Preliminary Study on the Location Selection of Microalgae Cultivation In Nusa Tenggara Region As A Potential Feedstock For Bioavtur

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Abstract. NTT is a province located in strategic areas between Bali and South Sulawesi which has economic growth 5,08% in 2016. This causes air transportation in NTT to grow rapidly so the need for avtur is increased by 6% per year. To meet the needs of avtur in NTT would require energy diversification with bioavtur development in which one of them comes from microalgae. The content of lipid and hydrocarbon in microalgae can be used as a source of bioavtur feedstock. The suitability of location for cultivation will influence the success of microalgae cultivation that will be used as a source of bioavtur feedstock. The purpose of this research is to choose the best location for microalgae cultivation in NTT by AHP method. The criteria used in this research are nutrient, water and technology. Sub criteria of nutrient elements are coal power plant emission, cement industry emission and synthetic fertilizers, sub criteria from water that is sea water, brackish water and fresh water, while sub criteria of technology are Photobioreactor, Open Raceway Pond and membrane. The result of AHP analysis shows the selection of microalgae cultivation location in Kupang with the weight of 0.308, with the source of nutrient derived from coal power plant emission, the type of water used is sea water and the technology used is Photobioreactor. Microalgae species used were *Nannochloropsis sp* with a lipid content of 31-68%. Based on the author assumption, microalgae have the productivity for bioavtur manufacture which amount of 24.489kL/ha/ yr. That can be used to meet the needs of 2% avtur in NTT which amount of 1.052,22 kL/yr and the area requirement for microalgae cultivation is 2,14 hectare.

1 Introduction

1.1 General

The province of East Nusa Tenggara is a provincial archipelago with 1.192 islands in total, with land area 47.931,54 km2 [1]. NTT is one of the provinces that has the most number of airports in Indonesia, to date there are 14 airports in operation. NTT has economic growth 5,18% in 2016[2]. As a developing region, many tourists who come to NTT using air transportation causing avtur demands to increase by 6% per year [3]. The government requires the use of bioavtures beginning in 2016 with a 2% mixture that could reduce dependence on imports while reducing air emissions resulting from exhausted fumes[4]. Microalgae have high lipid content, are easy to cultivate, produce high biomass and do not compete with food commodity so it can be developed as biofuel [5]. The location for microalgae cultivation is a major factor to be considered in the effort of providing bioavtur feedstock. In NTT there are 3 developing regions namely Kupang, Ende and Labuan Bajo which seen from the increase of flight passenger number in April 2017 are El

Tari airport 53,52%, Komodo 12,34% and Ende 6,17% [6]. NTT has many tourism destination such as Komodo island, Kelimutu Lake, Diving spot in Labuan Bajo, and soon. NTT government has agenda to improve the infrastructure one of them is transportation sector. NTT has the best weather to cultivate microalgae as a bioavtur feedstock. Kupang has annual relative humidity 72,1%, rainfall 1144,89 mm and sun radiation 22,92 20,76 MJ/m^2/d. Ende has annual relative humidity 76%, rainfall 1367,43 mm y-1sun radiation 20,76 MJ/m^2/d. That locations is a strategic area in NTT so it can be used as a microalgae cultivation site. Figure 1 is a map of microalgae cultivation location.

Fig. 1. Map of locations for microalgae cultivation

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1.2 Objective

The objective of this research is to choose the best location for microalgae cultivation in NTT by using AHP and to know the potential of microalgae to fulfill 2% of avtur requirement in NTT.

2 Methodologies

Analytic Hierarchy Process (AHP) is developed by Saaty (1980) and then it is used widely as an efficient multi criteria decision making (MCDM) method for ranking alternatives.

AHP is used on three principles :structure of the model, comparative judgment of the alternatives and criteria, synthesis of the priorities [7].

The main steps of AHP are given in the following: First of all, criteria and alternatives of the problem are defined. Then problem is organized hierarchically. The overall goal of this decision making problem is at the highest level and the alternatives are at the lowest level. Criteria and sub-criteria are placed between them [8]. The goal of the problem is located at level 1. Level 2 houses the major criteria. Level 3 houses sub criteria. Finally, the alternatives are located at the last level of the hierarchy. The hierarchy show in the Figure 2.
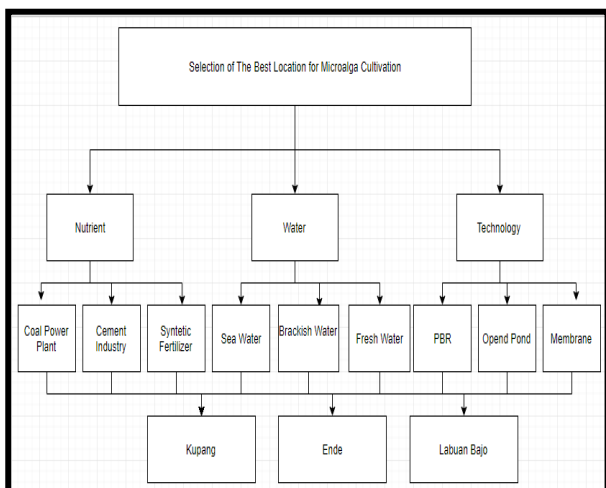

Fig. 2. The Hierarchy Structure for selection of the best location for microalgae cultivation.

After modelling the decision problem as shown above, data were collected from the decision maker by pairwise comparisons. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level [7],[9]. These main criteria dan sub criteria for selection the best location for microalgae cultivation are listed in Table 1. Hierarchy structured with criteria, sub criteria and alternatives location for microalgae cultivation is given in Figure 2. There are three levels in the hierarchy structure for selection for the best location of microalgae cultivation. Saaty's 1-to-9 scale shown in Table 2 is used while comparing n criteria in the same level.

Table 1. Main criteria and sub criteria for selecting location for microalgae cultivation

Criteria	Sub criteria	Explanation
Nutrient	Coal power plant emission	CO_2 emission from coal power plant can be used as a nutrient for microalgae growth. NTT has 3 coal power plants there are PLTU Ende 2x7 MW, PLTU Kupang 2x15 MW and PLTU Rote 2x3 MW.
	Cement industry emission	CO_2 emission cement factory can be used as a nutrient for microalgaee growth. NTT has 2 cement industries in Kupang
	Fertilizer	Sufficient nutrient for microalgae growth.
Water source	Sea water	Salinity 30-35 ppt
	Brakish water	Salinity 6-29 ppt
	Fresh water	Salinity 0-5 ppt
Technology cultivation	Photobioreactor	In closed systems, algae growth conditions can be regulated much easily and precisely by engineers. Photobioreactor are also optimized to maximize algae cultivation.
	Opend Raceway Pond	The biggest advantage of these open ponds is their simplicity, resulting in low production costs and low operating costs. While this is indeed the simplest of all the growing techniques.
	Membrane	Growing microalgae on membrane minimizes water use and reduce harvesting cost.

Table 2. Saaty's 1-9 scale

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values

In this research we use 3 experts. After the calculation of is finished pairwise matrix then it is

continued by the arrangement of pairing matrix for doing normalization of interest level value of each elements on each hierarchy.

Table 3. Pairwise Comparison

Criteria/ Alternative	1	2	3	N
1	1	W12	W13	W1n
2	W21	1	W23	W2n
3	W31	W32	1	W3n
4	Wn1	Wn2	Wn3	1

Assessment in comparing between one criteria and the other criteria is independent of each other, and this may lead to inconsistency. Saaty [10] has proved that the consistency index of the ordered matrix can be obtained by the formula:

$$CI = (\lambda maks-n)/(n-1) \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

C I= Consistency index

$\Lambda maks$ = The largest eigen value of the ordered matrix

The limit of inconsistency is calculated using consistency ratio (CR) that is by comparison of consistency index (CI) with consistency random index value (RI). Consistency ratios can be formulated:

$$CR=CI/RI \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

If the CR value is still less than 10%, then the inconsistency of opinion is still acceptable. The following is a list of random inconsistency indexes presented in Table 4.

Table 4. Index list of Random Inconsistency (RI)

n	1	2	3	4	5
RI	0.00	0.00	0.58	0.90	1.12

After AHP is finished then it is continued by modeling the productivity of *Nannochloropsis* sp as a bioavtur feedstock based on its productivity.

3 Result And Discussion

Based on the analysis of AHP, the obtained results are in accordance with the following figure.

Based on the above results, it is seen that the water source is the main criteria in the cultivation of microalgae with a weight value of 0.588. It is then followed by nutrient with a weight value of 0.159 and the last is technology with a weight value of 0.251.
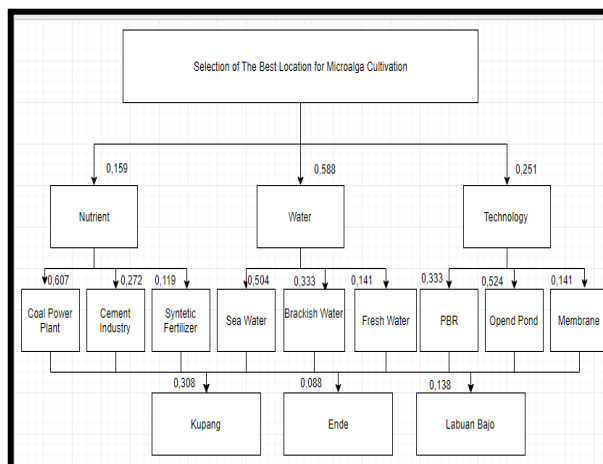

Figure 3. Result of selection for the best location for microalgae cultivation

Water is an absolute requirement of life for microalgae because it is a microalgae living habitat. Water criteria have priority of weighting result on sub-sea water criteria with value 0,524. Sea water has a salinity of 30-35 ppt which is a tolerable salinity for microalgae life. Sea water has a natural nutrient content that is used as a source of nutrients for microalgae life. The nutrient content of seawater is chloride (55%), sodium (31%), sulphate (8%), magnesium (4%), calcium (1%), potassium (1%) and the rest (less than 1%) comprises of bicarbonate, bromide, borax acid, strontium and fluoride[11]. The three main sources of salt in the ocean are from weathering of rocks on land, volcanic gases and the circulation of hydrothermal vents in the deep ocean.

Nutrient criteria have sub criteria of coal power plant emission with weight value of 0,607. In general, any source of CO_2 can be used for cultivating algae, however some options are more advantageous than others. Using CO_2 (~ 0.04 w%) and more must be supplied to facilitate optimal algae growth. The coal power plant's emissions can be used as a source of nutrients for microalgae growth because it contains high CO_2 content [12]. Microalgae require CO_2 to do photosynthesis so as to produce biomass. Biomass produced by microalgae can be used as a source of biofuel. According to the Ministry of Energy and Mineral Resources Regulation No 32nd 2008 [13] the definition of biofuels is that fuel is derived from vegetable materials or produced from other organic materials. In general, it takes an approximate mass ratio of 2.0 CO_2 to produce a quantity of algae biomass, e.g., around 2g of CO_2 are needed to produce 1g of ash-free dry algae. CO_2 purity is not required in microalgae culture so CO_2 emissions from coal power plant can be channelled directly to microalgae cultivation. Another advantage in utilizing CO_2 emissions from coal power plants in microalgae cultivation microalgae is that serves as carbon capture so as to reduce CO_2 emissions in the air. Water and nutrient management are used to tailor the biochemical composition of the produced algae biomass towards an economically viable biofuels feedstock.

In the criteria of technology, the sub-criteria of photobioreactor have weighting result of 0.524. The advantage of using photobioreactor is that the biomass produced is bigger than open pond, the cultivation condition can be regulated by the researcher, with low contamination risk and suitable for microalgae development using CO_2 emission as nutrient source.

Based on the results of AHP analysis it is seen that the priority of microalgae cultivation location is in the first position of Kupang city with a weighting of 0.308. This is supported by the existence of coal power plant located in Kupang. The existence of a coal power plant adjacent to the sea is in accordance with the weighting results stating that sea water is a priority in the selection of water sources. Then the technology used is photobioreactor which is considered more effective for mass scale cultivation of microalgae.

From the results it is assumed that microalgae used is *Nannochloropsis* sp which is a marine microalgae species with lipid content of 35-68% of its body so it can be used as source of bioavtur feedstock. Recent studies have reported that marine species *Nannochloropsis* sp are a potential microalgae for biofuel production owing to the fact that they are capable of producing lipid content as high as 27% (dry weight) and high biomass productivity [14].The screening of microalgae (*Chlorella vulgaris*, *Spirulina maxima*, *Nannochloropsis* sp., *Neochloris oleabundans*, *Scenedesmus obliquus* and *Dunaliella tertiolecta*) was done in order to choose the best one(s), in terms of quantity and quality as oil source for biofuel production. *Nannochloropsis* sp. proved to be suitable as raw materials for biofuel production, due to their high oil content (29.0 and 28.7%, respectively) [14].

The National Renewable Energy Laboratory (NREL) has extensive experience cultivating and manipulating microalgae to produce lipids or oils. NREL is now looking to re-establish its microalgae oil research in partnership with oil refiners, with a particular view towards jet fuel production [15].

Bio-jet fuel production by the blending process will be blended with Jet A (or JP5) and diesel to produce bio-jet fuel blend that can be used on a diesel engine. The US Navy has accepted bio-JP-5 as an alternative to JP-8 fuel [16].

Based on the assumption of microalgae biomass productivity cultivated with photobioreactor that is 24.489KL/Ha/yr [12,17]. The need for Avtur in NTT is 52.611 KL/Year. According to the KESDM appeal, the use of bioavtur 2% starts from 2016, which can be done using microalgae. The need for bioavtures 2% in NTT is 1.052,22 KL/Year which can be fulfilled from microalgae with productivity of 24.489kL/ha/yr and the area requirement for microalgae cultivation is 2.14 hectare.

4 Conclusions

Based on AHP results it is known that the best location for microalgae cultivation is in Kupang with nutrient source comes from steam power plant emission, type of water used is sea water and technology used is Photobioreactor. The Need of 2% bioavtur in ENT of 1052,22 kL/yr can be met by microalgae with productivity of 24489kL/ha/yr and the area requirement for microalgae cultivation is 2.14 hectare.

Acknowledgment

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