

Choosing Alternative Managements of Solid Waste from Tofu Producing Small and Medium Enterprises in East Aceh District by Analytical Hierarchy Process (AHP)

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Keywords : Small and Medium Enterprises, Analytical Hierarchy Process, Solid Waste Management.

Abstract. Many tofu is produced by small and medium enterprises (SME). The process of producing tofu the resulting output is tofu and secondary products. The secondary products are solid and liquid waste. The solid waste produced has a crude protein content of around 21.29%. Because the protein content found in high solid waste from tofu, it is very possible for the solid waste to be utilized. This research was conducted on SMEs who were in East Aceh District. The purpose of this study is to obtain alternative solid waste treatment in tofu SMEs. The method used in this study is the analytical hierarchy process (AHP). AHP is a process for ranking each alternative decision based on how well the alternative meets the decision-making criteria. The steps of this research are observation and study of literature, identification of problem, determining or research objectives, data collection, data processing, and discussion. The criteria that are taken into consideration by researchers for solid waste management are economical, technological and environmental aspects. From these aspects, we have examined the alternative waste management by the SME, whether it is used as material food, animal feed or not used (disposed). By using the AHP method, we will know the alternative weight of solid waste management by business actors. The results of this study obtained aspects of the criteria for waste management which are the top priority are economical aspects and the alternative choice of processing solid waste is material food with an alternative weight value of 63,11 percent.

1. Introduction

Small and medium enterprises (SME) that are engaged in tofu processing are often found in Indonesia, as well as in one district in the province of East Aceh. Tofu processing is applied on a small scale, this is due to people's high interest in tofu, the ease of obtaining raw materials and the simple production process of tofu. In the tofu production process, the output produced is tofu and side output, namely solid and liquid waste. The focus of this research is tofu solid waste management. Tofu solid waste contains protein (23.35%), fat (5.54%), sugar (26.92%), ash (17.03%), crude fiber (16.53%), and air (10, 53%) [1]. This causes solid waste to be used for food and animal feed without having to throw it into the environment.

This research was conducted in East Aceh District. This study aims to obtain an alternative selection of tofu processing from the perspective of tofu business actors. The aspects that are taken into consideration in management of solid waste from tofu are economical, technological and environmental aspects. From these aspects, the researcher conducted research on alternative waste management by the existing SME, whether it was used as food ingredients, animal feed or not used (disposed). The method used to select alternative solid waste management from tofu is the analytical

hierarchy process (AHP). AHP is a process for making a numerical score and ranking each decision alternative based on how well the alternative meets the decision-making criteria [2].

2. Literature Reference

Decision Support System (DSS) is a system that is used to support semi-structured decisions. DSS is used as a tool for decision makers to expand their capabilities, but not to replace their judgment. DSS is used for decisions that require assessment or in decisions that cannot be supported by an algorithm [3]. The objectives of DSS are as follows:

1. Helping managers in making decisions on semi structure problems.
2. Provide support at the manager's discretion and not intended to change the manager's function.
3. Increasing the effectiveness of decisions taken is more than an improvement in efficiency.
4. Enables decision makers to do a lot of computing quickly at low cost.
5. Increased productivity.
6. Improve quality.
7. Increasing competitiveness.
8. Overcoming cognitive limitations in processing and deviation.

Analytical Hierarchy Process is a decision support method developed by Thomas L. Saaty. This decision support model will outline multi-factor problems or complex multi criteria into a hierarchy. According to Saaty (1993) [4], hierarchy is defined as a representation of a complex problem in a multilevel structure where the first level is a goal, followed by a factor level, criteria, sub criteria, and so on to the last level of the alternative.

Analytical Hierarchy Process is used as a problem solving method compared to other methods, for the following reasons:

1. A hierarchical structure, as a consequence of the criteria chosen, reaches the deepest sub-criteria.
2. Taking into account the validity up to the tolerance limits of inconsistencies as criteria and alternatives chosen by decision makers.
3. Take into account the durability of the output of the decision-making sensitivity analysis.

Like an analysis method, AHP also has advantages and disadvantages in its analysis system. The advantages of this analysis are [5]:

1. Unity
AHP makes broad and unstructured problems into a model that is flexible and easy to understand.
2. Complexity
AHP solves complex problems through a system approach and deductive integration.
3. Interdependence
AHP can be used on system elements that are mutually independent and do not require linear relationships.
4. Hierarchy Structuring
AHP represents natural thinking that tends to group system elements into different levels of each level containing similar elements.
5. Measurement
AHP provides measurement scales and methods to get priority.
6. Synthesis
AHP leads to an overall estimate of how important each alternative is.
7. Trade Off
AHP considers the relative priority of the factors in the system so that people are able to choose the best alternative based on their goals.

8. Assessment and Consensus (Judgment and Consensus)
AHP does not require the existence of a consensus, but combines different assessment results.
9. Process Repetition
AHP is able to make people filter the definition of a problem and develop their judgment and understanding through the repetition process.

While the weaknesses of the AHP method are as follows:

1. Dependence on the AHP model on its main input. This main input is the perception of an expert so that in this case involves subjectivity of experts. In addition, the model becomes meaningless if the experts provide a false assessment.
2. This AHP method is only a mathematical method without statistical testing so that there is no limit of trust from the truth of the model formed.

AHP work steps as follows [6]:

1. Determining objectives, criteria and alternative decisions
2. Arrange hierarchies for various criteria and alternative decisions
3. Make pairwise comparisons matrix based on each criterion and sub-criteria. Pairwise comparisons matrix is made based on comparative judgment by assessing the importance of a criterion compared to other criteria. In the comparative judgment the comparison numbers are in the form of a scale of 1 to 9, where scale 1 shows the lowest level (equal importance) up to scale 9 which shows extreme importance. The values and definitions of the Saaty comparison scale can be seen in Table 1.

Table 1. Comparison Scale [7]

Interest level	Definition
1	Both elements are equally important
3	One element is a little more important than the other
5	One element is very important than the other
7	One element is clearly more important than the other elements
9	One absolute element is more important than the other elements
2, 4, 6, 8	The values between two considerations are close together

1. Determine the weight vector by:

- a. Normalization of each column j in matrix A such that:

$$\sum a_{ij} = 1 \tag{1}$$

a_{ij} is a matrix element A

- b. For each row i in the matrix calculate the average value (eigenvector)

$$w_i = \frac{1}{n} \sum a_{ij} \tag{2}$$

w_i is the weight of i of the weight vector

2. Testing the consistency of the comparison matrix by

If A is a pairwise comparison matrix and W is a weight vector, then the consistency of A can be tested by:

- a. Calculate t

$$t = \frac{1}{n} \sum_1^n \left(\frac{\text{elemen ke } i \text{ pada } (A)(W^T)}{\text{elemen ke } i \text{ pada } W^T} \right) \tag{3}$$

- b. Calculate consistency index

$$CI = \frac{t - n}{n - 1} \tag{4}$$

c. Check the consistency ratio

$$CR = \frac{CI}{RI} \quad (5)$$

If $CR < 0.1$ then A is consistent

RI values = random index values based on Table 2

Table 2. Random Index Value [2]

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

3. Determine global weights if there are sub criteria
4. Determine alternative ranking
5. If there are n criteria and alternative methods, the steps to determine alternative ranking are:
 - a. For each criterion i, specify the A_i pair comparison matrix for the alternative m.
 - b. Determine the weight vector for each A_i that presents the relative weight of each alternative to j in the criterion to i (s_{ij}).
 - c. Calculate the total score:

$$S_j = \sum (S_{ij}) (W_i)$$

3. Research Methods

The steps in this research are:

- a. Observation and study of literature
Observation is an activity that recognizes the condition of the company and finds problems that occur, and literature studies are activities to collect information related to the themes studied through text books, previous research journals and related magazines
- b. Identification of problem
Problem identification is the activity of identifying problems to be solved. The problem in this study is the problem in this research is solid waste from tofu processing.
- c. Determining or research objectives
Research objectives of this research is choosing Alternative Managements of Solid Waste from Tofu Producing Small
- d. Data collection
Data collection was obtained through the preparation of questionnaires, determining respondents, distributing questionnaires to respondents, and collecting questionnaires that had been filled out by respondents.
- e. Data processing
Data processing are recapitulation of the results of the questionnaire that has been filled out by the respondent then calculates the priority weight of alternative solid waste processing from tofu processing using the AHP method.
- f. Discussion
At this stage the steps taken are to discuss alternatives taken based on the calculation of priority weights.

The stages of this research can be seen in Figure 1

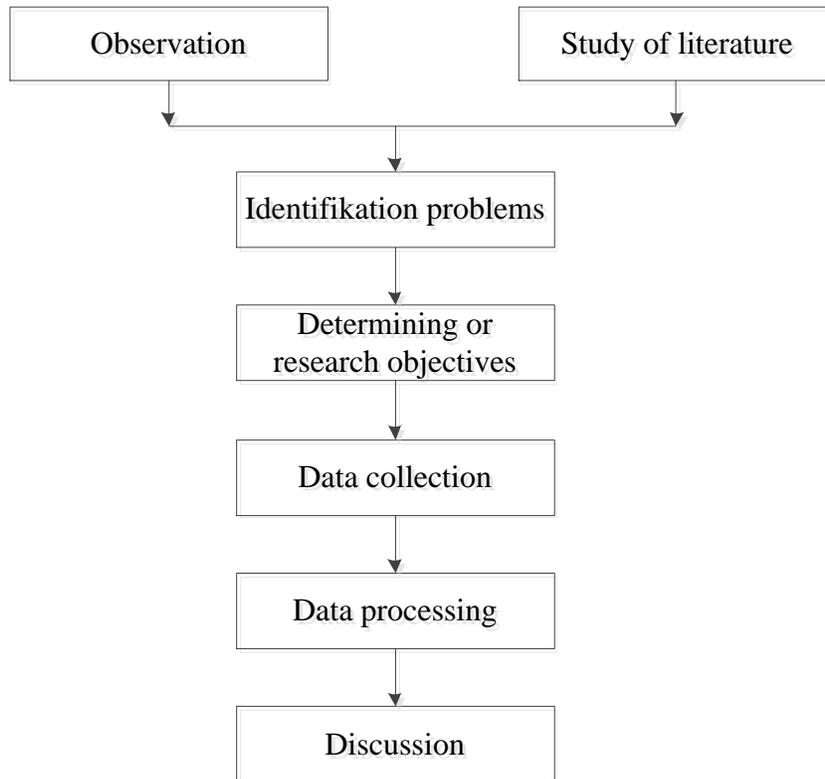


Figure 1. Research Steps

4. Result

4.1. Hierarchy of Alternatives For Solid Waste Processing From Tofu

The alternative management hierarchy of solid waste from tofu can be seen in Figure 2.

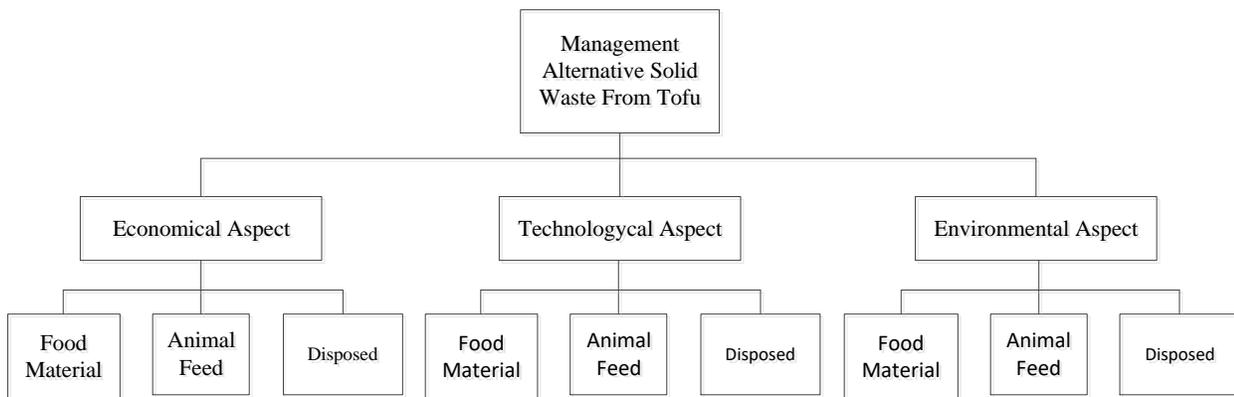


Figure 2. Management Hierarchy of Solid Waste from Tofu

4.2. Determine pairwise comparisons matrix

Pairwise comparisons matrix level 1 (solid waste management criteria from tofu) can be seen in Table 1.

Table 1. Pairwise Comparisons Matrix Level 1 Management Criteria for Tofu Waste

Criteria	Economical Aspect	Technological Aspect	Environmental Aspect
Economical Aspect	1	5	4
Technological Aspect	1/5	1	2
Environmental Aspect	1/4	1/2	1

Pairwise comparisons matrix level 2 economical aspect can be seen in Table 2.

Table 2. Pairwise Comparisons Matrix Level 2 Economical Aspect

Sub Criteria	Food Material	Animal Feed	Disposed
Food Material	1	3 1/4	4 2/3
Animal Feed	1/3	1	3 1/2
Disposed	2/9	2/7	1

Pairwise comparisons matrix level 2 technological aspect can be seen in Table 3.

Table 3. Pairwise Comparisons Matrix Level 2 Technological Aspect

Sub Criteria	Food Material	Animal Feed	Disposed
Food Material	1	3 3/8	4 3/4
Animal Feed	2/7	1	3 1/2
Disposed	1/5	2/7	1

Pairwise comparisons matrix level 2 environmental aspects can be seen in Table 4.

Table 4. Pairwise Comparisons Matrix Level 2 Environmental Aspect

Sub Criteria	Food Material	Animal Feed	Disposed
Food Material	1	3 3/4	5
Animal Feed	1/4	1	3 1/2
Disposed	1/5	2/7	1

4.3. Partial Weight Vector Calculation.

The partial weight vector is calculated using formulas 1 and 2. The results of these calculations can be seen in Table 5.

Table 5. Partial Vector Weight

Partial Weight			
Level 1	Level 2	Level 3	
Management Alternative solid waste from tofu	Economical Aspect (0,6775)	Food material	0,6274
		Animal feed	0,2680
		Disposed	0,1045
	Technological Aspect (0,1916)	Food material	0,6337
		Animal feed	0,2632
		Disposed	0,1030
	Environmental Aspect (0,1303)	Food material	0,6493
		Animal feed	0,2502
		Disposed	0,1005

4.4. Consistency Testing

The results of the consistency level of respondents can be seen in Table 6

Table 6. Consistency of Respondents

No	Criteria sub criteria	CR	Information
1	Management Alternative solid waste from tofu	0,0774	Consistent
2	Economical Aspect	0,0785	Consistent
3	Technologycal Aspect	0,0806	Consistent
4	Environmental Aspect	0,09513	Consistent

4.5. Calculation of Global Priority Weight

The calculation of global priority weights (level 3) is obtained by multiplying partial weights level 2 and 3. The results of calculating these weights can be seen in Table 7.

Table 7. Weight of Global Priorities

Level 1	Level 2	Level 3	Priority Weight	
Management Alternative solid waste from tofu	Economical Aspect (0,6775)	Food material	0,6274	0,4251
		Animal feed	0,2680	0,1816
		Disposed	0,1045	0,0708
	Technologycal Aspect (0,1916)	Food material	0,6337	0,1214
		Animal feed	0,2632	0,0504
		Disposed	0,1030	0,0197
	Environmental Aspect (0,1303)	Food material	0,6493	0,0846
		Animal feed	0,2502	0,0326
		Disposed	0,1005	0,0131

Level 2 weights are obtained by summing the weights at level 3. Level 2 priority weights can be seen in Table 8.

Table 8. Priority Level 2 Weight

No	Criteria	PriorityLevel 2 Weight
1	Economical Aspect	0,6774
2	Technologycal Aspect	0,1916
3	Environmental Aspect	0,1303

4.6. Alternative Ranking.

Alternative ranking is calculated by summing priority level 3 weights for alternative waste management. As for alternative management of solid waste from tofu can be seen in table 9.

Table 9. Alternative Weight

Management Alternative solid waste from tofu	Alternative Weight	% Alternative
Food Material	0,6311	63,11
Animal Feed	0,2646	26,46
Disposed	0,1036	10,36

5. Conclusion

The alternative management of solid waste from tofu in East Aceh District which has the highest alternative weight is used as food (63.11 percent) followed by animal feed (23.46 percent) and disposed (10.36 percent).

6. Acknowledgements

This work is financially supported by the UNSAM DIPA in the research schemes of young lecturers in 2019.

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