Community Empowerment Consideration On-Site Location Selection Using AHP and TOPSIS Methods

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Abstract

The company's location can affect the development and continuity of a business, Site selection is a strategic plan that is expected to become a company's competitive advantage. The Site selection process is not only about finding the optimal geographic point but also about synergy with the company's long-term business plan. Recently, a company not only focused on seeking profits, but the awareness about community and environment development around the site location has begun to grow in line with world priorities in managing various resources. The emergence of commitments such as the Sustainable Development Goals makes companies not only focus on business but also on the sustainability of the surrounding community. Site selection is a multi-criteria decision-making problem, with the objective of finding the most optimal and profitable location for the company's sustainability, in previous research, site selection has several criteria to be considered such as costs, infrastructure, environment, and economics but did not consider aspects of potential community empowerment in the selection. This research aims to observe the influence of potential for community empowerment in the site selection process of a toy manufacturing factory by using the analytical hierarchy process (AHP) method to weigh the criteria and combine it with the TOPSIS method to determine the ranking of the available alternative locations.

Keywords
Site Selection, AHP, TOPSIS, Multi-Criteria Decision Making, Community Development

1. Introduction
Choosing the optimal location for a factory is a challenge that will always exist, every year new businesses continue to develop and require expansion in terms of facilities and infrastructure to achieve business optimization. as a long-term strategic plan, Many people try to calculate the best option that is close to an optimal location using the scientific method. Often the choice of factory location in a location will have an impact on the environmental, social, and economic aspects of a location. The impact of selecting a factory location will be felt even in the process of building a factory, many aspects are starting to move in either a positive or negative based on factory construction.

The site selection decision came from organizations that wish to establish or expand their activities, Identifying, analyzing, assessing, and selecting alternatives are part of the location decision process The selection of a site starts usually when the need to expand is considered, then the search for the best place will begin (Yang et al.1997). Choosing an optimal location will be very beneficial for a business, from the production process to the marketing process, many processes can be effective and efficient in their implementation.

Challenge to solve problems related to determining optimal locations that include the involvement of various factors and criteria included in Multi-Criteria Decision Making (MCDM). MCDM is utilized to select the most suitable option from a range of alternatives, especially in cases where there are multiple criteria for evaluation, and these criteria often present conflicting considerations. Therefore, MCDM stands out as a valuable approach for addressing issues related to the selection of sites (Hsieh et al.2004). Selecting a site location involves identifying the most advantageous location for a building or facility, taking into account the requirements of the structure, and weighing them against the benefits of various potential locations. This decision-making process is influenced by numerous conflicting factors or criteria (Hoover, 1948).

Numerous tools associated with Multi-Criteria Decision Making (MCDM) aid decision-makers in choosing among alternative solutions, Two widely known MCDM techniques are the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) (Stecyk, A. 2019). The AHP method proves to be a valuable tool for system analysis, addressing decision problems through the simplification of complex decisions into a series of pairwise comparisons. Widely applicable, AHP serves as an effective multi-criteria decision-making technique, having been successfully applied across various fields (Torlak et al. 2011). Additionally, AHP incorporates a reliable mechanism for assessing the consistency of the decision-maker's judgments, thereby reducing bias in the decision-making process.

From several literature reviews, it was found that the combination of various criteria in location selection includes aspects such as infrastructure, economy, logistics, and market access, but there is little research that considers the criteria for location community empowerment potential. The current trend in running a business demands the company to comply with sustainability aspects. The impact of a business will affect the resources around the company in terms of economics, social, and environmental aspects where the company operates. Therefore, the form of corporate responsibility for the impact of their business includes actions related to corporate social responsibility. The objective of Corporate Social Responsibility (CSR) is to assume accountability for the actions of the company and promote a beneficial influence through its endeavors on the environment, consumers, employees, communities, stakeholders, and all other participants in the public sphere (Fontaine 2013). This research discusses the selection of a factory location by incorporating considerations related to the potential aspects of community empowerment in a case study of a toy manufacturing company in Indonesia using the AHP and TOPSIS methods.

1.1 Objectives

Determining optimal Site selection remains a relevant topic today, but currently, in choosing a factory location, not many considerations are given to the criteria of community empowerment potential of the alternative location. Therefore, this research is conducted with the aim of achieving:

1. Selecting an optimal location to determine the company's location.
2. Understand the alternative location's community empowerment potential influence on the selection of the company's location using the AHP TOPSIS method.

2. Literature Review

When deciding on the location for a manufacturing site location, it's crucial to take into account factors beyond just construction costs and timelines. Operational and service-related considerations, like high transportation costs and potential quality deterioration, should also be factored in (Aktas et al.2018). Consequently, site selection becomes a decision-making challenge involving multiple criteria and options. A comprehensive review of the literature was conducted to identify the primary factors influencing the selection of a location. Table 1 provides an overview of various MCDM-based works that have been conducted thus far.

The Analytic Hierarchy Process (AHP) is widely acknowledged and commonly employed as a methodology in Multiple Criteria Decision Making (MCDM). Rooted in priority theory, AHP is designed to address intricate problems involving the simultaneous consideration of multiple criteria and alternatives. Its notable feature is its capacity to systematically integrate both data and expert judgments in a logical manner, establishing a framework for evaluating intangible qualities (MacCormac 1983).

AHP organizes real-world problems in a hierarchical manner, and its robust mathematical foundation, coupled with a systematic approach to data collection, has led to its widespread application across various multidisciplinary fields since its inception. Its utility extends to unstructured Multiple Criteria Decision Making (MCDM) issues, where it employs pairwise comparisons. AHP finds application in diverse domains, ranging from engineering and management to social sciences and economics, as evidenced by a considerable body of research in recent years (Deshamukhya et al.2014).

The implementation of AHP relies on three fundamental principles: a) identifying the problem and constructing a hierarchy, (b) establishing a preference matrix for comparative decision-making, and (c) assigning weights to the factors. AHP employs pairwise comparisons of criteria to ascertain the relative importance of each criterion in comparison to others (Saaty 1987). Although AHP has been utilized for years to address numerous industrial challenges, it continues to hold a crucial role and remains a significant research tool in the lives of today's researchers. The most recent literature review indicates that AHP is still thriving and attracting attention in various innovative and exciting applications.

Table 1. MCDM Literature Review Overview

Year	Authors	Method	Implementation
2021	Zhang et al.	AHP	Manufacturing Plant Location Selection
2021	Karagöz, S et al.	Fuzzy ARAS	Solving the ELV recycling facility location problem.
2018	Singh et al.	Fuzzy AHP	Selection of warehouse location for a global supply chain
2018	Chatzoglou et al.	SEM	Identify Plant Location Factors
2018	Rahman et al.	AHP	Facility Location Selection for the Plastic Manufacturing Industry
2016	Murat et al.	AHP,TOPSIS	Facility Location Selection for a Plastic Goods Manufacturing Company
2016	Costa et al.	AHP	Facility Location Selection for a Jeans Manufacturing Company
2015	Chang et al.	AHP	Manufacturing plant location selection in the logistics network
2015	Gothwal et al.	AHP	Plant location selection of a manufacturing industry using
2013	Kengpol et al.	Fuzzy AHP,TOPSIS	Decision support system for the selection of solar power plant locations
2013	Devi et al.	Fuzzy AHP, Electre	Solving plant location selection Problem
2013	Chatterjee et al.	COPRAS	Windfarm site selection
2012	Tom James et al.	AHP,TOPSIS	Part Supply Chain Selection
2012	Choudhary et al.	Fuzzy AHP,TOPSIS	Plant Location Selection

To complement the use of the AHP method, the TOPSIS method is added to make decision-making more comprehensive. TOPSIS stands out as another well-known MCDM approach employed for addressing decision-making problems. The rationale behind the TOPSIS technique is highly logical and easily comprehensible, and the calculation processes are both accurate and straightforward. Furthermore, the TOPSIS concept yields optimal rankings for each criterion through a simple mathematical formula. Numerous studies in the literature showcase instances where researchers have utilized TOPSIS either independently or in conjunction with other MCDM approaches.

Since the early 1990s, the significance of corporate social responsibility (CSR) as a concept has grown. Numerous companies have directed their efforts towards the triple bottom line of CSR, encompassing people, planet, and profit. Due to the upheaval in global stock markets, credit crises, and a widespread economic recession, there was a noticeable shift in corporate priorities. Consequently, concerns related to climate change and broader aspects of corporate social responsibility began to ascend on the corporate agenda (Ghewari et al.2013).

Although widely accepted, CSR remains an ambiguous concept and is open to various interpretations. According to Crane et al. (2013), the main attributes of CSR represent key elements of the existing concept. These attributes include (1) Willing participation on a voluntary basis; (2) addressing externalities, such as the effects on local communities; (3) recognizing stakeholders as entities beyond mere shareholders; (4) harmonizing social and economic responsibilities; (5) establishing business practices and values that tackle social issues; and (6) extending efforts beyond mere philanthropy.

Based on the literature review outlined and the summarized information in Table 1, it is evident that there is a gap in the existing studies. Specifically, there are no reported investigations on facility location selection that incorporate the potential for social empowerment among the available location alternatives. In this research, an AHP (Analytic Hierarchy Process) methodology is employed, characterized by a systematic and mathematical structure, to establish priorities for location selection for production plants with the consideration of the social empowerment potential of the alternatives.

3. Methods

This study was carried out in a toy industry situated in Indonesia. Primary data were gathered through questionnaires distributed to respondents. Meanwhile, secondary data were acquired through a review of literature and websites. The assessment was enriched by the input of experts, comprising managerial-level employees and staff from both internal and external company sources, academics, and governmental industrial department representatives. A total of 7 experts provided feedback in response to the distributed questionnaires. The research followed a systematic approach in multiple stages to address problems in a quantifiable manner.

The procedure for implementing the AHP evaluation model in location selection involves the following steps:

1. Define site selection criteria and establish a hierarchical structure.
2. Compile a Pairwise Comparison Matrix.
3. Perform Partial Weighting.
4. Determine the overall priority weight and assess the consistency index.

The steps for implementing TOPSIS are outlined as follows:

1. Create a normalized decision matrix.
2. Apply weights to the normalized decision matrix.
3. Determine the positive ideal solution matrix and negative ideal solution matrix.
4. Calculate the gap between the values of each alternative and the positive and negative ideal solutions.
5. Determine the preference value for each alternative.

Following the data analysis, the results underwent a hierarchical consistency test using the AHP method. This test aimed to ensure that the confidence level in the data remained consistent when collecting data using the same instrument and repeating the process. Once the questionnaire was deemed valid with the consistency ratio (CR) < 0.1, the TOPSIS method was subsequently employed.

4. Data Collection

The data used in the selection of priority criteria for site location selection consists of six main criteria and thirteen sub criteria. The criteria and sub-criteria were obtained from the results of several literature sources and the results of interviews with several experts from the company. Furthermore, data processing analysis is carried out for each criterion and alternative. The criteria and sub-criteria are then selected based on their relevance to the company. This is done using a questionnaire related to the level of importance of criteria and sub-criteria for location selection. The hierarchy of criteria can be seen in Figure 1.

The chosen criteria and sub-criteria were further refined into a pairwise comparison matrix for each level. The initial step involved comparisons between criteria and sub-criteria, where criteria were assessed against targets and subsequently compared to sub-criteria. The development of the pairwise comparison matrix was facilitated through questionnaires to respondents. Data collected from pairwise comparison questionnaires are shown in Table 2 below,

Table 2. Pairwise Comparison Matrix

	Cost	Infrastructure	Human Resources	Conduciveness	Logistic	Community Empowerment
Cost	1,00	1,53	2,11	0,98	0,61	4,88
Infrastructure	0,65	1,00	1,35	0,93	0,58	5,63
Human Resources	0,47	0,74	1,00	0,58	0,47	2,73
Conduciveness	1,02	1,08	1,72	1,00	0,85	3,00
Logistic	1,64	1,72	2,12	1,17	1,00	5,43
Community Empowerment	0,21	0,18	0,37	0,33	0,18	1,00

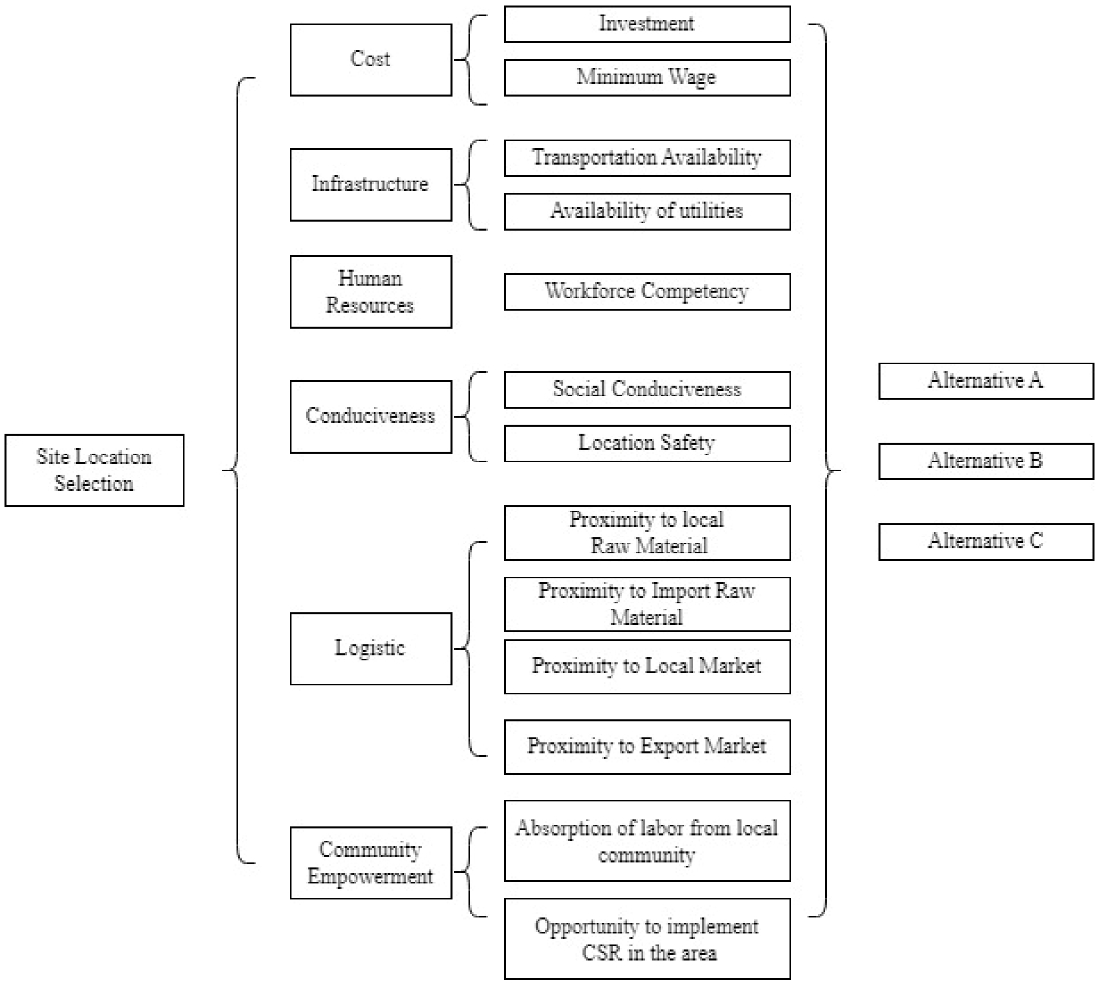

Figure 1. The research Criteria & Sub-criteria Hierarchy

From the obtained data, the pairwise comparison matrices are then processed using the Super Decisions software to determine the weighting of each criterion. The result is shown in figure 2

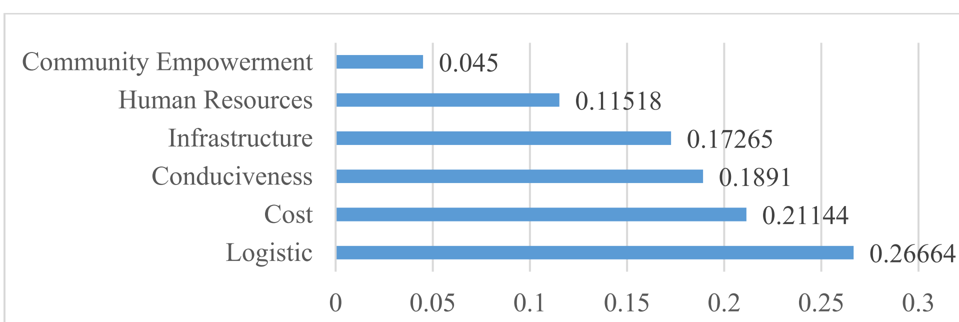

Figure 2. Weight of Criteria

To be acceptable, the consistency ratio (CR) for criteria and sub-criteria should be (CR) < 0.1. the value of CR from Super Decision software is 0.0143 and the criteria are acceptable. The next step involves calculating the global weight values for sub-criteria and assessing their consistency.

Table 3. weight of sub-criteria

Rank	Code	Criteria	Sub-Criteria	Global Weights
1	A2	Cost	Minimum Wage	0,1466
2	B2	Infrastructure	Availability of Utilities	0,1301
3	D1	Conduciveness	Social Conduciveness	0,1079
4	D2	Conduciveness	Location Safety	0,1058
5	E4	Logistic	Proximity to Export Market	0,1035
6	A1	Cost	Investment	0,0924
7	E3	Logistic	Proximity to Local Market	0,0905
8	E1	Logistic	Proximity to Local Raw Material	0,0769
9	B1	Infrastructure	Transportation Availability	0,0650
10	F1	Community Empowerment	Absorption of labor from local community	0,0439
11	E2	Logistic	Proximity to Import Raw Material	0,0305
12	F2	Community Empowerment	Opportunity to implement CSR in the area	0,0070

The weights obtained from the criteria and sub-criteria, as shown in Table 3, will be used as input for the TOPSIS method to perform the subsequent matrix calculations. The next step is to implement the TOPSIS method by collecting data based on questionnaires distributed to the respondents. The data obtained from the respondents are then used to create a decision matrix for normalization.

Table 4. Input of TOPSIS

Weight	Code	Criteria	Alternative A	Alternative B	Alternative C
0,0817	A1	Investment	3,80	4,69	2,03
0,1160	A2	Minimum Wage	3,25	4,65	2,48
0,0575	B1	Transportation Availability	4,39	3,93	3,77
0,1151	B2	Availability of Utilities	4,84	4,36	4,19
0,1152	C	Workforce Competency	4,22	3,48	4,32
0,0955	D1	Social Conduciveness	4,50	4,09	3,77
0,0936	D2	Location Safety	4,40	3,50	2,38
0,0680	E1	Proximity to Local Raw Material	3,02	3,45	4,54
0,0270	E2	Proximity to Import Raw Material	4,69	3,13	1,95
0,0800	E3	Proximity to Local Market	4,54	3,26	2,67
0,0916	E4	Proximity to Export Market	4,84	3,13	2,03
0,0388	F1	Absorption of labour from local community	3,93	2,85	4,05
0,0062	F2	Opportunity to implement CSR in the area	4,69	3,09	3,93

With input from Table 4, the next step involves weighting the normalized decision matrix. The matrix created is then processed with the weighting results obtained from the AHP process for criteria and sub-criteria. The results of the weighting of the normalized matrix can be observed in Table 5.

Table 5. Weighted Normalized

Code	Alternative A	Alternative B	Alternative C	Min or Max	A*	A-
A1	0,04878	0,06016	0,02608	+	0,06016	0,02608
A2	0,06813	0,09740	0,05195	+	0,09740	0,05195
B1	0,03611	0,03233	0,03103	+	0,03611	0,03103
B2	0,07197	0,06481	0,06220	+	0,07197	0,06220
C	0,06979	0,05744	0,07139	+	0,07139	0,05744
D1	0,06008	0,05460	0,05030	+	0,06008	0,05030
D2	0,06744	0,05368	0,03646	+	0,06744	0,03646
E1	0,03186	0,03632	0,04790	+	0,04790	0,03186
E2	0,02120	0,01413	0,00882	+	0,02120	0,00882
E3	0,05869	0,04207	0,03451	+	0,05869	0,03451
E4	0,07259	0,04685	0,03048	+	0,07259	0,03048
F1	0,02409	0,01750	0,02487	+	0,02487	0,01750
F2	0,00425	0,00280	0,00356	+	0,00425	0,00280

Based on the weighting of the normalized decision matrix, the next step is to determine the positive (A*) and negative ideal solutions (A-), taking into account whether the criteria have a positive or negative impact on the selection of the factory location. The positive and negative ideal solutions are used to determine the consistency index of the sought alternatives. The results of the TOPSIS calculation will indicate the ranking of alternatives based on the priority of the consistency index obtained.

5. Results and Discussion

The application of the TOPSIS method is utilized to calculate the ranking of facility locations. The evaluation results and the ultimate ranking of site locations are presented in Table 6.

Table 6. Outcome of TOPSIS Analysis

	Alternative A	Alternative B	Alternative C
S+	0,03531	0,04073	0,08315
S-	0,06828	0,06263	0,02251
Ci	0,65914	0,60596	0,21302
Rank	1	2	3

Based on the data processing results using the AHP method, an initial decision matrix is obtained, which will be further processed using the TOPSIS method to determine the factory location selection. The initial decision matrix includes elements such as the criteria and sub-criteria weights, as well as the weights of each alternative as potential location options.

The first step in the TOPSIS method is to determine the normalized initial decision matrix. Calculations are performed to obtain the values of the normalized initial decision matrix. Subsequently, the normalized initial decision matrix is weighted by multiplying each criterion and sub-criterion weight by the weight of each alternative. From the weighting of the normalized decision matrix, calculations are then carried out to obtain the positive and negative ideal solutions and the distances of alternatives to the positive (S+) and negative (S-) ideal solutions. The preference ranking of the consistency index (Ci) is determined based on these calculations and shown in Table 6.

Logistics emerged as the most influential criterion among the six, contributing significantly with a value of 27%. This highlights the pivotal role of the logistics criterion in the location determination process for the company. The community empowerment criteria exhibited the least impact on site location selection decisions, contributing approximately 5%. Among the three alternative locations, alternative A stands out as the preferred alternative location with a substantial percentage of 45%.

6. Conclusion

In this research, various criteria and sub-criteria were processed to obtain priorities for selecting the location of the toy factory, taking into account the potential for community empowerment. The criteria related to determining the location include cost criteria with sub-criteria of investment costs and minimum wages; infrastructure criteria with sub-criteria for the availability of transportation modes and utility availability; human resource criteria with job competency suitability; conduciveness criteria with sub-criteria for social conduciveness and general security; logistics criteria with sub-criteria for access to local and imported raw materials, as well as domestic and international marketing access; and community empowerment criteria with sub-criteria for the potential absorption of labor from the surrounding community and the potential implementation of CSR for the surrounding community.

Based on the research results, logistics criteria is the criterion with the highest weight of influence, with a value of 27%, compared to the weights of other criteria. Meanwhile, community empowerment criteria have the lowest level of influence with a weight value of 5% in the selection of the location of the ABC factory branch. Based on the AHP-TOPSIS method processing in the research on the selection of the ABC factory branch location, the ranking results show that the alternative location A is the top priority, ranking first with a percentage of 45%, followed by Alternative B with a percentage of 41% in the second rank, and in the third rank is alternative C with a percentage of 14%.

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