[2] C. Zhao, “Two Generative Design Methods of Hospital Operating Department Layouts Based on Healthcare Systematic Layout Planning and Generative Adversarial Network,” *J. Shanghai Jiaotong Univ.*, vol. 26, no. 1, pp. 103–115, 2021, doi: 10.1007/s12204-021-2265-9.

[3] A. R. S. C. Rodriguez, “An extension of systematic layout planning by using fuzzy AHP and fuzzy VIKOR methods: A case study,” *Eur. J. Ind. Eng.*, vol. 16, no. 1, pp. 1–30, 2022, doi: 10.1504/EJIE.2022.119368.

[4] L. S. Goecks, “Analytic hierarchy process as a decision-making tool for systematic layout planning, involving social responsibility criteria: A case study,” *Int. J. Ind. Syst. Eng.*, vol. 40, no. 1, pp. 29–50, 2022, doi: 10.1504/IJISE.2022.120806.

[5] A. Onaga-Nishimura, “Service Management Model Based on Lean Service and Systematic Layout Planning for the Improvement of Customer Satisfaction in an SME in the Restaurant Sector in Peru,” *ACM International Conference Proceeding Series*. pp. 242–249, 2022. doi: 10.1145/3568834.3568853.

[6] F. A. Pacheco-Colcas, “Production Model based on Systematic Layout Planning and Total Productive Maintenance to increase Productivity in food manufacturing companies,” *ACM International Conference Proceeding Series*. pp. 299–306, 2022. doi: 10.1145/3568834.3568854.

[7] S. Cáceres-Gelvez, “A Systematic Layout Planning and TOPSIS Application for the Design of a Power Generation Turbine Parts Repair Workshop,” *Ing. y Univ.*, vol. 26, 2022, doi:

10.11144/Javeriana.iued26.slpt.
[8] V. Kumar, “Improvement of facility layout design using Systematic Layout planning methodology,” *Journal of Physics: Conference Series*, vol. 2312, no. 1. 2022. doi: 10.1088/1742-6596/2312/1/012089.
[9] L. Zhu, “Factory layout optimization based on Systematic Layout Planning and genetic algorithm,” *Proceedings of SPIE - The International Society for Optical Engineering*, vol. 12176. 2022. doi: 10.1117/12.2636407.
[10] P. Burggräf, “Fields of action towards automated facility layout design and optimization in factory planning – A systematic literature review,” *CIRP J. Manuf. Sci. Technol.*, vol. 35, pp. 864–871, 2021, doi: 10.1016/j.cirpj.2021.09.013.
[11] G. J. L. Micheli, “A revised systematic layout planning to fit disabled workers contexts,” *Sustain.*, vol. 13, no. 12, 2021, doi: 10.3390/su13126850.
[12] M. Faishal, “Reducing Waste of Material Transport in Manufacturing Facility using Systematic Layout Planning and Simulation Approach,” *ASM Sci. J.*, vol. 16, pp. 134–142, 2021, [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85134722795
[13] D. Ramadhan, “Redesigning the facility layout with systematic layout planning method and lean manufacturing approach on the production floor at PT. Baruna Trayindo Jaya,” *Proceedings of the International Conference on Industrial Engineering and Operations Management*. pp. 2596–2609, 2021. [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85114242883
[14] A. E. F. Pérez, “Design of improvement proposal for the reduction of waste through the 5s methodology and systematic layout planning under a kaizen environment in a bakery company in the food sector, 2022,” *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, vol. 2023. 2023. [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85172397133
[15] J. Zhang, “Research on the Planning and Layout of Shanghai-Hangzhou Railway Corridor Based on Systematic Thinking,” *J. Railw. Eng. Soc.*, vol. 40, no. 6, pp. 12–17, 2023, [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85172198698
[16] M. Xu, “Optimization algorithms for construction site layout planning: a systematic literature review,” *Engineering, Construction and Architectural Management*, vol. 27, no. 8. pp. 1913–1938, 2020. doi: 10.1108/ECAM-08-2019-0457.
[17] S. Su, “Cabin Placement Layout Optimisation Based on Systematic Layout Planning and Genetic Algorithm,” *Polish Marit. Res.*, vol. 27, no. 1, pp. 162–172, 2020, doi: 10.2478/pomr-2020-0017.
[18] M. Rabanal, “Systematic layout planning: A research on the third party logistics of a peruvian company,” *Advances in Intelligent Systems and Computing*, vol. 1018. pp. 988–993, 2020. doi: 10.1007/978-3-030-25629-6_153.
[19] H. Liu, “A study of the layout planning of plant facility based on the timed Petri net and systematic layout planning,” *PLoS One*, vol. 15, no. 9, 2020, doi: 10.1371/journal.pone.0239685.
[20] K. B. Bagaskara, “Redesign layout planning of raw material area and production area using systematic layout planning (SLP) methods (case study of CV oto boga jaya),” *IOP Conference Series: Materials Science and Engineering*, vol. 852, no. 1. 2020. doi: 10.1088/1757-899X/852/1/012122.
[21] L. Gozali, “Planning the New Factory Layout of PT Hartekprima Listrindo using Systematic Layout Planning (SLP) Method,” *IOP Conference Series: Materials Science and Engineering*, vol. 847, no. 1. 2020. doi: 10.1088/1757-899X/847/1/012001.
[22] S. Khariwal, “Layout improvement of railway workshop using systematic layout planning (SLP)-A case study,” *Materials Today: Proceedings*, vol. 44. pp. 4065–4071, 2020. doi: 10.1016/j.matpr.2020.10.444.

[23] Sunardi, "Redesign of the Production Facility Layout by Using Systematic Layout Planning Method at Cahaya Bintang Mas Company Surabaya," *Journal of Physics: Conference Series*, vol. 1569, no. 3. 2020. doi: 10.1088/1742-6596/1569/3/032007.

[24] D. Zhao, "Layout Design of Warehouse Based on Systematic Layout Planning and GA-ACO Algorithm," *Proceedings - 2020 Chinese Automation Congress, CAC 2020*. pp. 7101–7104, 2020. doi: 10.1109/CAC51589.2020.9327612.

[25] N. R. Alfiansyah, "Increase Productivity by Eliminating Waste and Using Systematic Layout Planning in Airline Catering Service," *IOP Conference Series: Materials Science and Engineering*, vol. 1003, no. 1. 2020. doi: 10.1088/1757-899X/1003/1/012051.

[26] F. Budianto, "Redesigning Furniture Production Floors Using Systematic Layout Planning and ALDEP Method to Minimize Material Handling Costs," *MECnIT 2020 - International Conference on Mechanical, Electronics, Computer, and Industrial Technology*. pp. 84–90, 2020. doi: 10.1109/MECnIT48290.2020.9166613.

[27] D. K. Sobek, "Teaching systematic layout planning using a problem-solving studio approach," *Proceedings of the 2020 IISE Annual Conference*. pp. 1163–1168, 2020. [Online]. Available: https://api.elsevier.com/content/abstract/scopus_id/85105630458

[28] F. G. Tsegay, "Mathematical optimization methods for inner-city construction site layout planning: a systematic review," *Asian Journal of Civil Engineering*. 2023. doi: 10.1007/s42107-023-00713-2.

[29] S. Rohmawati, "The Simulation SIMULASI MODEL SISTEM PELAYANAN TRUCK PADA PROSES MUAT PUPUK DENGAN MENGGUNAKAN SOFTWARE ARENA UNTUK MENGOPTIMALKAN FASILITAS PELAYANAN (Studi Kasus: Gudang Multiguna (GMG) PT Petrokimia Gresik)," *JUSTI (Jurnal Sist. dan Tek. Ind.*, vol. 3, no. 2, pp. 204–216, 2023.

[30] D. Santoso, M. Pradipto, and R. Setiowati, "Usulan Layout Lantai Produksi Industri Mebel Menggunakan Systematic Layout Planning Dan Simulasi," *J. Optimasi Tek. Ind.*, vol. 4, no. 1, pp. 7–12, 2022.