Improving Pallet Control in Mass Consumption Companies: A Proposal for Layout Optimization

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Abstract

The article proposes optimizing pallet control in mass-consumption companies through layout optimization. The study will be conducted in a Peruvian company that experiences an annual loss of $175,000 due to the absence of pallet traceability and management in its distribution centers. The methodology will be the SLP, precisely the quantity, distance, and effort matrix, to develop an appropriate layout design and implement a barcode system to manage and track pallets properly. The study aims to reduce pallet waste and save 32% on indirect materials supply at least annually. The implementation of an automated warehouse, which provides significant improvements to the processes of organizations and better traceability of pallet flows, will be proposed. The study also aims to identify the current management of pallets and their movement in the plant and implement the optimized flow within the plant, adapting it to the company's needs and specificities. The proposed design is expected to improve the company's gross profit and reduce the amount allocated to acquire pallets annually.

Keywords
Pallet, Distribution, Production Plant, WMS, Warehouse

1. Introduction
The mass consumption industry projects an increase since 2020 in Peru of 4.7 million dollars in the 2022 to 5.1 million at the end of 2023 and 5.6 million by 2024. (Euromonitor, 2023). Increased productivity brings the greatest use of indirect manufacturing materials. These materials do not have correct management and traceability, which generates losses of up to 175 thousand dollars annually, which affects the gross profit of the company, according to what was discussed with the head of indirect materials. (McLean et al., 2014), assures that the redesign of the plant improves traceability and organization of indirect and direct materials.

The general objective of the research is to propose an adequate design of a model of Layout in center D for tracking and managing pallets in mass consumption companies. Not without first knowing the current management so that the proposal adapts to the specific needs of the plant and in search of a reduction in the amount allocated to the acquisition of pallets by the company annually.

The design of an automated warehouse is an industry 4.0 solution, since it provides significant improvements to the processes of organizations and is widely used in storage, which proposes better traceability of pallet flows, as well as space optimization (Edouard et al., 2022). One of the main tools to improve the flow of direct materials and indirect, is the design of facilities or PSL (Systematic Layout Planning), which allows reducing the distance traveled by the materials (Meyers et al., 2006). In addition, this methodology provides different distributions to evaluate the one that best suits the company.

In relation to pallet control, barcodes will be implemented, which will be verified by means of a barcode reader or scanner. The implementation of this tool will be integrated into the company's ERP system, which will facilitate the tracking and traceability of pallets throughout the supply chain.

1.1 Objectives
The main objective of this paper is to design of an adequate Layout model in center D for the monitoring and management of litters in mass consumption companies. Identifying the optimal flow of movement of pallets inside the plant by means of simulation in the Arena program. Secondly, to know the current management of the pallets and the movement of them in the plant. Lastly, to implement this flow within the plant adapting it to its needs and particularities.

2. Literature Review

- Auxiliary handling materials: Indirect materials that support manufacturing but are not directly part of it (Chemistry, 2022). They are usually associated with incoming and outgoing logistics. For example: plastic and wooden pallets, stretch film to wrap the direct materials, cardboard to place between the pallets and the direct material. between the pallets and the material.

- Pallet: An indispensable tool for organizations, especially in the supply chain, as it is of utmost importance for the transportation, handling and storage of different types of products, since it is transportation, handling and storage of different types of products, either initial material or finished product (Hung-Lung & Yu-Yu, 2021). These are constructed from layers of boards that are nailed together to give a specific width and thickness (Kaltenbrunner, Kaltenbrunner, 2021). (Kaltenbrunner, Huka, & Gronalt, 2022).

- Environmental Mitigation: Environmental mitigation is an action plan implemented by various private and public entities in order to control, reduce, and avoid environmental impacts associated with the implementation of industrial, agricultural, and commercial projects. (Diéguez Santana, Velin Zabala, Quijano Villarroel, & Pereira Sarduy, 2020).

- Inventory Management: It plays a vital role in the business environment since it is one of the logistics activities in which it is possible to find a high probability of reducing companies' costs. In addition, it regulates stocks such as raw materials, inputs, and components, among others (Lopez, 2018).

- Manufacturing plant: Start-to-finish supply chain for manufacturing a finished product. It includes packaging and input storage, a production plant, finished product storage, a stocking area, and a maintenance warehouse.

- Periodic inventory: Loss control system through taking inventories of material groups, manufacturing code, and production plant every certain established period to control what is available and what is missing and being consumed. Moreover, what is missing and being consumed (Fernández Bedoya, 2020).

3. Methods
An experimental type of investigation will be carried out, since the variables, such as the number of offices, times, distances and loads on the route and amount on pallets can be evaluated in the same company, as many times as needed. The engineering techniques used are the load, distance and effort matrix, the systematic planning of Layout and the simulation in Arena and the relational table of activities to validate the proposal. The research will also be applied, because its purpose will be to resolve a specific problem based on the findings obtained from the experimental material. The center on which the experiment will be carried out was chosen based on three variables; material consumption monthly, number of pallets lost and tons produced annually. Based on this, manufacturing center D was chosen. of 4 centers that the company has to develop research. To compare the situation, act with the proposal; Two variables were evaluated; the plant design, as an independent variable, and the supply cost, as a dependent variable.

In addition, other indicators were included for the evaluation of the proposal, such as annual investment in pallet supply, and average pallet life time.

4. Data Collection

The method applied in order to collect data for the investigation, includes sampling, collecting a measuring the data one site. The sampling size is calculated via the management system that the company uses to save historical data. To approve the future proposals, the inicial sampling size is used to estimate the values on Arena if the proposal was approved.

In regard to comparing the company and its processes with other companies in the market, they were compared with certains kpis to evaluate if the possible results were of the same nature. Average tons shipped monthly, average tons of finished goods produced, cost of indirect material monthly and type of company, foods or nonfoods.

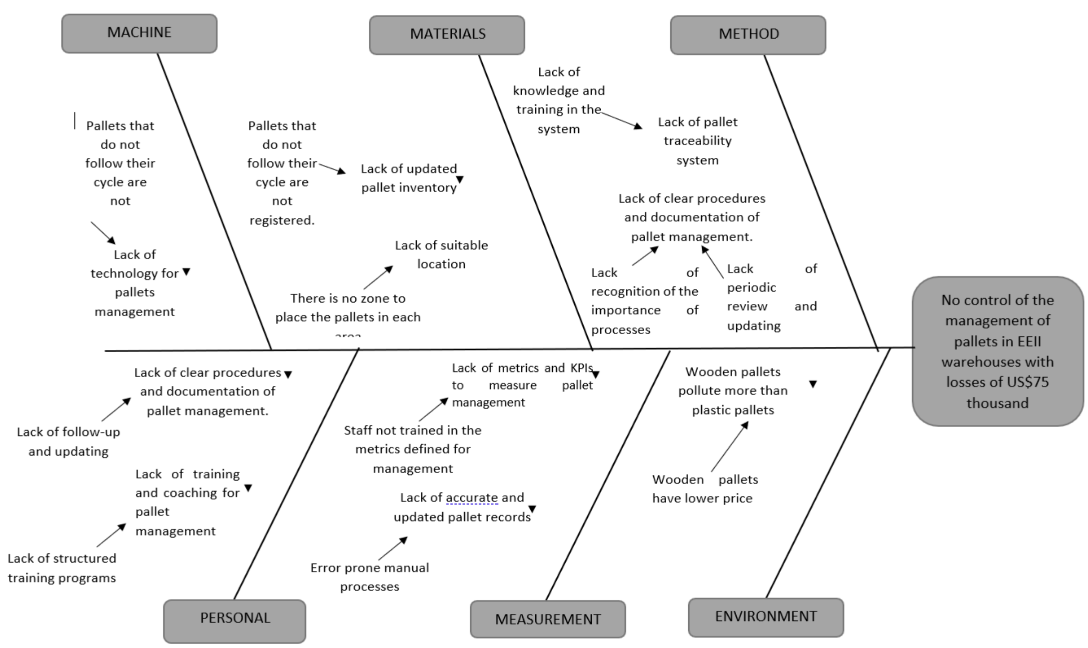
5. Results and Discussion

Because the company has 4 manufacturing centers, the matrix is made considering the monthly material consumption (A), the number of pallets lost (B) and the tons produced monthly (C) as factors to select the sample that will be the center for studying (Table 1-Table 10).

Table 1. Table of factors

Factor	Weighted	Center A	Center B	Center C	Center D
A	50%	1.5	1	2	1.5
B	25%	0.25	0.25	0.5	1
C	25%	1	0.25	0.5	0.75
Total		2.75	2	3	3.25

Then, the Ishikawa diagram is made.



From this, it is determined that the main root cause of poor pallet control is the lack of adequate distribution within the plant. Thirdly, the sample size of shipments on pallets in center D is determined, considering the last 6 months.

Table 2. Average Dispatches

Month	Dispatches in pallets
July 2022	5194
August 2022	5020
September 2022	5754
October 2022	5635
November 2022	4603
December 2022	5170
Average	5229

From this, the sample size statistical formula is applied taking into account 5000 shipments on pallets as the total population. Resulting in the ideal sample size of 94 dispatches on pallets in center D.

Table 3. Sample's size calculation

Factor	Result
Confidence Level	95%
Population size	5000
Margin of error	5%
Sample size	94 shipments on pallets

Below, the current plane and the points through which the pallet flow occurs (Figure 1).

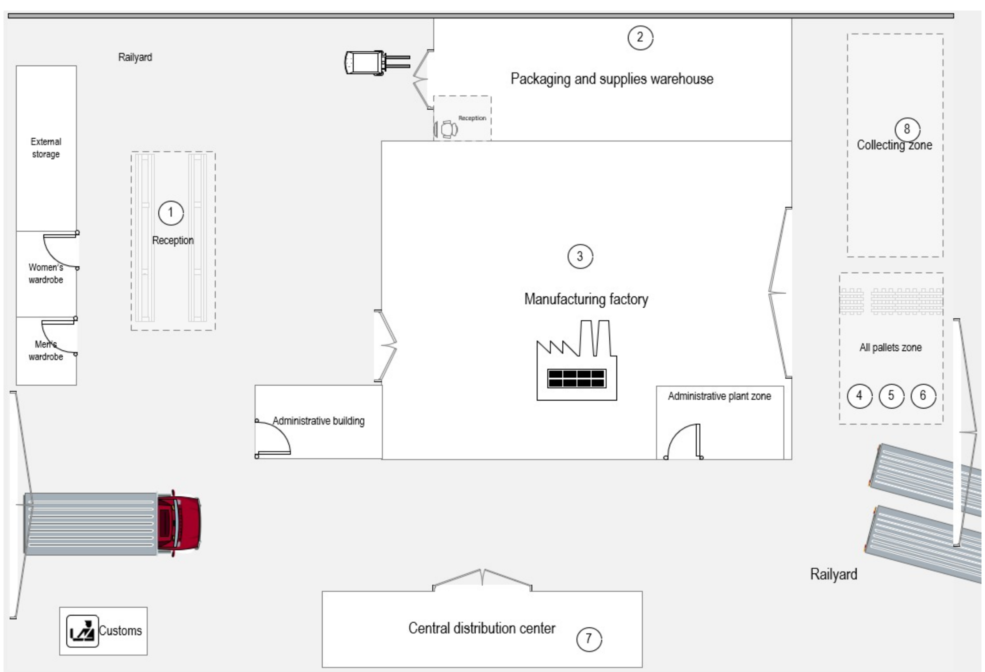


Figure 1. Initial Plan

Sampling results, the diagram is shown with the average pallet loads between the points on the map (Figure 2).

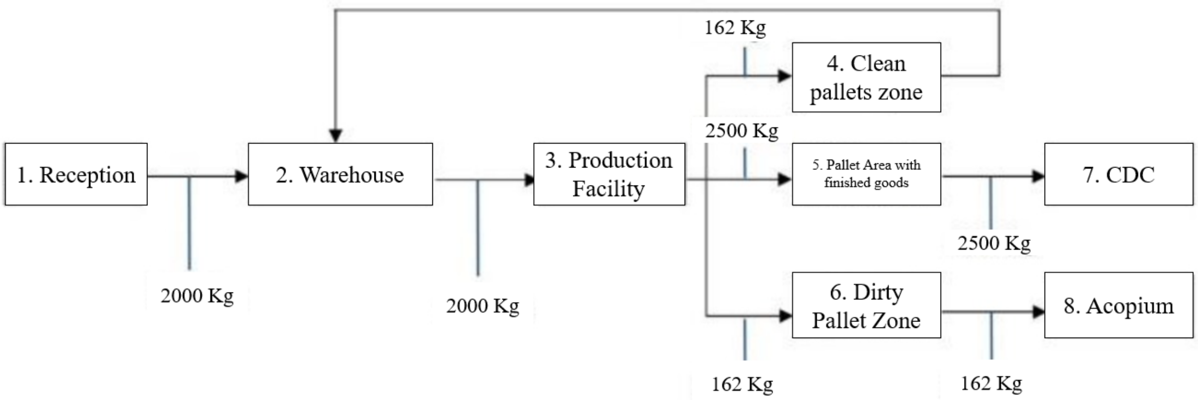


Figure 2. Block Diagram

With this, the load matrix and the distance matrix are determined. From these two matrices, the current total effort made by the operational team in handling litters is calculated.

Table 4. Effort matrix – distance and effort

	Load (kg)	Distance (m)	Effort (kg - m)
1-2	2,000	50	100,000
2-3	2,000	15	30,000
2-4	162	150	24,300
3-4	162	20	3,240
3-5	2,500	20	50,000
3-6	162	20	3,240
5-7	2,500	65	162,500
6-8	162	20	3,240
Total			376,520

The ideal areas that warehouses should have in the new proposal were calculated from the average turnover days. In addition, three floors in the racks and 70% of the total warehouse area dedicated to storage were taken into account.

Table 5. Estimation of the area of the input warehouse

Concept	Value	Measurement unit
Average turnover days	35	days
Daily consumption	10	pallets
Average inventory	350	pallets
Rack leves	3	levels
Minimun positions	120	positions
Percentage dedicated to storage	144	m2
Total requiered meters	206	m2

Table 6. Estimation of the area of the distribution warehouse

Concept	Value	Measurement unit
Average turnover days	15	days
Daily consumption	30	pallets
Average inventory	450	pallets
Rack leves	5	levels
Minimun positions	90	positions
Percentage dedicated to storage	108	m2
Total requiered meters	154	m2

With the results of the effort matrix it is observed that points 1-2 and 5-7 must be brought closer together. Based on this and the established minimum areas, two distribution plans are proposed, shown below. In this first proposal, the packaging and supplies warehouse is located between the lifeline reception area and the production plant so that, with the same load, the effort emitted is reduced. Respecting the minimum area with parameters of 11x20m2. In addition, a pallet area is proposed for clean pallets and finished product, each with its own access route. Within it, the clean pallet area is closest to the packaging and supplies warehouse since it is where they must return and the finished product area to the distribution center. Regarding the pallets with shrinkage, a space is allocated in the upper right corner of the plane, so that it does not have contact with the other areas for the health and safety of the staff. Finally, the collection area is exchanged with the distribution center in order to mitigate the proximity between the finished products with the storage area. Again, the distribution center respects the total area determined, which follows the parameters of 8mx20m.

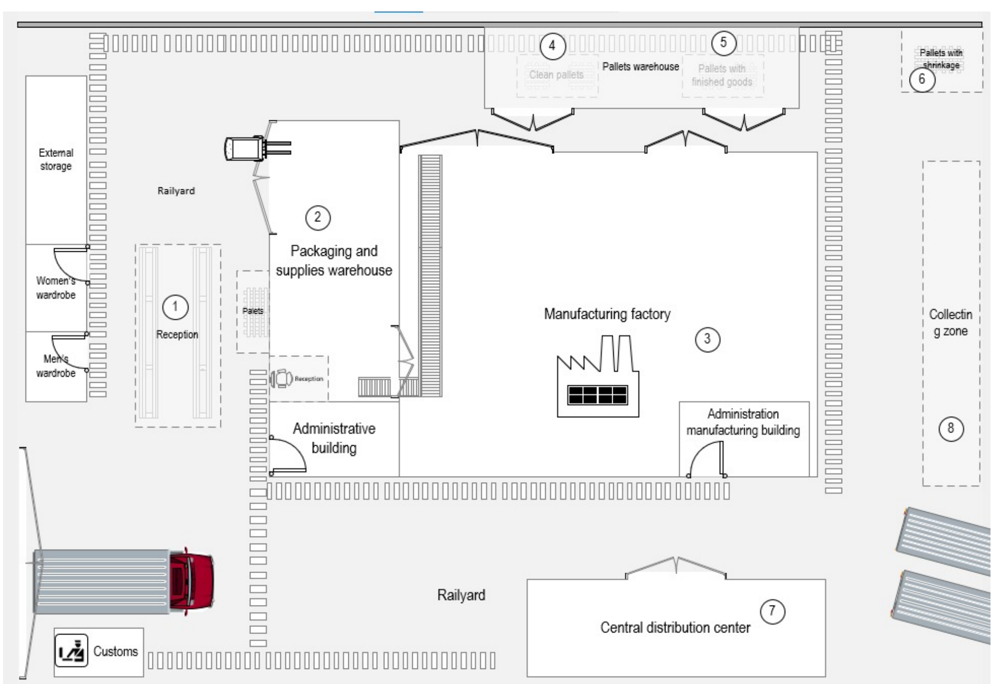


Figura 3. Proposed Plan 1

Below is the loading distance matrix calculated for the first proposal.

Table 7. Effort matrix – distance and effort

	Load (kg)	Distance (m)	Effort (kg - m)
1-2	2,000	15	30,000
2-3	2,000	10	20,000
2-4	162	35	5,670
3-4	162	10	1,620
3-5	2,500	10	25,000
3-6	162	10	1,620
5-7	2,500	60	150,000
6-8	162	10	1,620
Total			235,530

In the second proposal, the packaging and supplies warehouse is placed again between the supplies reception area and the production plant, respecting the required area of 11 x 20 m2.

Regarding the clean pallet areas, an area of 4 x 3 m2 was assigned outside the production plant and within close reach of the input warehouse, so as to facilitate handling. As for the pallets with finished product, they were also assigned another space of the same size outside the production plant, in the upper corner of the plan and in front of the distribution center. This, so that it is not close to the collection area and has no possibility of contamination. Finally, the pallet area with shrinkage was located on the other side of the plant and to the side of the storage area. The search for the proximity of these last two areas and their distance from the rest of the warehouses and areas is vital for the management of solid and liquid waste. As can be seen in the Figure 3-6, this reorganization locates each pallet area by creating new exit and access doors to the production plant. In turn, each area is located next to the warehouse, distribution center or collection area by exchanging pallets between them. This facilitates the exchange of pallets without margin for error.

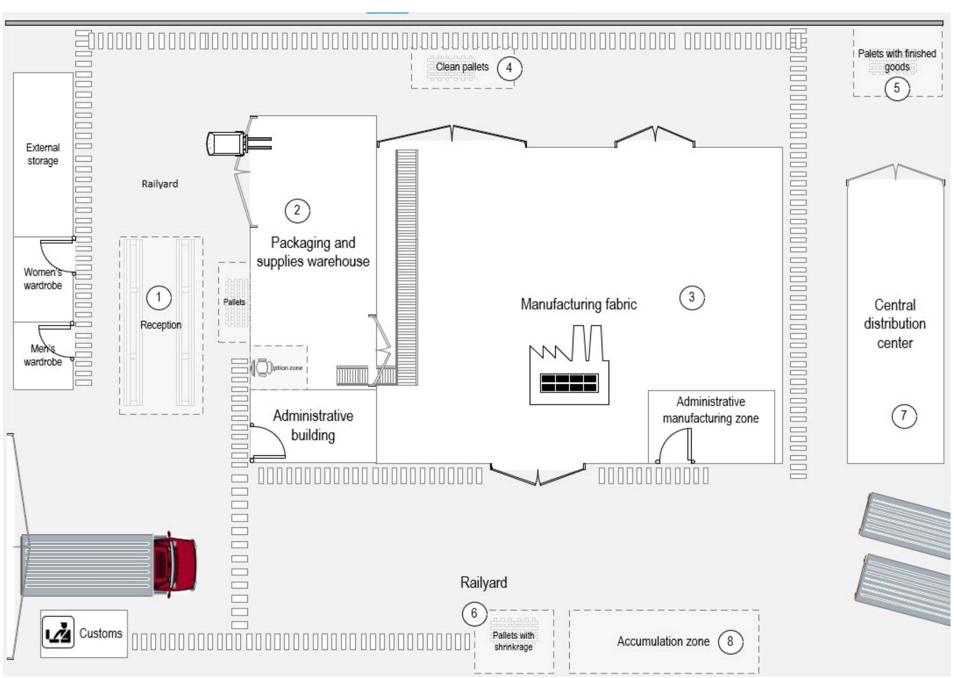


Figure 4. Proposed Plan 2

Below is the loading distance matrix calculated for the second proposal.

Table 8. Matrix – load, distance and effort

	Load (kg)	Distance (m)	Effort (kg - m)
1-2	2,000	15	30,000
2-3	2,000	10	20,000
2-4	162	40	6,480
3-4	162	5	810
3-5	2,500	15	37,500
3-6	162	20	3,240
5-7	2,500	10	25,000
6-8	162	5	810
Total			123,840

Finally, the first proposal presents a total effort of 235,530 kg-m, compared to the second, which presents an effort of 123,840 kg-m. With these two results, the second distribution to be implemented is chosen. The summary of the results is shown below and its variation with respect to the other proposals.

Table 9. Variation of efforts

Efforts	Original layout	Proposal 1	Proposal 2
Differential	329,770	235,530	123,840
		28%	62.40%

5.4 Validation

To validate the chosen proposal, the simulation was carried out in the Arena program, in order to compare indicators previously obtained in the sampling and the following results were obtained.

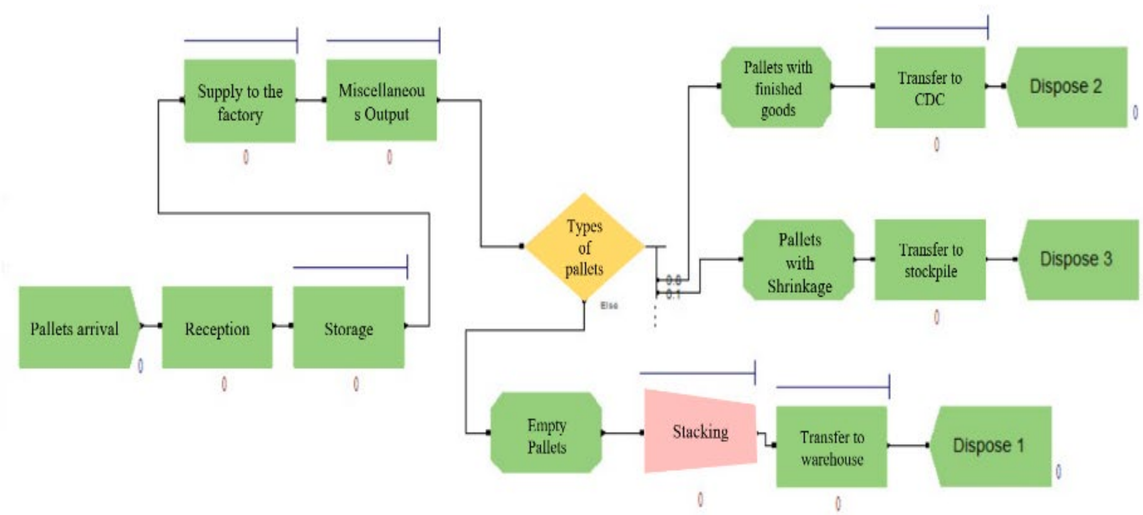


Figure 5. Arena

Table 10. KPIS

KPIS	Original layout	Proposal 1
Average travel time	45 min	15 min
Average lifetime of a pallet	1 year	2.5 years
Loss rate	22%	4%

The relational table of activities is also shown in order to verify that the proposal considers the closeness or distance that each of the areas should have them.

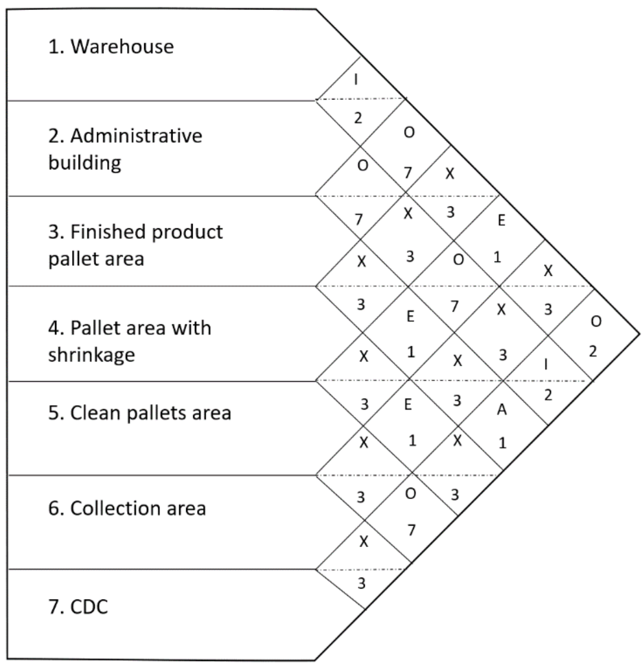


Figure 6. Relational Table of Activities

The size of the order to be placed was recalculated taking into account that of the total pallets used each year, 30% expire (Table 11-Table 13)

Table 11. Estimation of the size of economical lot

Concept	Value
Demand	280 pallets
Order cost	55 USD/order
Storage cost per position	15 USD/month
Pallets per position	6 pallets
Size of economical lot	27.7 pallets

Table 12. Total annual cost

Concept	30 pallets
Adquisition cost	450 USD
Orders per year	10 orders
Anual adquisition cost	4500 USD
Order cost	55 USD/ order
Total anual order cost	550
Total anual cost	5050 USD

From this, it was validated that acquisition costs decrease compared to the initial situation

Table 13. Comparison

Concepto	Value
Total anual base cost	15700
Total anual proposed cost	5050

Finally, the steps to follow for the implementation of the WMS on the pallets, a tool that connects to the company's ERP.

1. Obtaining the supplier's barcodes
2. Request for pallets from the supplier.
3. Entry of pallets to the warehouse, in which the logistics operator places the codes. This store information such as pallet supplier, returns made, manufacturing batch, age of the pallet, etc.
4. Use of scanning pallets at each point in charge of each logistics operator.
5. Disposal of the pallets and sending to the collection area in which the barcode is also removed.

6. Conclusion

This work started from the perspective of a plant that had a poor distribution, which meant that the pallets did not have correct traceability. It is for this reason that the Layout design and the effort matrix were applied, which allowed us to identify which of The proposals generate less effort to be the one chosen. According to Súle (2001), efficient distribution can also contribute to the reduction in production cycles, material handling, etc. For the correct distribution, loads and the distance to the travel point were taken, to later make calculations of the effort and the number of pallets that are removed during the process. It is in this sense that the proposed distribution presents less effort than the current one. Furthermore, as Batista Martins & Tavares de Freitas (2011) mention, good distribution helps with flexibility and reduction of time by up to 20%. In the same way, the new proposed distribution presents a travel time of 15 minutes compared to 45 minutes in the current version, the result being 66% less than in the original plan. Furthermore, according to Mejia et al. (2011) the correct tracking of materials through a control system improves the lifetime of indirect materials by not rotating outside their established flow. The average lifetime of the pallets in the current distribution is 1 year; however, in the proposed design it is 2.5 years.

Finally, the research allowed us to determine what would be the ideal flow through which the pallets should be managed, and this also allowed savings of 32% of the total annual supply costs of indirect materials. Finally, this could be achieved with the WMS tool connected to the company's ERP.

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