

APPLYING THE AHP METHOD FOR SELECTING THE LOCATION OF A FINISHED GOODS WAREHOUSE: A CASE STUDY IN AN EMULSIFIER COMPANY IN THE VALE DO PARAÍBA

**APLICAÇÃO DO MÉTODO AHP NA ESCOLHA DO LOCAL DE
ARMAZENAGEM DE PRODUTOS ACABADOS: ESTUDO DE CASO
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ABSTRACT

This study aims to analyze the feasibility of relocating the finished goods storage facility of a natural emulsifier manufacturing company, which currently stores its products in a rented warehouse in Taubaté city, São Paulo, Brazil, located at a distance from its production unit in Potim. This arrangement results in high logistics costs and operational challenges, such as frequent transportation, quality control, and product traceability. The proposal to centralize storage operations in Potim emerges as a strategic alternative to reduce costs and optimize cross-department integration. Additionally, the relocation may contribute to reducing the company's carbon footprint by minimizing material handling and transportation, in accordance with sustainability demands and international certifications such as FSSC 22000, Halal, and Kosher. To support decision-making, the Analytic Hierarchy Process method will be applied, which enables the structuring and prioritization of technical, logistical, operational, and strategic criteria through pairwise comparisons. The analysis will consider three alternatives: maintaining the current rented warehouse, refurbishing an existing facility in Potim, or constructing a new structure at the same site. Evaluation criteria include cost, return on investment, flexibility for expansion, sustainability, integration with production, and asset security. The study begins with mapping the current storage process, followed by defining the key decision criteria and applying AHP to rank and analyze the alternatives. The results include identifying the most efficient solution aligned with the company's strategic goals. It is concluded that the AHP method can significantly support complex logistics decisions by providing a structured and quantitative basis for selecting the most suitable storage location.

Keywords: Storage; Logistics; Decision-Making; AHP; Sustainability

RESUMO

Este trabalho tem como objetivo analisar a viabilidade da mudança do local de armazenagem de produtos acabados em uma empresa fabricante de emulsificantes naturais, atualmente localizada em galpão alugado em Taubaté, São Paulo, Brasil, distante da unidade produtiva localizada na cidade de Potim. Tal disposição gera custos logísticos elevados e dificuldades operacionais, como controle de qualidade e rastreabilidade. A proposta de centralizar a armazenagem em Potim visa reduzir custos e otimizar a integração entre setores. Além disso, a mudança pode contribuir para a redução da pegada de carbono, atendendo a exigências de sustentabilidade e certificações internacionais, como FSSC 22000, Halal e Kosher. Para embasar a tomada de decisão, será utilizado o método Analytic Hierarchy Process (AHP), que permite estruturar e hierarquizar critérios técnicos, logísticos e estratégicos por meio de comparações pareadas. A análise considera três alternativas: manutenção do galpão atual, reforma de galpão em Potim ou construção de nova estrutura. Os critérios de avaliação incluem custo, retorno do investimento, flexibilidade, sustentabilidade, integração com a produção e segurança. O estudo parte do mapeamento do processo atual de armazenagem, seguido pela definição dos critérios e aplicação do AHP para hierarquização e análise das alternativas. Os resultados envolvem a identificação da opção mais eficiente e alinhada às necessidades estratégicas da empresa. Conclui-se que a aplicação do AHP pode contribuir significativamente para decisões logísticas complexas, ao fornecer uma base quantitativa e estruturada para a escolha do local de armazenagem mais adequado.

Palavras-chave: Armazenagem; Logística; Tomada de Decisão; AHP; Sustentabilidade

Como Citar:

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INTRODUCTION

This study aims to analyze the feasibility of relocating the storage site for finished products in a company that manufactures natural emulsifiers. Currently, the company uses a rented warehouse in Taubaté, located away from the production plant in Potim. This arrangement generates high logistical costs and operational difficulties related to frequent material handling, quality control, and product traceability.

The proposal to centralize storage at the production facility in Potim emerges as a strategic alternative to the current condition, seeking to reduce logistical costs and optimize integration between departments. Such centralization would enable more efficient inventory management, greater agility in order fulfillment, and improved product traceability. Furthermore, it aligns with the principles of Lean Manufacturing, a management philosophy focused on waste elimination and continuous improvement (Womack; Jones, 2004), since decentralized storage represents a significant source of operational waste, particularly through excessive transportation and duplicated movements (Rios, 2015).

According to Slack et al. (2009), the application of lean practices allows for significant improvements in quality, speed, and reliability, which is particularly relevant in demanding supply chains such as the food industry. The proposal also contributes to reducing the company's carbon footprint, aligning with current trends in operational sustainability.

Given the rigor of certifications required in the sector, such as FSSC 22000 (Food Safety System Certification, 2024), Halal, and Kosher (Ifanca, 2023; Kosher, 2023), the change in storage location must consider not only logistical and operational criteria but also quality and food safety requirements, which are essential to maintaining compliance with international markets and specific customers. To support the decision-making process, the Analytic Hierarchy Process (AHP), developed by Saaty (1980), was adopted. The AHP is widely applied in solving complex problems involving multiple decision criteria. It enables the hierarchical structuring of technical, logistical, operational, and strategic criteria based on pairwise comparisons, resulting in an objective prioritization of alternatives (Vargas, 2010).

Several recent studies highlight the effectiveness of the AHP method in logistical and storage decisions. Panek et al. (2025) applied AHP in the technological selection of logistics facilities, demonstrating improvements in reliability and efficiency. Similarly, Testoni et al. (2024) used AHP to prioritize logistics providers in banking services, while Vieira et al. (2017) proposed a framework

based on the method for distribution center operations. Garcia et al. (2025) explored the use of AHP to evaluate operational integration and the feasibility of warehouse relocation, emphasizing its usefulness in optimizing physical structures and logistical flows. Herrera and Santos (2024) developed an AHP-based model for distribution centers, reinforcing the applicability of the technique in strategic storage contexts. The combination of AHP with Geographic Information Systems (GIS) was investigated by Rodriguez and Vargas (2025), who applied both in the selection of logistics center locations, strengthening multicriteria analysis with geospatial data.

In the industrial context, Soares et al. (2012) demonstrated how integrated logistics can benefit specific production chains, such as swine farming, when combined with process centralization. Weiland et al. (2022) reinforce this perspective by proposing production management models that consider the nature of inputs and storage structures as critical factors. Based on the reviewed literature, this study structures three storage alternatives: (1) maintaining the current situation with the rented warehouse in Taubaté; (2) refurbishing an existing warehouse in the Potim industrial complex; and (3) constructing a new facility in the same location. These alternatives will be evaluated using the AHP method based on criteria such as cost, return on investment, operational efficiency, and compliance with regulatory requirements, thereby enabling a robust and well-founded comparison among the options.

This approach will allow the company to identify the most advantageous alternative not only from a financial standpoint but also from strategic and operational perspectives, contributing to enhanced competitiveness in the sector. Beyond its applied relevance, this study offers both scientific and practical contributions. From an academic perspective, it expands the understanding of the use of the Analytic Hierarchy Process (AHP) in the evaluation of logistical alternatives in industrial contexts particularly in the food sector, where regulatory and quality requirements are critical. By incorporating multiple technical, operational, and strategic criteria, the research demonstrates the robustness of AHP as a decision-support tool for complex, multi-objective problems, corroborating recent studies such as those by Garcia et al. (2025), Herrera and Santos (2024), and Rodriguez and Vargas (2025). From a practical perspective, the results provide direct support to the company's logistics management, guiding decision-making regarding the centralization of finished product storage and promoting improvements in efficiency, traceability, and sustainability. Thus, the study not only contributes to

the literature on industrial logistics and multicriteria decision-making but also presents concrete recommendations with the potential to generate measurable operational gains.

This work is structured into six sections: the present introduction, which outlines the context and objectives of the study; theoretical framework, which discusses the main concepts related to logistics, storage, and the AHP method; methodology, which details the adopted procedure; case study, which characterizes the company and the problem; application of the AHP method, with an analysis of criteria and alternatives; and finally, the conclusion, which synthesizes the main findings and proposes directions for future research.

LITERATURE REVIEW

The reduction of operational costs combined with sustainability is one of the main challenges and objectives of modern logistics operations. In the logistics chain of the company under analysis, the centralization of storage in Potim, where the production plant is located, emerges as a strategic alternative to reduce transportation costs and improve overall system efficiency. This change directly impacts business sustainability by decreasing unnecessary movements, reducing the use of fossil fuels, and contributing to the reduction of carbon emissions actions aligned with SDG 13 of the United Nations 2030 Agenda (UN, 2025).

According to Bai et al. (2021), minimizing transportation is one of the most effective strategies for reducing greenhouse gas emissions, especially in operations with high frequency of material handling. The proposal to integrate storage and production can significantly contribute to the decarbonization of operations and compliance with regulatory and environmental requirements. Moreover, sustainable practices such as the adoption of clean technologies, material reuse, and automated systems reinforce the company's commitment to environmental responsibility (Seuring; Müller, 2023).

From an economic standpoint, Carter and Rogers (2008) argue that sustainable practices contribute to reducing operational costs and increasing competitiveness. Companies that adopt solutions such as efficient inventory management, emissions monitoring, and the integration of green technologies tend to improve their organizational performance (Pereira *et al.*, 2022). Transportation reduction also enhances predictability and logistical reliability, while mitigating operational risks

associated with losses, delays, and damages.

Thus, the centralization of storage not only optimizes resources and reduces waste but also strengthens the company's institutional image before consumers and partners, consolidating its position in markets that value sustainability.

The Analytic Hierarchy Process (AHP) is one of the most widely used techniques in multicriteria decision-making involving both quantitative and qualitative factors, and it can contribute to reducing operational costs. Developed by Saaty (1980), AHP enables the hierarchical structuring of criteria and alternatives through pairwise comparisons, assigning relative weights that reflect the importance of the factors considered. This methodology is extensively applied in organizational and logistical contexts that require structured decision-making in complex environments (Vargas, 2010).

The applicability of AHP in logistics decision-making has been demonstrated in several recent studies. Garcia et al. (2025) highlight the effectiveness of the method in evaluating alternatives for warehouse relocation, considering not only costs but also operational and strategic criteria. Herrera and Santos (2024) demonstrate the usefulness of AHP in the integrated management of distribution centers, showing its contribution to improving operational efficiency. Rodriguez and Vargas (2025) combine AHP with Geographic Information Systems (GIS) to define ideal storage locations based on accessibility, infrastructure, and regional logistics.

Similarly, Testoni et al. (2024) applied AHP to the prioritization of third-party logistics providers in the banking sector, highlighting the method's flexibility in diverse contexts. Panek et al. (2025) reinforce this versatility by applying AHP in the selection of technologies for logistics facilities, combining technical, environmental, and operational reliability criteria. In addition to its logical structure and adaptability, AHP promotes participatory and transparent processes, involving different stakeholders in decision-making. Vieira et al. (2017) argue that the clarity in defining criteria and the ability to represent human preferences are determining factors for the method's widespread adoption in corporate environments. The research of Weiland, Abreu, and Piran (2022) in the food industry further reinforces the value of AHP for logistics decisions involving safety, quality, and sustainability.

METHODOLOGY

This study can be classified as an applied, quantitative field research, focused on the analysis of multiple criteria for decision-making within a specific case study. Field data collection enabled the gathering of information, providing a detailed understanding of the case under investigation. In this process, the study applies the Analytic Hierarchy Process (AHP) to rank and weight relevant criteria, using numerical scales to represent preferences and qualitative judgments.

The AHP facilitates a structured analysis of alternatives based on multiple criteria, which may be either subjective or objective, thereby helping to identify the most suitable solution within the specific context of the case study. This research is also characterized as descriptive and exploratory, since it seeks to characterize the problem or the alternatives involved in the decision-making process, while simultaneously exploring feasible solutions for the case under analysis. Field data collection offers a comprehensive view of different perspectives, while the AHP method organizes this information into a hierarchical structure, enabling more well-founded and effective decision-making.

By integrating qualitative and quantitative data, the research becomes a powerful tool for addressing complex problems and decisions involving multiple criteria, providing an in-depth understanding of the specific case. Regarding the methodological flow, this study adopts a structured approach in seven stages: (1) Literature Review; (2) Case Study; (3) Hierarchical Structuring of the Decision; (4) Application of the AHP Method; (5) Technical Evaluation of the Alternatives; (6) Analysis and Discussion of Results; and (7) Conclusion Development.

CASE STUDY

The company under analysis is a Brazilian manufacturer of natural emulsifiers, primarily used in the food industry. Currently, its finished products are stored in a rented warehouse located in the municipality of Taubaté (SP), approximately 58 km from the industrial plant situated in Potim (SP). This logistical configuration has generated significant impacts on the company's operational efficiency and costs, mainly due to the constant need for transportation between the two locations, the duplication of material handling, and limitations in the integration of production, quality control, and shipping areas. The absence of a storage center integrated with the manufacturing facility also undermines

product traceability and sanitary control, which represents relevant operational risks, especially given the requirements of international certifications such as FSSC 22000, Halal, and Kosher.

In this context, the company is considering the possibility of centralizing its storage operations at the Potim plant, as a means to reduce costs, minimize logistical losses, and increase compliance with the standards demanded by national and international markets. The proposed change is aligned with the principles of Lean Manufacturing, a management approach focused on waste elimination and increased production efficiency, particularly in operations where excessive transportation and decentralized logistics do not add direct value to the customer. Frequent transportation of materials between separate facilities also undermines predictability and operational safety, which can be mitigated by implementing an integrated storage solution. Leaner and better-coordinated operations tend to improve key performance indicators such as quality, speed, and reliability, which are essential in highly demanding production chains such as the food industry.

To structure the analysis and support decision-making, the Analytic Hierarchy Process (AHP) was adopted. This method allows for the hierarchical structuring of criteria and the evaluation of alternatives based on multiple factors. AHP is widely applied in logistics to support complex decisions, ranging from the selection of distribution center locations to the choice of third-party providers. The method decomposes problems into a clear hierarchical structure, comparing elements through relative judgments. The methodological contribution of AHP has been recognized in technological selection decisions focused on reliability and efficiency in logistics facilities.

The study considered three distinct logistical scenarios: maintaining storage in Taubaté, refurbishing a decommissioned warehouse at the Potim plant, and constructing a new storage facility at the same site. The analysis was based on the evaluation of criteria such as investment cost, payback period, flexibility, environmental sustainability, compliance with international standards, integration with production, and asset security. The identification and prioritization of these criteria were conducted through an adapted SWOT analysis, mapping the strengths, weaknesses, opportunities, and threats associated with each alternative. This process enabled the construction of the AHP judgment matrix and the application of the method for comparing alternatives.

The application of AHP revealed that centralizing storage at the Potim plant, whether through refurbishment or new construction, outperformed the current arrangement in nearly all criteria analyzed, particularly regarding operational integration, sanitary control, and sustainability. The construction alternative proved advantageous in terms of flexibility and compliance with international technical standards, although refurbishment offered a quicker return with lower investment. Maintaining the current situation, despite avoiding immediate investments, was the least favorable option, as it perpetuates high logistical costs and existing operational risks.

By adopting a multicriteria approach based on AHP, the study provides a robust foundation to support the company's strategic decisions, contributing to a more efficient and integrated logistical redesign aligned with sustainability and competitiveness objectives. Furthermore, by incorporating both qualitative and quantitative criteria, the analysis balances financial, technical, and regulatory factors an essential aspect for industries embedded in complex supply chains such as the food sector. The literature review and applied study also reinforce the importance of coordinated management of inventories and production operations.

APPLICATION OF THE AHP METHOD

This section presents the application of the Analytic Hierarchy Process (AHP) to support decision-making regarding the most suitable warehousing alternative for the company. Based on the information gathered in the case study, the evaluation criteria and the logistical alternatives were defined. AHP was employed to structure the problem, perform pairwise comparisons among criteria, assign relative weights, and, finally, rank the options according to their feasibility.

The objective of this study is to apply AHP to compare three warehousing alternatives and, based on previously defined criteria, identify the most viable option for the company. AHP stands out for enabling structured decision-making in situations involving multiple criteria, combining qualitative and quantitative assessments in a hierarchical manner. In this study, the method is used to weigh and prioritize the logistical options according to strategic, operational, and financial factors aligned with the organization's context and objectives.

The alternatives considered were derived from the analysis of the company's current situation and its future possibilities regarding finished goods storage. The first alternative is to maintain the warehouse in Taubaté, where the company already has an operational facility, albeit with high monthly costs and long-term limitations. The second alternative is to refurbish an existing warehouse at the Potim plant, which would require a significant initial investment but could lead to substantial monthly savings, greater integration with production, and reduced operating expenses such as rent. The third alternative is to construct a new warehouse in Potim, involving a higher initial investment but offering the opportunity to design a facility fully aligned with the current and future needs of the operation.

The development of these alternatives considered not only direct costs, such as refurbishment or construction, but also operational factors including proximity to production, efficiency of logistical processes, reduced transportation needs, and potential for expansion. From a strategic perspective, the analysis also examined how each alternative could affect the company's growth, flexibility to meet future demand, and the long-term sustainability of operations. These considerations provided the basis for defining the criteria used in the AHP model.

Through the application of AHP, the study aims to produce a clear ranking of the alternatives, indicating which one offers the best balance between cost-effectiveness and strategic alignment. The resulting analysis will support the company in selecting the most advantageous solution for its context, grounded in a solid and well-established methodology. Thus, the study contributes not only to the immediate decision on warehousing but also to enhancing logistics management and strengthening analytical capacity in complex decision-making processes.

For the application of AHP, it was necessary to define criteria representing the main aspects to be considered in selecting the best warehousing alternative. These criteria were established based on the analyses conducted throughout the case study, taking into account operational, financial, and strategic factors relevant to the company. The careful selection of these elements ensures that the comparison among alternatives is consistent with organizational objectives and the reality observed in practice. Table 1 presents the criteria adopted in the hierarchical structure of the method.

Table 1 | Evaluation Criteria.

Criteria	Description
Payback	Time required to recover the investment
Expansion Flexibility	Ability of the alternative to support the company’s future growth
Sustainability	Environmental impact, energy efficiency, and carbon emissions
Quality Control and Traceability	Ability to maintain high standards of food safety and logistics traceability
Accessibility	Ease of access for companies to retrieve materials
Costs	Operational costs of the alternative
Integration with Production	Degree of connection between the storage facility and the production line
Asset Security	Risks of theft, vandalism, or accidents at the site
Implementation Time	Time required to make the alternative operational
Strategic Location	Proximity to customers, suppliers, or distribution centers

Source: Prepared by the authors.

Defining the evaluation criteria is a crucial step in the application of the Analytic Hierarchy Process (AHP), as they guide the comparison among alternatives in a structured and coherent manner aligned with the study’s objectives. The first criterion considered is payback, which represents the time required for the investment in each alternative to be recovered through the generated savings. This indicator is fundamental in financial analyses, as alternatives with shorter payback periods tend to be more attractive economically, particularly in contexts with limited resources or the need for rapid returns.

Another important criterion is expansion flexibility, which assesses the ability of the alternative to support the company’s future growth. Facilities that allow for expansion or adaptation to new logistical processes represent a strategic advantage, as they reduce the need for additional investments in the short or medium term. This criterion is especially relevant in dynamic markets, where the company must quickly respond to changes in demand or increase production capacity. Sustainability was also included as a criterion, considering environmental impact, energy efficiency, and carbon emissions associated with each alternative’s operation. Given the growing importance of Environmental, Social, and Governance (ESG) practices in corporate settings, choosing more sustainable solutions can generate long-term value, enhance the company’s institutional image, and even create opportunities for tax incentives or strategic partnerships.

The quality control and traceability criterion is directly related to the alternative’s capacity to maintain high standards of food safety and logistical control. In sectors dealing with sensitive products,

such as food or industrial inputs, rigorous oversight of processes and material traceability is essential to meet regulatory requirements and ensure customer trust. Alternatives that provide better conditions for these controls tend to be prioritized.

Accessibility to the storage location directly influences delivery speed, supply chain efficiency, and the satisfaction of both internal and external customers. Operational costs, including expenses related to energy, labor, and maintenance, also directly impact operational profitability. Thus, an alternative with lower operating costs may be favored, even if it requires a higher initial investment. Considering all these criteria, AHP enables a balanced and strategic evaluation, resulting in a well-grounded choice aligned with the company's needs.

Integration with production is a fundamental criterion in internal logistics and operational efficiency. This criterion evaluates the physical and functional connection between the storage facility and the company's production line. Warehouses located near or integrated with the manufacturing plant tend to significantly reduce material transport times, lower the risk of communication failures between departments, and facilitate a more continuous and lean production flow. Additionally, this integration can simplify inventory control and material replenishment, optimizing workflow and overall operational productivity.

Asset security is another critical aspect in selecting the best warehousing alternative. This criterion considers risks associated with the location, such as theft, vandalism, or accidents that may compromise the integrity of stored products. A warehouse offering higher physical protection such as access control, monitoring systems, alarms, and adequate lighting tends to reduce losses and insurance costs while enhancing reliability for partners and clients.

Implementation time is also a relevant factor, especially in contexts where the company needs to make prompt decisions to address logistical bottlenecks or meet increased demand. This criterion accounts for the time required for each alternative to become fully operational. Solutions requiring structural renovations or new construction naturally demand more time, representing an opportunity cost. Alternatives that require fewer adjustments or leverage existing facilities can be implemented more quickly.

Finally, strategic location examines the warehouse’s geographic position relative to customers, suppliers, and distribution centers. A well-located warehouse can reduce transportation costs and lead times, improve customer service, and facilitate the receipt and dispatch of goods. This criterion also affects access to labor, third-party logistics services, and urban infrastructure, which can be decisive for operational success. By including location as an AHP criterion, the company ensures that the decision considers not only physical space but also the warehouse’s strategic role within the supply chain.

To continue the application of the AHP method, a pairwise comparison matrix was developed for the defined criteria. This step is essential for assigning relative weights to each criterion according to its importance in the decision. The matrix allows criteria to be compared two by two based on the judgment of decision-makers in this case, one of the authors, who is an employee and manager within the studied company. From these comparisons, it is possible to calculate the weights each criterion will carry in evaluating the alternatives, ensuring that the final choice reflects the company’s strategic, operational, and financial priorities. In the Analytic Hierarchy Process, pairwise comparisons are used to evaluate the relative importance of one criterion against another. The values follow a scale proposed by Saaty (1990), as shown in Table 2.

Table 2 | Saaty scale.

Values	Intensity of Importance	Description
1	Equal Importance	Both criteria have equal importance
3	Weak Importance	One criterion is slightly more important
5	Moderate Importance	One criterion is moderately more important
7	Strong Importance	One criterion is strongly more important
9	Absolute Importance	One criterion is absolutely more important

Source: Prepared by the authors.

It is important to highlight that when fractions such as 1/2, 1/3, or 1/5 are used, it indicates that the criterion in the column is more important than the one in the row. The Saaty scale is designed to reflect human perception in comparing criteria, allowing a balance between simplicity and precision. It provides a range of values that not only clearly differentiate the relative importance of each criterion but also allow for expressing uncertainties or nuances in decision-making.

For example, choosing between “one criterion is slightly more important than the other” (value 3) or “moderately more important” (value 5) can capture subtleties that make the analysis more faithful to reality (Saaty, 1990). Moreover, the Saaty scale facilitates normalization and the subsequent calculation of weights, which are essential for aggregating preferences into a single decision framework. Table 3 presents the comparison among criteria, using a scale from 1 to 9 (where 1 represents equal importance and 9 represents extreme preference of one criterion over another).

Table 3 | Criteria comparison.

Criteria (Description)	1.PB	2.EF	3.QC	4.AC	5.OC	6.IP	7.AS	8.IT	9.SL
1. Payback (PB) – Investment payback period	1	1/2	2	2	1	1	2	3	2
2. Expansion Flexibility (EF) – Ability to adapt the space for future expansions	2	1	3	2	2	2	2	3	2
3. Quality Control (QC) – Ease of ensuring product	1/2	1/3	1	2	1/2	1	1	2	1
4. Accessibility (AC) – Ease of entry and exit for transportation and personnel	1/2	1/2	1/2	1	1/2	1	1	2	2
5. Operational Costs (OC) – Recurring expenses for warehouse maintenance and operation	1	1/2	2	2	1	1	2	3	2
6. Integration with Production (IP) – Ease of communication and workflow with the production	1	1/2	1	1	1	1	2	2	2
7. Asset Security (AS) – Capacity for physical protection against losses and damages	1/2	1/2	1	1	1/2	1/2	1	2	1
8. Implementation Time (IT) – Estimated duration to implement the alternative	1/3	1/3	1/2	1/2	1/3	1/2	1/2	1	1
9. Strategic Location (SL) – Potential of the area regarding geographic and logistical position	1/2	1/2	1	1/2	1/2	1/2	1	1	1
Total	7.33	4.67	12	12	7.33	8.5	12.5	19	14

Source: Prepared by the authors.

This approach adopted in the AHP method allows for a structured comparison of the criteria's relevance, reflecting the decision-makers' perception of the relative importance of each factor in selecting the storage location. Normalization in the AHP criteria matrix is a fundamental process to ensure that all comparative values in the matrix are adjusted consistently, allowing for the determination of each criterion's relative weight. Each value in the comparison matrix is divided by the sum of the values in its respective column to obtain the normalized matrix (Saaty, 1990). Table 4 presents the normalized matrix.

Table 4 | Standardized matrix.

Critérios ↓ / →	1.PB	2.EF	3.QC	4.AC	5.OC	6.IP	7.AS	8.IT	9.SL	Average
PB	0,136	0,107	0,167	0,167	0,136	0,118	0,160	0,158	0,143	0,144
EF	0,273	0,214	0,250	0,167	0,273	0,235	0,160	0,158	0,143	0,208
QC	0,068	0,071	0,083	0,167	0,068	0,118	0,080	0,105	0,071	0,092
AC	0,068	0,107	0,042	0,083	0,068	0,118	0,080	0,105	0,143	0,090
OC	0,014	0,107	0,167	0,167	0,136	0,118	0,160	0,158	0,143	0,130
IP	0,136	0,107	0,083	0,167	0,136	0,118	0,160	0,105	0,143	0,128
AS	0,068	0,107	0,083	0,083	0,068	0,059	0,080	0,105	0,071	0,080
IT	0,045	0,071	0,042	0,042	0,045	0,059	0,040	0,053	0,071	0,052
SL	0,068	0,107	0,083	0,042	0,068	0,059	0,080	0,053	0,071	0,070

Source: Prepared by the authors.

The objective of normalization is to transform the comparative values (obtained from pairwise comparisons among criteria) into a common scale, so that each criterion has a weight proportional to its impact on the final decision. The AHP (Analytic Hierarchy Process) alternatives evaluation matrix is a tool that allows for the comparison of different decision options based on multiple, well-defined criteria. Each criterion represents an important aspect to be considered in the selection process, such as payback, operational costs, implementation time, among others. To ensure a fair and coherent comparison, each criterion is assigned a weight indicating its relative importance in the decision-making process, so that the most relevant criteria have greater influence on the final outcome. According to Saaty (1990), "the hierarchy represents a natural perception of a complex problem, where decision objectives, criteria, and alternatives are organized into levels of importance."

After defining the criteria and their weights, each alternative is evaluated against each criterion by assigning scores on a numerical scale, usually from 1 to 9. This scale reflects the relative performance of the alternative for that specific criterion: higher scores indicate better performance. For instance, an alternative demonstrating excellent integration with production may receive a score of 9 for this criterion, while another with only acceptable performance may receive a score of 5. Saaty (1990) explains that “the use of a fundamental scale from 1 to 9 allows subjective judgments to be quantified in a logical and consistent manner, transforming qualitative comparisons into numerical values.” Table 5 presents the Alternatives Evaluation Matrix.

Table 5 | Evaluation matrix.

Criteria	A1 – Renovation in Potim city	A2 – New Warehouse in Potim city	A3 – Maintain in Taubaté city
Payback	7	4	9
Expansion Flexibility	6	9	5
Quality Control	7	9	6
Accessibility	6	7	9
Costs	8	5	7
Integration with Production	9	9	6
Asset Security	8	9	7
Implementation Time	9	5	10
Strategic Location	6	6	9

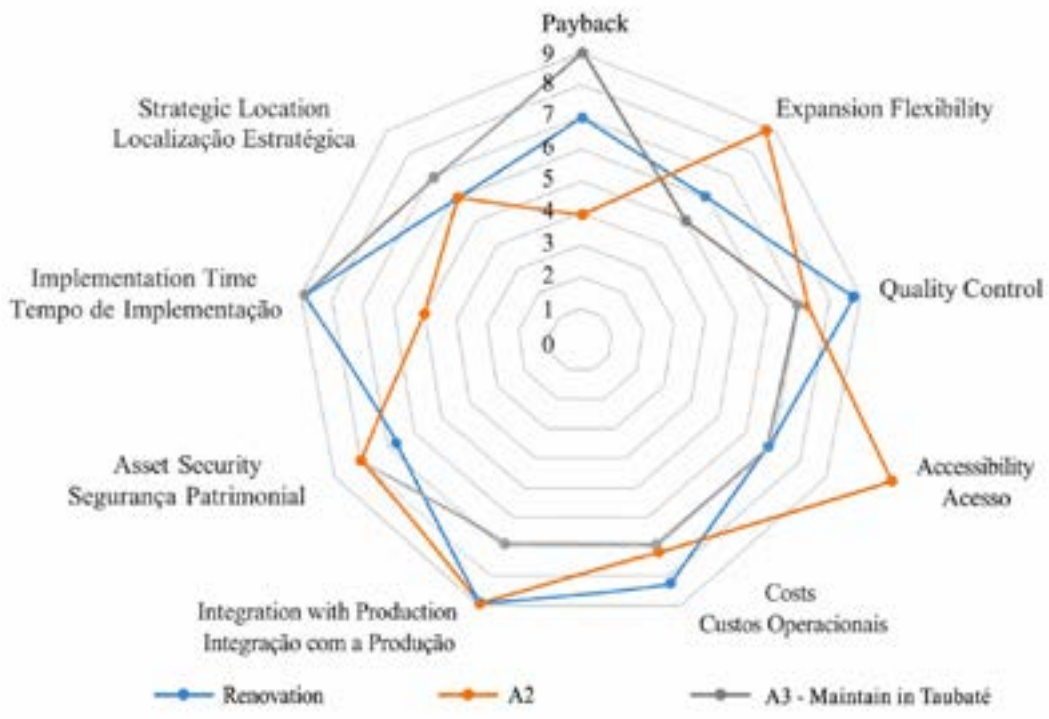
Source: Prepared by the authors.

Based on the evaluation matrix, which compares three alternatives A1: Renovation in Potim, A2: New Warehouse in Potim with Lean concept, and A3: Maintain logistics operation in Taubaté it is possible to analyze the relative performance of each option against nine strategic criteria for decision-making. Alternative A3 (Maintain in Taubaté) demonstrates the highest performance in the criteria Payback (9), Accessibility (9), Implementation Time (10), and Strategic Location (9), indicating a strong logistical advantage and agility for operational continuity. This alternative is particularly attractive when the priority is rapid implementation, investment return, and geographic connectivity.

On the other hand, A2 (New Warehouse in Potim) stands out in criteria such as Expansion Flexibility (9), Quality Control (9), Integration with Production (9), and Asset Security (9). This suggests that this alternative is more suitable from a long-term strategic perspective, as it offers modern infrastructure aligned with Lean Manufacturing principles, supporting sustainable growth, operational efficiency, and process quality. A1 (Renovation in Potim) shows intermediate performance, with good results in Payback (7), Operational Costs (8), Integration with Production (9), and Implementation Time (9). This alternative represents a compromise solution, combining controlled costs and relatively rapid implementation with an existing structure that can be optimized to partially meet the company's needs.

Figure 1 presents a radar chart comparing the performance of the three alternatives evaluated for the storage location of finished products, based on the criteria defined by the Analytic Hierarchy Process (AHP). This visualization supports the comparative analysis of the options and underpins the selection of the alternative most suitable for the company's strategic needs.

Figure 1 | Radar chart comparing the alternatives.



Source: Prepared by the authors.

The final score for each alternative is obtained by multiplying the values in the alternatives evaluation matrix by the criteria weights, which correspond to the averages of the rows in the comparison matrix. In other words, for each criterion, the value assigned to the alternative is multiplied by the corresponding criterion weight. These products are then summed, providing an overall score for each alternative. This process ensures that both the relative importance of the criteria and the performance of the alternatives are taken into account in a balanced manner. The alternative with the highest final score will be considered the most suitable according to the parameters defined by the decision-making team. In this way, AHP provides a logical, structured, and transparent approach for choosing among different options. Table 6 presents the final calculations for each alternative. entre diferentes opções. A Tabela 6 apresenta os cálculos finais para cada alternativa.

Table 6 | Final score.

Items	Calculations
A1 (Renovation in Potim city)	$(7 \times 0,144) + (6 \times 0,208) + (7 \times 0,092) + (6 \times 0,090) + (8 \times 0,130) + (9 \times 0,128) + (8 \times 0,080) + (9 \times 0,052) + (6 \times 0,070) = 7,160$
A2 (New Warehouse in Potim city)	$(4 \times 0,144) + (9 \times 0,208) + (9 \times 0,092) + (7 \times 0,090) + (5 \times 0,130) + (9 \times 0,128) + (9 \times 0,080) + (5 \times 0,052) + (6 \times 0,070) = 7,108$
A3 (Maintain in Taubaté city)	$9 \times 0,144 + (5 \times 0,208) + (6 \times 0,092) + (9 \times 0,090) + (7 \times 0,130) + (6 \times 0,128) + (7 \times 0,080) + (10 \times 0,052) + (9 \times 0,070) = 7,086$

Source: Prepared by the authors.

The most advantageous alternative, according to the criteria defined and weighted using the AHP method, is Renovation in Potim, with a final score of 7.160. This result reflects a more balanced performance of this option across key criteria such as integration with production, operational costs, and implementation time, highlighting it as the most suitable choice among the evaluated alternatives.

CONCLUSION

A The application of the AHP method enabled a structured and well-founded analysis of the storage alternatives considered by the company, allowing for a rational decision-making process based on multiple strategic, operational, and financial criteria. By defining and weighting criteria such as payback, expansion flexibility, sustainability, quality control, accessibility, operational costs, integration with production, asset security, implementation time, and strategic location, it was possible to quantify subjective aspects and organize the company's preferences in a logical and hierarchical manner. The data analysis indicated that alternative A1 (Renovation of the Potim warehouse) demonstrated the best overall performance, combining a good financial return with significant operational advantages, such as integration with production, asset security, and shorter implementation time. This option also stood out for offering a balanced solution between cost and structure, providing agility in execution while aligning with the organization's long-term objectives.

Alternative A2 (Construction of a new warehouse in Potim) proved attractive in terms of expansion flexibility and structural quality; however, it was penalized by higher implementation time and costs. Alternative A3 (Maintaining the operation in Taubaté), while presenting immediate logistical advantages and a well-established strategic location, was less favorable in terms of integration with production, cost-effectiveness, and operational sustainability. Based on the results obtained through the AHP method, it is recommended that the company prioritize the renovation of the warehouse at the Potim unit as the most viable solution for finished product storage. This choice represents a balance between operational efficiency, financial return, and strategic alignment, reinforcing the importance of using multicriteria methods as a tool to support management and complex decision-making.

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