Stipulations Forthe Tofu Factory Location by Employing The AHP Method

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Abstract - The best qualifiedtofu will win the competition, so geological and climate citeria are considered the main priorities based on the analysis results involving AHP to determine the tofu factorylocation. Tofu factories are assigned as one of the small and medium industries and determining their locations greatly influences the sustainability of such industries since the determination not only greatly brings positive impacts on the factoryconstruction, but also reduces economic problems in the future. This research was aimed at specifying the priority criteria percentage in the locationselection; therefore, the research applied the use of AHP to determine them. The research found that the percentage of the next priority might refer to the availability of labors(26.94%), the criteria for market and marketing distance (14.93%), the criteria for transportation facilities (11.36%), the criteria for supporting facilities and utilities (7.08%), and finally the distance criteria fromthe location to the raw material suppliers. The distance to the raw material suppliers is very much prioritized in stipulating the location because the supply of raw materials does not take place every day, for example, the main raw materials, such as,soybeans, can be ordered once a month. Other aspects of the criteria are relied on the level of importancewhich is the final choice for building a tofu factory objectively.

Keywords - Analytical Hierarchy Process, tofu

INTRODUCTION

1.1 Background

Tofu is one of the well-known foods in Indonesia, which is processed using soybeans as raw materials, has a high vegetable protein content, and tends to be a substitute for animal protein to meet human nutritional needs. Apart from that, tofu is also a food that is affordable for the wider community and can be made quite simply.

The tofu industry is experiencing relatively rapid development, especially on the island of Java, which has 86,400 units with a production capacity of more than 2.56 million tons per year, so it is surprising that the growth of the tofu industry has been quite significant.

As the tofu industry increases in Indonesia, environmental problems arise because environmental awareness of the waste produced is not followed. Many small and medium scale tofu industries, especially in Medan, still do not handle the liquid waste they produce. This tofu industry disposes of its liquid waste in rivers, so many tofu industries are built near rivers. Some people think that small and medium industries cannot influence environmental quality. Apart from that, the level of awareness and understanding of industry players regarding waste handling is still small (Ariani, 2011).

The tofu production process requires a lot of water, so the volume of liquid waste produced is quite large, which is a problem for the tofu industry itself. According to Pamungkas & Slamet (2017), liquid waste is produced from the washing and boiling process. pressing, and molding tofu. In the liquid waste there are organic materials such as COD and BOD at high levels. If the waste is channeled into rivers without prior processing, it will cause river pollution and, if the river is used to meet the daily needs and activities of local residents, the water can cause health problems such as diarrhea, itching, colitis, cholera, and other diseases (Kaswinarni, 2007).The high volume of waste and levels of organic matter produced will have an impact on the pollution load received by rivers and high pollution can result in a decrease in the environmental carrying capacity in recovering from the influx of pollutants. If the pollution load is greater than the maximum pollution load, it means that the capacity of the process of degrading organic matter in water that can decompose naturally becomes very limited (Sahubawa, 2008). The increase in pollution is caused by the level of awareness of tofu industry owners and inadequate financial capabilities (Zannah, 2017), so this becomes an obstacle in handling tofu waste. Therefore, a way is needed to overcome the waste problem in the tofu industry, and one of them is by implementing the concept of clean production to minimize the waste produced in the tofu industry.

Clean production is a form of strategy to minimize the use of raw materials in the production process, for example, water, energy, and also to reduce or prevent pollution, with the target of increasing productivity and reducing the waste produced (Fauzi, Rahmawakhida, & Hidetoshi, 2010). Clean production is preventive or is an effort to reduce the production of waste, hazardous materials, etc. so that they do not cause pollution by looking at the cycle or life cycle of a product (Ariani, 2011). The efforts made for this concept are early prevention, reducing the formation of waste, and utilizing recycled waste. Clean products result in benefits in the form of savings and increased efficiency (Probowati & Burhan, 2011). Implementing cleaner production is also something that must be implemented, even if the industry is small scale. This approach is expected to reduce and minimize tofu waste produced, and also to improve the quality of tofu products, save energy, and increase profits from this industry.

1.2 Research Problems

The formulation of the problems in this research is written below:

1. What factors influence in stipulating tofu factory locatin by AHP?
2. How to minimize liquid waste by using clean production methods?

1.3. Research objectives

The aims of this research are:

1. To identify the factors influencing the stipulations of tofu factorylocation.
2. To calculate the waste discharge from the tofu production process.
3. To analyze clean production methods in order to minimize waste.

1.4. Research benefits

It is hoped that this research can be a reference for the tofu industry in Medan which should implement clean production, so that it can increase production efficiency and minimize the waste.

1.5. Research assumptions

Clean production through waste minimization can be applied to reduce the waste produced based on the waste minimization priority hierarchy.

1.6. Scope

The scopes of this research are:

1. To observe the tofu production process.
2. To identify the amounts of raw materials, water, additional materials, and fuel usedin every stage of production.
3. To carry out sampling to stipulate the discharge of tofu waste in eachproduction stages.
4. To make a mass balance by the use of water, fuel, additional materials,and raw materials from each stage of production as well as to create a water balance and layout process of siteproduction.
5. To plan alternative waste opportunities through clean production.

II. RESEARCH METHODOLOGY

2.1 Research location and time

The research was conducted in Mabar District, Medan and took place from February up to April 2024.

2.2 Research methods

This research employed an analytical survey method by observing several locations under theadministration of *Kelurahan Mabar*, Medan, North Sumatra Province, because this *kelurahan*possessed strategic position and hada lot of tofu industries.

2.3 Data collection methods

The following are the data collection methods used in this research.

1. Observation is an activity regarding a process or object with the aim of feeling and understanding a phenomenon that has knowledge and ideas that are generally understood beforehand, so in order to obtain the required information this research is carried out
2. An interview is an activity carried out to obtain information directly by asking questions to respondents. Interview means face-to-face activities between the interviewer and the respondent, and the activities are carried out orally
3. Questionnaires with the Analytical Hierarchy Process AHP scale were distributed directly to selected respondents with the following conditions:

a. The tofu entrepreneurs who were 40 years old and had been running his business formore than 20 years
b. The tofu entrepreneurswho were 43 years and had beenrunning their business for almostfive years.
c. The tofu consumers aged 55 years old

2.4 Analytical hierarchy process (AHP)

Decision making is a thought process in the context of problem solving to obtain the final result that will be implemented. According to Saatr (2014), AHP is a method for ranking decision alternatives and selecting the best one using several criteria. AHP develops a numerical value to rank each decision alternative, based on the extent to which each alternative meets the decision maker's criteria. Meanwhile, according to Nugeraha (2017), AHP is a concept for multicriteria-based decision making. Several criteria that are compared with each other (level of importance) are the main emphasis on the AHP concept.

2.5Basic principles ofanalytical hierarchy process (AHP)

The first refers to the arrangement of hierarchies, and with hierarchies, a complex problem can be broken down into groups which are then arranged into a form of hierarchy so that the problem will appear more structured and systematic.
Saaty (1994) in Hanien Nia H Sega (2012) explains that hierarchy is a description of complex problems in a multi-level structure where the top level is the goal and is followed by the level of criteria, sub-criteria and so on until the bottom level is the alternative level. Based on the background in the introduction, the criteria that will be used in "Determining the Location of Tofu Factory Using AHP" can be determined. The Hierarchy Scheme is shown in Figure 1.

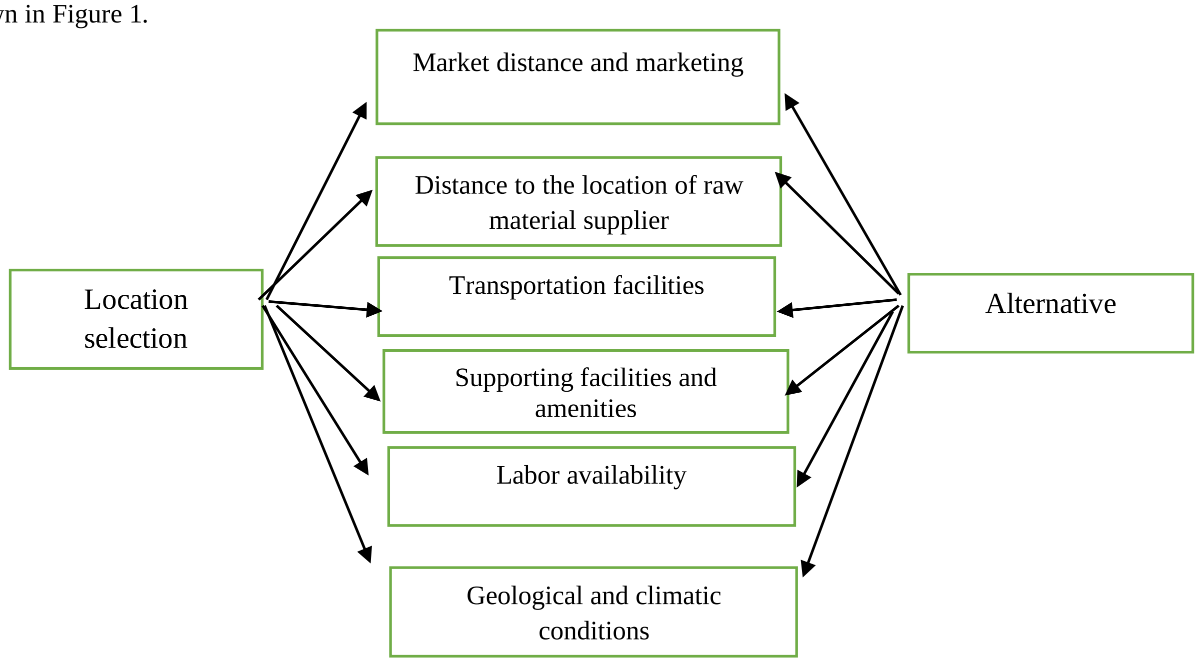

Figure 1. Hierarchical Scheme for Selection of Tofu Factory Locations with AHP

Before selecting the location or land that will be used as a factory location, of course the location and land in question must comply with the conditions determined by the local government. From several sources and interviews with respondents, it can be concluded that there are six criteria used in determining the location of the *tempe* factory in this research, with the following criteria:
1. Market and marketing distance will affect distribution costs and other costs related to product distribution, which will increase distribution costs.
2. The close location of raw material suppliers will ensure supply stability and reduce shipping costs.
3. Transportation facilities in terms of the smoothness of the mode of transportation influence the distribution of products from the factory location to consumers and raw materials to the factory location.
4. The supporting facilities and utilities referred to are equipment such as water supply, electricity networks, telecommunications and waste processing.
5. The availability of skilled labor in industry greatly influences the smooth running of production. The unavailability of labor close to the factory location will result in employers bringing in workers from far away from the factory location, and this can increase costs related to labor wages.
6. Geological and climatic conditions such as land contour, temperature and humidity are important considerations in determining the location of the factory.

The second refers to the assessment of the criteria, in carrying out calculations using the AHP method. To quantify qualitative opinions, a rating scale is used so that opinions can be assessed in numerical/quantitative form. According to Saaty (1986), for various problems, a scale of 1 to 9 is the best scale for qualifying opinions, with its accuracy based on the RMS (Root Mean Square Deviation) and MAD (Median Absolute Deviation) values.

The third determines the quality of the criteria and priorities for proving the consistency of pairwise comparisons with AHP, with the following steps:

$a(ij) = Ai / Aj$, by : $i,j = 1,2,3,...n$…………….. (1)

Wi = n√(ai1 x ai2 x ai3,….x ain) …………………(2)
Xi = (Wi / Σ Wi) ………………………………….(3)
λmaks = Σ aij.Xj……………………………………...(4)

The last is related to proof of comparative consistency by calculating control of the Consistency Index (CI) and Consistency Ratio (CR).

-Consistency Index (CI) = (λmaks.–n)/(n-1), in which the n = matrix size.

- Consistency Ratio (CR) = CI/RI, Value of Consistency Ratio (CR) must be smaller than 10%, according to the consistency requirements, namely that it must be smaller than 0.1 or 10%.

2.6Advantages and Weaknesses of the Analytical Hierarchy Process (AHP)

As an analysis method AHPhas advantages and disadvantages in which the first is concerned with its hierarchical structure, its consequence of the selected criteria, and its deepest sub-criteria. In addition,the AHP can give an account from validity up to the inconsistency tolerance limit which is used as the criteria and alternatives that are selected by the decision maker. It is also able to give an account of the durability of the decision sensitivity analysis output. This is in accordance with research conducted by Suci Oktri Viarani and Hilma Raimona Zadry entitled Analysis of Supplier Selection using the Analytical Hierarchy Process Method inIndarung VI Project managed by PT Semen Padang. They argued that the AHP method is a systematic method and does not require a long time, and can show the priority weight of the selected criteria and suppliers. Mentari Rika Noviandri, et al., in her research entitled Analysis of Metallic Box Supplier Selection Using the Fuzzy Analytic Hierarchy Process (AHP), explained that supplier selection is a multi-criteria problem where each criterion applied has different interests and the information about this is not known precisely. In this case, selecting suppliers based on low price offers is no longer efficient. To obtain maximum SCM performance, you must combine other criteria that are relevant to the company's objectives, so the calculations are carried out using the fuzzy AHP method.

Meanwhile, the second (or the weakness of the AHP method) is related to the dependence of the AHP model on its main input which is in the form of an expert's perception, so, in this case, it involves the expert's subjectivity. Additionally, the model becomes meaningless if the expert provides an erroneous assessment. Furthermore, the AHP method is only a mathematical method without any statistical testing so there is no confidence limit for the correctness of the model formed.

III. RESULTS AND DISCUSSION

After collecting answers from the AHP questionnaire filled in by respondents, the researcher then assessed the criteria as presented in table 1:

Table 1. Assessment of Criterion Importance

Resp	The scoring scale														
	A-B	A-C	A-D	A-E	A-F	B-C	B-D	B-E	B-F	C-D	C-E	C-F	D-E	D-F	E-F
R1	5	1/3	1/5	1/5	1/5	1/5	1/7	1/7	1/5	1/3	1/3	1/5	1/3	1/3	1/7
R2	3	3	1/3	3	1/7	1/3	1/5	1/3	1/5	3	1	1/7	1/3	1/7	3
R3	3	1/3	1/7	1/3	1/3	1/3	1/7	1/5	1/3	5	1/5	1/3	1/9	1/5	1/9
R4	3	5	3	1/3	1/5	1/3	3	1/5	1/5	3	1/5	1/7	1/7	1/5	3
∑Resp	14	8,67	3,68	3,87	0,88	1,20	3,49	0,88	0,93	11,33	1,73	0,82	0,92	0,88	6,25
Resp/4	3,50	2,17	0,92	0,97	0,22	0,30	0,87	0,22	0,23	2,83	0,43	0,20	0,23	0,22	3,56

The next step is to find the criteria weights and prove the consistency of pairwise comparisons with AHP. The criteria for each consistency value are calculated.

The value used refers to the cumulative average (Σ Resp/4). In the diagonal matrix AA = BB = CC= DD = EE = FF = 1, the factors are compared.

Table 3. Initial Criteria Matrix

Criteria	A	B	C	D	E	F
A	1,00	3,50	2,17	0,92	0,97	0,22
B	0,29	1,00	0,30	0,87	0,22	0,23
C	0,46	3,33	1,00	2,83	0,43	0,20
D	1,09	1,15	0,35	1,00	0,23	0,22

E	1,03	4,57	2,31	4,34	1,00	1,56
F	4,57	4,29	4,88	4,56	0,64	1,00
Total	8,44	17,83	11,01	14,53	3,49	3,44

The next step is to calculate the eigenvectors of each initial criteria matrix.

Table 4. Criteria Vector Eigen Values

Criteria	A	B	C	D	E	F	∑	Wi	E-Vector
A	1,00	3,50	2,17	0,92	0,97	0,22	1,48	1,07	0,14
B	0,29	1,00	0,30	0,87	0,,22	0,23	0,004	0,40	0,05
C	0,46	3,33	1,00	2,83	0,43	0,20	0,39	0,85	0,11
D	1,09	1,15	0,35	1,00	0,23	0,22	0,02	0,53	0,07
E	1,03	4,47	2,31	4,34	1,00	1,56	74,03	2,05	0,27
F	4,57	4,29	4,88	4,57	0,64	1,00	279,0	2,56	0,34
TOTAL	8,44	17,83	11,01	14,53	3,49	3,44	354,92	7,45	1,00

The maximum Eigen value is obtained from the initial matrix multiplied by the E-vector of each matrix and then the results of the multiplication are added up. The assessment criteria are as follows:

Table 5. Criteria assessment

CRITERIA	A	B	C	D	E	F		E Vector		
A	1,00	3,50	2,17	0,92	0,97	0,22		0,14		0,98
B	0,29	1,00	0,30	0,87	0,22	0,23		0,05		0,33
C	0,46	3,33	1,00	2,83	0,43	0,20		0,11		0,75
D	1,09	1,15	0,35	1,00	0,23	0,22	X	0,07	=	0,47
E	1,03	4,57	2,31	4,34	1,00	1,56		0,27		1,78
F	4,57	4,29	4,88	4,57	0,64	1,00		0,34		2,28
								Total	=	6,59

Maximum Eigen (λmax) = Σ aij. Xj = 6.59

- Consistency Index (CI) = (λmax.–n)/(n-1), where n = matrix size 6 x 6
- Consistency Ratio (CR) = CI/RI, for n = 6, then RI = 1.24.

Consistency Ratio Value(CR) is smaller than 0.09, meaning it is smaller than 10%, then such value is correctaccording to the consistency requirements, which must be smaller than 0.1 or 10%.

On assessment criteria

CI = (6.59 – 6) / (6 - 1) = 0.12

CR = 0.12 / 1.24 = 0.09 < 0.1 consistent!

It can be seen that the respondents' assessment of the criteria for determining the location of a tempe factory is consistent. The results of the priority weights for the normalized criteria are presented in Table 6 below:

Table 6. Criteria Weight

Criteria	Market distance and marketing	0,98/6,59 x 100% = 14.93 %
	Distance to the location of raw material suppliers	0,33/6,59 x 100% = 5,02 %
	Transportation facilities	0,75/6,59 x 100% = 11,36%
	Supporting facilities and utilities	0,47/6,59 x 100% = 7,08%
	Labor availability	1,78/6,59x100% =26,94%
	Geological and climatic conditions	2,28/6,59 x 100% = 34,67%

From the results of the analysis using the AHP method, the criteria for geological and climatic conditions of the factory location are the main priority when setting up a tempeh factory with a criteria weight of 34.67%, this is because geology influences the physical construction work methods of the factory

Meanwhile, climate has a big influence on tofu products. Tofu is a food made from soybeans or several other ingredients which are processed through several stages. Through this process, soybean seeds undergo a process of breaking down into simple compounds so they are easily digested.

Some deviations and causes of failure in making tofu are suboptimal fermentation due to unfavorable humidity and temperature. Air humidity is also an element that influences the weather and climate conditions or conditions in a particular area. The optimal conditions for tofu formation are at a temperature of 24°C. With suitable geological and climatic conditions, tempe products will be in accordance with consumer desires, because the final product result is the most important. Tofu products that have the best quality will survive the competition, so geological and climate criteria are the main priority according to the results of analysis with AHP in determining the location of the tofu factory

.The next priority is the availability of labor (26.94%), market and marketing distance criteria (14.93%), transportation facilities criteria (11.36%), supporting facilities and utilities criteria (7.08%) and finallythe criterion for the distance to the location of raw material suppliers. The distance to the location of the raw material supplier is the last priority in determining the location of the tofu factory because the supply of raw materials does not need to be done every day, main raw materials such as soybean can be orderedonce in a month. This will affect the transportation budget when bringing in raw materials which are only issued approximately once a month. This is different from the budget for labor wages, which, in the wage system, is daily. If you bring in workers far from the factory then the transportation budgetwill also be included in the list for them. Apart from that, the criteria for distance to market and marketing and for transportation facilities will also be covered every day, so distance to market and marketing and transportation facilities are more important priorities than distance to raw material suppliers. Meanwhile, the criteria for the availability of supporting facilities and utilities are higher than the criteria for distance to raw material suppliers because the supporting facilities and utilities are also used every day, but only with good maintenance will the supporting facilities and utilities be optimally arranged during the production process.

IV. CONCLUSION AND SUGGESTIONS

1.1 Conclusion

From the research carried out on several criteria, it can be concluded that the priority scale for determining the location of the tofu factory, after being analyzed with AHP, referred to geological and climatic conditions (34.67%), availability of labor (26.94%), distance to market and marketing (14.93%), transportation facilities (11.36%), supporting facilities and utilities (7.08%), and distance to locationsof raw material supplier (5.02%). Referring to the results and discussion above, respondents prioritize product quality, andthey also determine the costs as their other priority criteria.

4.2 Suggestions

Some suggestions for further research include:

1. Add sub-criteria in selecting the location of the tofu factory, so the alternative locations selected are more detailed.

2. The use of the AHP method in selecting a tofu factory location needs to be made by using the calculation software to make it faster and easier to use.

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