Determining Warehouse Location by Analytic Hierarchy Process A Case Study: Nong Khai Special Economic Development Zone

Aekkawit Pimpatchim, Naratip Supattananon*, Raknoi Akararungrunngkul
Department of Industrial Engineering
Faculty of Engineering, Khon Kean University, Khon Kean 40002
*Department of Logistiics and Supply Chain
College of Logisitcs and Supply Chain, Sripatum Khon Kaen University, Khon Kaen 40000
E-mail: aekkawit.pimpatchim@kkumail.com

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1. INTRODUCTION

The Thai government has enacted policies for Nong Khai is a special economic development zone due to Nong Khai's location near the capital of Laos (Vientiane). The government has supported investments, a one stop service center, tax benefits, labor, infrastructure development, and customs with the purpose of bringing the country into the ASEAN community. [1] Consistent with the export of beverages that has increased by 1,355.4 million dollars per year, the volume of non-alcoholic beverages is at 921.67 million dollars per year. Consumption of beverages in Thailand has increased 3.5 billion baht per year, including alcoholic beverages (Beer and Spirits) at a volume of 2.4 hundred billion baht per year and non-alcoholic beverages at a volume of1.1hundred billion baht per year. [2] These trends show an increasing demand for beverages in the country, which affects exports and government support policy. The beverage industry, therefore, requires a warehouse location in Nong Khai to respond to both domestic and international demand.

Determination of potential warehouse locations was accomplished using an Analytical Hierarchy Process (AHP) by considering basic factors related to warehouse businesses. i Important factors related to business interests include demand, investment, delivery time, road infrastructure, and port facilities. [3] Next, this study considered the readiness of information systems and communication equipment to respond to demand and support the business operation in effective delivery of products. [4] Most recently, warehouse locations have been determined by considering factors that continuously reduce the impact on and benefit the organization. In addition, economic impact was considered in terms of impact on the organization. The Analytic Hierarchy Process also considers the factors that affect society and the environment. [5]-[7] Therefore, this research used the Analytic Hierarchy Process to determine optimal warehouse locations within the Nong Khai Special Economic Development Zone.

2. METHODOLOGY

The Analytic Hierarchy Process as used to determine optimal warehouse locations within the Nong Khai Special Economic Development Zone was carried out according to the following steps:

2.1 Specify 3 alternative warehouse locations, including Naimueang, Phochai, or Meechai.The warehouse presenting by the company management of case studies

2.2 Determine the main factors and sub factors in the analysis of warehouses, [3-7] as shown in Table 1.

Table 1 Main factors and sub factors

Main factors	Sub factors	Explanation
1.Cost	1.1 Warehouse cost	Cost of warehouse and equipment construction
	1.2 Transportation cost	Inbound and outbound transportation costs
	1.3 Labor cost	Labor costs of storage and transportation
2. Infrastructure	2.1 Access to main road	Road availability for transportation
	2.2 Distance to border	Distance to 1st Thai–Lao Friendship Bridge
	2.3 Public utilities	Availability of electrical, plumbing, and information systems
3.Society and Environment	3.1 Air pollution	Air pollution effects near community
	3.2 Noise pollution	Noise pollution effects near community
	3.3 Impact on the road	Damage to roads in the community as caused by transportation

2.3 Each pair in Pairwise Comparison was given a numerical rating from 1 to 9 by four experts, [5] including the company owner, warehouse manager, transport manager, and marketing manager. The comparison is determined to matrix A in which A_{ij} is the priority level.

2.4 The average weight of the main factors was assessed, as shown in equation (1):

$$\text{Average weight}_i = \sum_j^n W_{ij} / n \quad (1)$$

W_{ij} =Weight level n = Number of comparison metrics

2.5 The average weight of the sub factors in the equation was assessed according to article 2.3 to article 2.4, which has normalized from equation (1), to analyze with the average weight of the main factors.

2.6 The consistency ratio (CR) was analyzed to find the average weight of the appropriateness of the determined warehouse location, according to the following steps:

1) Calculate the consistency vector in each factor.

2) Calculate λ_{max} in each factor.[3]

3) Calculate the consistency index(CI) as in equation (2)

$$CI = \lambda_{\max} - n / (n-1) \quad (2)$$

4) Determine the consistency random index (RI), [7] as shown in Table 2.

Table 2 Consistency random index

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

5) Calculate the consistency ratio. The number of factors less than 3 must have a consistency ratio no greater than 0.07 and the number of factors greater than or equal to 4 must have a consistency ratio no greater than than 0.10, as in equation (3)

$$CR = CI / RI \qquad (3)$$

2.7 Analyze warehouse locations by prioritizing according to the following steps:

1) Compare different factors between warehouse locations for each sub factor. The comparison is in the form of matrix A by A_{ij} according to Article 2.3.

2) Calculate the average weight of warehouse locations with each sub factor according to Article 2.4.

3) Calculate the average weight sum of all factors of each warehouse location according to Article 2.5 from four experts. The warehouse location that has the highest average weight is the most appropriate warehouse location.

3. RESULTS & DISCUSSION

The results of the weighting of the factors according to Articles 2.2-2.6 show the main factor of cost has the highest average weight of 0.4718 and the warehouse cost sub factor has the highest average weight of 0.2338. It was found that the consistency ratio of each factor is less than 0.07, [7] as shown in Table 3.

Table 3 Results of main and sub factors

Main factor	Average weight	Sub factor	Average weight	Rank
1.Cost	0.4718 (47.18%)	1.1 Warehouse cost	0.2338	1
		1.2 Transportation cost	0.1725	2
		1.3 Labor cost	0.0655	6
2. Infrastructure	0.3015 (30.15%)	2.1 Access to main road	0.1391	3
		2.2 Distance to border	0.1116	5
		2.3 Public utilities	0.0508	8
3.Society and Environment	0.2267 (22.67%)	3.1 Air pollution	0.1319	4
		3.2 Noise pollution	0.0616	7
		3.3 Impact on the road	0.0332	9

The analysis of the 3 warehouse locations using the Analytical Hierarchy Process found that the most appropriate warehouse location is the Naimueang warehouse location, with an average weight of 0.3636, as shown in Table 4.

Table 4 Warehouse location results

Location	Expert				Average weight	Rank
	1	2	3	4		
Naimueang	0.3535	0.3745	0.3797	0.3468	0.3636	1
Phochai	0.3327	0.3134	0.3198	0.3201	0.3215	2
Meechi	0.3138	0.3121	0.3004	0.3331	0.3149	3

4. CONCLUSION

This analysis of appropriate beverage warehouse locations in the Nong Khai Special Economic Development Zone using the Analytic Hierarchy Process was accomplished by considering the main factors of cost, infrastructure, society and environment, and sub factors of warehouse cost, transportation cost, labor cost, main road access, distance to border, public utilities, air pollution, noise pollution, and road impact. It was found that the most appropriate warehouse location is the Naimueang warehouse location, with an average weight of 0.3636. The next best locations were the Phochai and Meechi warehouse locations, with average weights of 0.3215 and 0.3149, respectively.

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