Decision Support System for Selection and Assessment of Solid Waste Processing Technology from Oil Palm Industry using Analytical Hierarchy Process (AHP)

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Abstract. The waste produced by the palm oil industry contributes greatly to environmental damage if it is not operated properly. Waste from palm oil processing consists of 70% of the amount of raw material which is almost half in the form of liquid. Over time the growth of the palm oil industry has always increased, therefore the waste from the palm oil industry will increase. The palm oil industry must have environmentally friendly solid waste treatment technology that is able to provide added value. There are many alternatives to treat the palm oil industry’s solid waste, from the most advanced technology to conventional technology. Decision Support Systems have been developed to assist companies in identifying, evaluating and choosing technologies for processing solid waste. In this study, three operations have been developed in MySQL, the database for waste treatment technology has criteria and sub criteria selection criteria using the DELPHI method; Introduction of criteria using the Analytical Hierarchy Process (AHP) approach. This study can assist in decision making and optimize the reprocessing of solid waste from palm oil mills.

1. Introduction
The palm oil industry continues to grow from year to year. The palm oil industry processes palm oil into Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). Comparison of the amount of coconut produced by the two products is only 30% of the raw material. This means that 70% is industrial waste. The quantity of palm oil waste will increase along with the growth of the palm oil industry. The amount of waste produced by the company if not handled properly and effectively will have a significant impact on environmental damage both at the input and in the output of industrial activities.

Solid waste consists of empty bunches, leaves, shells, etc [1]. One effort to reduce solid waste is by processing it into a nutrient source that can replace synthetic steel [2]. Solid waste produced more than 20% by weight of fresh fruit bunches [3]. Each producing one ton of palm oil requires 5.8 tons of fresh fruit bunches and produces empty fruit bunches equivalent to 20-28.5% [4]. Empty fruit bunches are ideal raw materials for recycling because they are produced in large quantities and are often used as fuel for boilers and boiling processes. At present, a large number of empty fruit bunches are used as gardens,
almost entirely replacing combustion, which is currently limited to only a few industries, the level of regular TBK use is 40-70 tons / hectare [2].

The most common problem is the difficulty in applying the most appropriate technology from a series of alternative industrial solid waste treatment technologies in certain companies. Factors such as capital costs, operating and maintenance costs and area requirements are important considerations in selecting technology for processing palm oil solid waste. Sustainability criteria also need to be included in the decision making process so that the right technology will be chosen. Developing assessment criteria and methods that provide sustainability measurement is a prerequisite for selecting the best alternative, to identify the requirements for solid waste technology in the palm oil processing industry, informing integrated design of producers of alternative performances and the effects of social environmental monitoring. Diversifying the latest criteria and measurement tools in this rapidly expanding field shows the importance of conceptual and methodological work in this field. The development and selection of criteria requires parameters related to reliability, suitability, practicality and size limits. Although many technologies have been developed. Unfortunately, technology selection is difficult because there are no databases and technology assessment methods.

Election problems show how important it is to have a decision support system. The work concept and methodology in developing evaluation criteria and methods that provide sustainability measurement are prerequisites for model development. The development and selection of criteria requires parameters related to reliability, suitability, practicality and size limits. The decision support system to be developed is expected to be used as a tool for the palm oil industry in the selection and evaluation of the IKM to be used. This system was built in the form of a decision support system to optimize the use of solid waste in the palm oil industry. This decision support system is also expected so that the palm oil industry can identify the benefits of good value that can be obtained from various methods of handling solid industrial waste so that the value of applying industrial solid waste handling methods is not only delivered from the implementation costs, but also from the value of benefits too. to choose and evaluate technology wisely.

The choice of appropriate solid waste treatment technology enables sustainable development to be a challenge for national, regional and local policy makers. Technology selection and alignment involves decision makers who are critical of the company’s profitability and growth in an increasingly competitive global environment. In the process of selection and alignment it requires analysis of a large number of economic factors and analysis [5]. Decision support tools for the selection of solid waste treatment technology are needed in developing countries, such as Indonesia, mainly because there is nothing suitable for use in the context of economic growth and an increase in the burden of natural resources. The need for such decision support tools is very prominent in Indonesia because there is a large gap between oil palm solid waste and available waste treatment technology. it will produce 5,678 million m$^3$ of liquid waste per year, 1,135 million tons of mud and 1,865 million tons of fruit bunches. Many technologies have been developed for waste treatment.

The palm oil industry produces 5,678 million m$^3$ of waste every year, 1,135 million tons of mud and 1,865 million tons. Solid waste from this process consists of empty fruit bunches, kernels and fibre. Shells and fibre are generally used as boilers or sold to others, while empty bunches are used in the plantation area as a greeting. The content of biomass in solid waste that is naturally degraded creates a very low risk of environmental pollution. Meanwhile, solid waste from liquid waste is mud [6].

The challenge in waste management is the selection of the best technology available for special waste processing needs in certain situations. The choice of technology is complex decision-making activities which if not managed properly will lead to a rapid decline in organizational well-being [7]. At present there are many methods of waste treatment technology developed to deal with residual solid waste. Various methods of waste management technology that exist and produce products that can be utilized by the company itself, for example, processing solid waste companies produce boiler fuel that can be used as an energy source and empty fruit bunches that can be processed into compost that can be used in the garden instead inorganic price fertilizer is more expensive.
The method in the literature about the right decision-making activities is that decision makers use subjective judgment and their experience to choose the right technology. AHP is an organized multicriteria procedure for sorting out and examining complex choices dependent on numerous models [14]. AHP provides a methodological approach to decision-making problems that requires the accuracy of expert judgment to adequately assess existing technologies. Comparison of pairs compares criteria in pairs to evaluate criteria to be chosen, or has a greater number of values. Subjective approaches such as AHP depend on the opinion of the team's decision to evaluate alternative options. AHP can deal with subjective and quantitative elements from dynamic cycle for all intents and purposes, methodically and quickly [15].

The decision support system to be developed is expected to be used as a tool in the selection and evaluation of solid waste processing by the palm oil industry operators. The system must be based on the web to allow users to access it via the Internet. The development uses MySQL 4.1.14. This system will be built in the form of a decision support system to optimize the use of solid waste.

2. Methodology

The Delphi method is a method that is carried out by forming groups or communication groups consisting of experts to discuss a problem. The Delphi method has been widely used in social, ecological and economic work and generally involves experts with expertise in the area of the problem being discussed [8,12]. The Delphi method is generally used as an opinion network of groups of experts who have competence in their fields. Characteristics of Delphi Method: (1) the ability to accommodate subjective opinions of each individual iteratively and the existence of familiarity with the assessment of the collection of responses, and (2) not using names in the question of probing allowing free dissemination of opinion and no impression of dominance, and (3) all experts are actively involved in the beginning of the process and the pleasure of the review.

AHP provides a AHP was developed independently of other decision theories where the main feature of the AHP method was the use of paired comparisons, which were used to compare alternatives with respect proven and effective way to handle complicated decision making and can assist in analyzing collected data and speeding up decision making methods and identifying and weighing criteria [9-11].

MySQL is an open relationship management system. Which means that MySQL can be downloaded by anyone and is user friendly, both the original version of the program code and the binary version and can be used relatively free for both custom and computer programs. MySQL uses standard SQL language as a language that is interdependent in managing data. Tools in SQL are often also referred to as Queries. Because it uses the same standard language, which is a programming language.

The object of the research observed was the processing of solid waste from the oil palm industry. The variables used in the assessment of solid waste treatment technology were identified using the Delphi method which was divided into 5 respondents. Then the next variable is identified based on the most influencing criteria aspects. The variables contained in this study are:

- The dependent variable in this study is the assessment of solid waste treatment technology.
- The independent variable in this study is the supplier selection criteria, namely the criteria of environmental aspects, technological aspects, economic aspects, and social aspects.

The stages carried out in evaluating solid waste processing technology are divided into 4 stages, namely:

- Survey stages
  To obtain qualitative data about existing solid waste treatment technologies, such as criteria and sub-criteria for determining the method of solid waste treatment technology
- Stage of criteria assessment
  To define criteria and sub criteria that have been obtained at the survey stage.
- Third Stage
The stages of making design algorithms are evaluating solid waste processing technology for decision making

- Fourth Stage
  Implementation of criteria and algorithms designed on the decision-making system that has been made after compiling the algorithm and carrying out verification.

Data collection in this study was conducted using a questionnaire about determining criteria, sub-criteria using the Delphi method. Steps to collect data in this case study. The stages of conducting research are:

- Preliminary study related to the problems found in the company and the problems found in the environment.
- Preparation of questionnaires from the review literature on solid waste treatment technology and technology selection over the past few years.
- Conduct interviews using the Delphi method with experts to obtain data on solid waste treatment technology.
- Making a decision system using the AHP method so that qualitative data and decision systems are obtained.
- Making MySQL Data Structure which contains datasets for processing solid palm oil industry waste.
- Implementing the problems found in the company
- Evaluate the effectiveness and efficiency of decision support systems

3. Results and Discussion

3.1. Results of Solid Waste Technology Methodology

The technology of solid waste processing in the palm oil industry obtained 5 solid waste processing technologies, among others: composting systems, mulching, boiler fuel, fodder and briquet. The following is the result of distributing questionnaires using the Delphi method.

| No | Description                          | Mulching | Composting System | Boiler Fuel | Livestock Feed | Briquet |
|----|--------------------------------------|----------|--------------------|-------------|----------------|---------|
| 1  | The rest is controlled               | Solid    | Solid              | Solid       | Solid          | Solid   |
| 2  | Area Requirement (Ha)                | 1200 Ha  | 3 Ha               | 5 Ha        | 3 Ha           | 1200 Ha |
| 3  | Cost of Investment Cost (Billion)    | 0        | 11.97              | 1           | 11.97          | 0       |
| 4  | Labor (person)                       | 5 /Ha    | 10                 | 5 /Ha       | 10             | 5 /Ha   |
| 5  | Negative social impact               | Not Available | Not Available | Not Available | Not Available | Not Available |
| 6  | Added value for SMIi                 | Easy     | Easy               | Easy        | Easy           | Easy    |
| 7  | Maintenance                          | Yes      | Yes                | Yes         | Yes            | Yes     |
| 8  | Meet with clean production programs  | 30       | 30                 | 30          | 30             | 30      |
| 9  | Capacity of BTS in FFS (tan / hour)  | 20       | 20                 | 20          | 20             | 20      |
| 10 | Processing hours (hours / day)       | 300      | 300                | 300         | 300            | 300     |
| 11 | Weekday processing (day / year)      | 180.000  | 180.000            | 180.000     | 180.000        | 180.000 |
| 12 | Number of BTS processed (tan / year) | 21.50    | -                  | 21.50       | -              | 21.50   |
| 13 | BTS Conversion to TBK (%)            | 38.700   | 38.700             | 38.700      | 38.700         | 38.700  |
Technology for processing and utilizing the palm oil industry has been developed based on information and data obtained from literature and interviews on the management methods of the palm oil industry fluid presented in the survey. There are 34 data that explain the differences of each solid waste treatment technology.

3.2. Solid Waste Technology Evaluation Criteria and Sub-criteria Results

Selection of criteria and sub-criteria is done by interviewing experts with Delphi method, in the criteria of solid waste treatment technology and sub-criteria considered to affect the alternative solid waste treatment technology. An interview summary with sub criteria for selection and criteria for solid material assessment processing technology can be shown in Table 2.

| Criteria | Sub Criteria | Description |
|----------|--------------|-------------|
| Environmental Aspect | 1. Release of CO2 | There is waste in a form of CO2 |
| | 2. Energy use | the energy used to support transformation activities |
| | 3. Waste integration | Integration of oil palm waste technology and interconnection in order to increase added value |
| | 4. Energy efficiency | the most frequently used criteria for assessing technology and usage systems |
| | 5. Emission Level | reducing the emission level of greenhouse in order to reduce fuel consumption |
| Technology Aspect | 1. Technology maturity | Technology readiness in processing waste |
| | 2. Technology development efforts | evaluates every technology associated with efforts for future development |
| | 3. Technology industry support | Recommended as an ability where innovation linkages or industry backing can be looked for during the advancement of void waste bunk preparing plant innovation |
| | 4. Ease of operation | Ease of use of technology by operators in processing waste |
| | 5. Failure Rate | Percentage failure of a technology in processing waste |
| | 6. Performance | Capacity of palm oil solid waste processing technology in terms of producing optimum output and input in system use |
| | 7. Maintenance | Technology capabilities can be treated |
| | 8. Human resource | Sufficient human resources for technology development |
| | 9. Industrial support | the capabilities in which technological linkages or industrial support can be sought during the development of empty fruit bunches solid waste processing technology |
| | 10. Durability | Technology resilience |
| Economic Aspect | 1. Initial investment | cost of industrial facilities and facilities needed for technological solid waste processing |
| | 2. Operating costs | the costs incurred in the process of processing solid waste of empty fruit bunches |
| | 3. Maintenance costs | the costs incurred in the process of processing solid waste of empty fruit bunches |
| | 4. Human Resource Cost | Costs incurred for recruiting human resources |
| Social Aspect | 1. Area use | the proportion of area (area) is needed for the waste processing of solid waste bunches |
| | 2. Social acceptance | Set as if the system is safe for people and people |
| | 3. Technological impact | Empty waste processing of solid waste bunches does not pollute the environment and disturb the community |
Selection criteria and sub-criteria are conducted in interviews with experts in solid waste processing technology on the criteria and sub-criteria are considered to be influential in the rest of the alternative solid processing technology. The stages in this study are the determination of the criteria and sub-criteria of the evaluation of waste processing technology.

From the interview results obtained 4 criteria of solid waste treatment technology, namely environmental aspects, technological aspects, economic aspects and social aspects. Sub-criteria obtained from the results of the interview were 22 sub-criteria [13].

3.3. Results of Solid Waste Management Technology Hierarchy Structure
The hierarchical structure results based on the criteria and sub criteria obtained, four criteria and seventeen sub-criteria were selected. The Hierarchical Structure results can be seen in Figure 1.

From the above hierarchy, it can be seen that there are objectives in this research, namely solid waste treatment technology, with 4 criteria in the selection of technology, namely environment, technology, economy, and social. and there are 16 sub criteria and there are 5 alternatives for choosing solid technology, namely composting, mulch, bio fuel, animal feed, and briquet.

From the result of calculation of criterion weight and sub-criteria got technology aspect criterion have the biggest weight that is 0.3869 so that criterion can be used as the biggest assessment aspect in selection of solid waste processing technology. While the sub-criteria of social acceptance has the biggest weight that is 0.3456 so that sub-criteria can be used as consideration in selecting solid waste processing technology. The best solid waste treatment technology is the composting system because of the weighting of the composting system is the biggest weight.

4. Conclusion
The search for par value for solids waste processing technology has been obtained, where the value proposition technology uses the Analytical Hierarchy process to help determine the oil palm waste processing technology based on objectives, par value, sub-values and alternative. The selection and evaluation of solid waste treatment technology of palm oil industry is designed to determine the processing technology and utilization of palm oil industry that can be optimally utilized by the palm oil industry. This program uses the analytical hierarchy process called Analytical Hierarchy Process (AHP).
Developing software can be created. In the design used in the phpMyAdmin interface, the MySQL database, the company needs a system that will simplify the selection of waste technology processing technology to address the problems that occur without any regulatory standards and criteria. There are 4 criteria of solid waste treatment technology that can be used in selecting the best processing technology and the best decision making method using the Analytical Hierarchy Process (AHP) method.

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