# A Review: Clearing Oil Palm Plantation with Multi-Stakeholder Model

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## ABSTRACT
The clearing land or clearing of oil palm plantations needs stakeholders' involvement in decision making, such as the role of government group, environmentalists, investors and the agricultural community groups from *non-governmental organizations* (NGO). This paper discusses about the Group Decision Support (GDS) that can be used for Oil Palm Plantation Land Clearing cases involving various stakeholders. Problem solution of Group Decision Support Clearing Oil Palm Plantation (GDS-COPP) can be categorized based on the stakeholder's model. The grouping results showed that Multi-Criteria Decision Analysis (MCDA) methods most widely used in previous papers. This paper aims to provide an overview that MCDA models and Analytic Hierarchy Process (AHP) method can be used in cases involving stakeholders in decision-making groups for plantation land clearing cases.

## Keywords
Oil Palm, Plantation, Multi-stakeholder, Group Decision Support.

## 1. INTRODUCTION
Based on the economic growth in Indonesia and Malaysia, oil palm plantations are the largest contributor in the development of the country, so that Indonesia and Malaysia became the largest producer of palm oil contributors in the world up to 42% [1], [2]. The land area of oil palm plantations in Indonesia is estimated to be 20.6 million ha [3] and Indonesia has lost 40 million hectares (Mha) of forest land or forest lands decreasing by 30% and 20% in Malaysia [4]. So that the effect of excessive land clearing peat annually can reduce the water content and change the biophysical characteristics of peat, so that the degradation that causes acidity of water or the pH (potential of Hydrogen) water and ash content increased [3].

Since 2007, the needs of world palm oil reach 40 million per metric tons, so the need of palm oil in the last 20 years become an important thing for the various needs of the industry [5]. The results of the census of 2012 Unites States Department Of Agriculture (USDA) shows that Indonesia and Malaysia are The world's largest palm oil producer, not only to supply foreign markets but also domestic demand increase to vegetable oil. Indonesia has 50% of global palm oil production compared with 37% of Malaysia and other countries. If the consumption of palm oil between Indonesia and India are compared, Indonesia consumes 14% and India consumes 2% higher than Indonesia [6]. The percentage of oil production and consumption needs of global oil is shown in Figure 1.

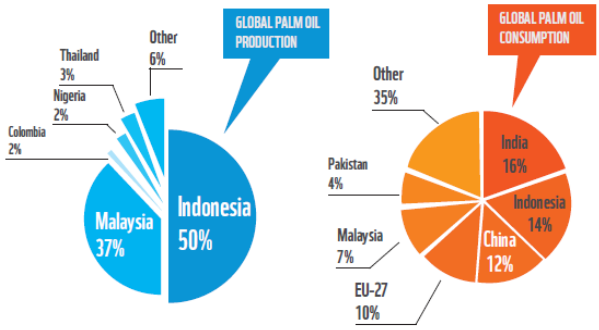



**Figure 1. The need for production and consumption of oil globally**, [6].

Based on the data needs of the world's palm oil, shows that Indonesia has a large production and consumption of palm oil compared with other countries. Based on the Central Bureau of Statistics (BPS) Indonesia, it is said that the distribution company for the clearing of oil palm plantations in Indonesia on the island of Sumatera has the highest ratings reached 63% [7]. The chart percentage of oil palm plantation companies in Indonesia is shown in Figure 2.

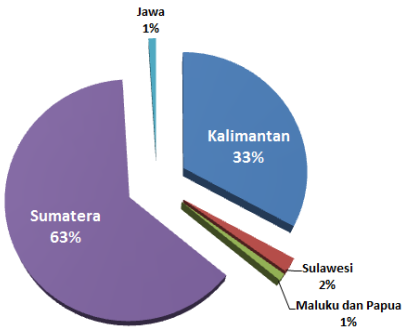



**Figure 2. Percentage the number of oil companies in Indonesia until 2013**, [7].

From the data sources of USDA and BPS, Indonesia has potential resource for oil palm plantations to help economic growth. Problems arise at the clearing of plantations, it can reduce water source [8] on irrigation in the area and reduce the supply of water resources contained therein [9]. Agricultural problems is very important for the survival of the people. The management of agricultural resources is needed but is also expected to manage natural resources well [1], [2], [5], [8], [9], so the need for oil palm plantations help farmers and governments to pursue development of agribusiness. GDS-COPP in plantations is needed to manage natural resources and ecosystems contained therein, and can help stakeholders to make decisions in the field, so the clearing of

oil palm plantations is really felt very important in the agricultural sector [10].

Problem related to clearing of plantation land needs a development model of group decision support (GDS) which involves principles of multi-stakeholder institutions, such as government, environmentalists, investors [11] to NGO to provide assessment criteria in decision making together [12]. Decision making in groups on agriculture or land clearing palm plantation is highly influential in government and society environment. The decision-making system can help make decisions based on uncertainty, so that the necessary tools are needed for agriculture community [13]. Involvement of stakeholders in the oil palm plantation land clearing is intended that each land managers of oil palm plantations also consider the government rule. As it is written in Indonesian government rule about the guidelines on the use of peat land for the cultivation of oil palm plantations Number: 14/Permentan/PL.110/2/2009 and is available on the laws of Indonesia Number 18 of 2004 Article 1. It stated that the plantations are all activities that cultivate certain crops on soil or other growing medium in the ecosystem, processing and marketing of goods and services resulting from the plants, with the help of science and technology, capital and management for the welfare of farm businesses and the community. Multi-criteria models can help the role of stakeholders in decision making palm plantation land clearing based on the aspects of environmental impact, economic, and social [14]–[26].

Model of GDS can be applied to help making decisions based on a multi-decision making (MDM). This model is part of the method of multi-criteria decision analysis (MCDA). It can give contribution for the field of science of GDS farm or plantation as on paper [27]–[30] that have been using GDS models in agriculture, but not thorough the land clearing stage involving stakeholders. To manage environmental resources for clearing plantation land requires the involvement of various stakeholders. The involvement of stakeholders for decision-making is necessary to involve the social environmental problems [12] particularly in the case of the opening of oil palm plantations in Indonesia. Oil palm plantations are contributing to local governments to increase revenue income. The involvement of stakeholders is expected to help the complex decision-making such as land clearing plantations involve various stakeholders to manage the preservation of the natural and social environment [27]–[38].

The purpose of this study is to determine the decision models that involving multi-stakeholders in plantation land clearing and environmental impact. This review shows how many models used by the stakeholders in their involvement in decision-making and the analysis methods of most widely used in the decision to clearing oil palm plantations. This survey aims to determine the most method widely used in the decision-making involving or not involving stakeholders. Many studies using the same method with different cases, so the number of case studies and methods have been used need to compare.

## 2. RESEARCH METHODOLOGY

The review for this grouping technique of stakeholder model is formed to determine the involvement of stakeholders in decision making together. The stakeholder model is a group that involves the participation of an individual or community, or institution with preferences identified to be one unit of decision maker [39],[40]. It showed that the decision maker models are widely used in the case of land clearing in managing natural resources. The example of multi-stakeholder models are shown in Table 3 an 4 at section five. The grouping of MCDA model is expected to know how big a role MCDA for decision-making on agricultural and environmental issues. This model grouping techniques are expected to know the method most widely used related wit MCDA models that do not involve stakeholders.

## 3. STAKEHOLDER MODEL

The stakeholder theory to solve the problem of cooperation between business partners, who possible conflict between the government and private communication that requires the involvement of many stakeholders in addressing issues or interests that are vital to both sides [28], [31], [33], [39], [41]. The involvement of stakeholder model intends to incorporates a broad problem, in previous research to mention this model merging opinion of each stakeholder, in this case due to a group of managers who are not generally considered as a group of stakeholders [40]. Suggested control group of stakeholders to hold the executive power should be a central topic at this stakeholder theory. This model also involves too many groups of people who are not directly involved in the decision-making interests of land clearing. So as to unite the opinion of each group of stakeholders to make decisions together.

## 4. MULTI CRITERIA DECISION ANALYSIS (MCDA) METHOD

Multi-Criteria Decision Analysis (MCDA) is a part of basic theory of Multi-Criteria Decision Making (MCDM) which is a part of analysis method to categorize and decide some of the best alternatives based on particular criteria, so that the complex issues can be determined in advance [42]–[46]. MCDM decision making determines the priority or rank based on the given criteria. For instance FCDM also occurs in Yager model, which is the standard form of MCDM [47].

The model is expected to help the stakeholder to support good decisions in opening the farm land. This model of decision uses Fuzzy Inference System (FIS) method, Analytic Hierarchy Process (AHP), Ehmrlfiatfon Et Cbofx madufsantfa reair'tE (ELECTRE), Policy Analysis Matrix (PAM), Multi-Objective Optimization by Ratio Analysis (MOORA), Techniquefor Order Preference by Similarity to Ideal Solution (TOPSIS) to solve the issue of farm land opening. The matter is known to use more orf AHP Method. MCDA classification solution, where MCDA issues do not always provide unique solution, the language barrier provides different solution such as; ideal solution, non-dominated solution or pareto-optimal solution, satisfying solution, and preferred solution [48]. MCDA model process also apply three steps that has to go through, such as the arrangement of situation component, analysis, and synthetic information [48]–[51].

In each alternative x ∈ X will be maked by how to compare with the dataset through profile Q (x) = {$Q_1$ (x), $Q_2$ (x), $Q_3$ (x), $Q_4$ (x)}. The first set contains alternative that does not care with the x, the second set is that the x is preferred, therefore on the alternative set preferred for x, so that eventually the alternative set is not worth with the x [48]. For instance when $A = \{a_i \mid i = 1, \dots, n\}$ is a compilation of alternative decision and $C = \{c_i | j = 1, \dots, m\}$ is a compilation of expected objective, so that the alternative is $x^0$ and has the highest degree of relevance towards $c_j$. On the issue of MCDA, it will evaluate m alternative $A_i$ (i=1,2,…,n) towards the group of criteria $C_j (j = 1,2, \dots, n)$. For each decision matrix and alternative towards X are:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{12} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{13} & x_{23} & \ldots & x_{3n} \end{bmatrix} \quad (1)$$

For $x_{ij}$ is the first rating alternative towards attribute j. Each mark shows that $W = \{w_1, w_{2,}, \ldots, w_3\}$, which is for the sake of the importance of each attribute relative.

## 4.1 Analytic Hierarchy Process (AHP) Method

The implementation of MCDM on the method of AHP lies on [52], [53]. On the methods Analytic Hierarchy Process (AHP) is a theory used to measure the comparison. Basically, AHP is to decreasing measuring scale of 2 comparison continuously [54]. AHP is designed to catch the rational perception of the people related to particular issues through a procedure designed to reach a scale of preference amongst some alternatives. AHP is also used on the decision of multi-criteria, planning, management, resource allocation and the determining the priority owned within conflict [54]–[56] even the completion of group decision making [55], [56].

Some steps of AHP can apply data analysis such as; identifying issue and determining expected solution so that it results a decision: identifying and analyzing a system by filling the reference and based on the data of some experts encountering the issue, so that the concept obtained is relevant with the issue faced; the arrangement of hierarchy structure started with general objectives, continued by sub criteria: objectives, criteria and alternative possibilities – alternative on the level of the highest and lowest criteria; making comparison, describing the relative influence of each element towards each objective or criteria above it. For example on the data analysis in the level of importance using AHP, the matrix can be made as follows:

**Table 1. Level of importance**

| Value | Interpretation of level of importance |
|---|---|
| 1 | C1 and C2 if similarly important |
| 3 | C1 if it is a little more important than C2 |
| 5 | C1 if it is more important than C2 |
| 7 | C1 if it is very important compared to C2 |
| 9 | C1 if it is absolutely very important compared to C2 |
| 2,4,6,8 | Some gap values or intermediate |

Matrix of individual opinion, the formula can be presented as follows:

$$A = \{a_{ij}\} = \begin{array}{c|cccc} & C_1 & C_2 & \ldots & C_n \\ \hline C_1 & 1 & a_{12} & \ldots & a_{1n} \\ C_2 & 1_{/a_{12}} & 1 & \ldots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_n & 1_{/a_{1n}} & 1_{/a_{2n}} & \ldots & 1 \end{array}$$

In this matter $C_1, C_2, \ldots, C_n$ are a set of element in a level of a hierarchy. Quantification of opinion from the result of comparing the couple form a matrix n $x_n$. the value of $a_{ij}$ is matrix value of opinion of comparing result describing the value of importance of $C_i$ and $C_j$ [55], [56].

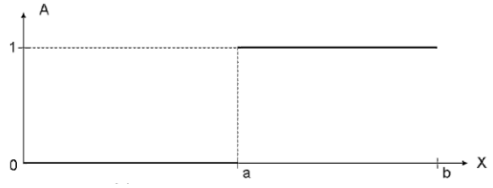
## 4.2 Elimination Method Et Choix Traduisant la Réalité or Elimination and Choice Translating Reality (ELECTRE) Method

ELECTRE Method is concept of ranking the couple comparison between alternative match within a criteria. In ELECTRE method the formation of compilation of concordance index and discordance index for each alternative through prediction towards the relation of ranking [57]–[60]. Each matrix concordance contains elements disconcordance. According to the definition, concordance index $c(a', a)$ is a strong positive argument which is able to validate statement $(a'Sa)$ which is the strongest from the criteria $c(a'Sa)$. While for weak positive argument comes from the criteria $c(aQa')$ because the criteria shown doubt between two possibilities such as in $a'I_j a$ (that supports $a'Sa$) and $aP_j a'$ (which does not support $a'Sa$). And then contribute to the second part $c(a', a)$:$c_2(a', a)$ [57], such as in:

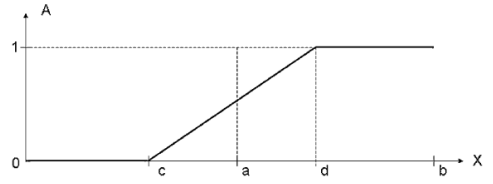
$$c(a', a) = c_1(a', a) + c_2(a', a). \quad (2)$$

## 4.3 Fuzzy logic and Method of Fuzzy MULTIMOORA Method

Basic theory of Fuzzy in Multi-Criteria Decision Making (MCDM) is used to make decision for determining priority or rank based on the uncertain given criteria. Such as in the application of Fuzzy MCDM method using basic theory such as the use of decision making, which Fuzzy Logic (FL) theory was first introduced by Professor Lotfi A Zadeh in University of California, Berkeley, United State. In FL with firm compilation (crisp) a value of membership of x within the compilation A, such as $\mu_A[x]$, that has two of the possibilities, such as value 1 and 0. The model is used to present the issue of uncertainty, so that issues of decision making using multi-criteria can be applied using FL method [42]–[47]. The characteristic of fuzzy compilation seen from the curve is as follows;




*(a) Characteristic function of crisp set*




*(b) Characteristic function of fuzzy set*

**Figure 3. Characteristic function of (a) crisp set and (b) fuzzy set**

The involvement of FL to develop model Multi-Criteria Decision Making (MCDM) is based on to improve the bias decision making. The basic of the operation of FMCDM to analyse is based on the model of the previous classic MCDA consisting of some theories such as, Fuzzy AHP, Fuzzy TOPSIS etc. the method is used for group decision making which is possible to combine subjective assessment from the decision makers and offer some opportunities to implement the procedure of stronger selection of personnel. Multi-Objective Optimization with the method of Analysis of Ratio (Moora) was first introduced by Brauers and Zavadskas in 2006. Moora Method starts with matrix X where the elements of xij has shown with alternative objectives j (i = 1, 2, …, m and j = 1, 2, …, n). it means that MOORA has equally similar important objective for decision making. While in Fuzzy MULTiMOORA was introduced by Brauers in 2011. Fuzzy MULTIMOORA method for decision making of group (MULTIMOORA-FG) Starts with the matrix of decision $X^{\sim k} = x_{ij}^{\sim k} = \left(x_{ij}^{k}1, x_{ij}^{k}2, x_{ij}^{k}3\right)$. (Baležentis, Baležentis, & Brauers, 2012)**.** While using Fuzzy MULTIMOORA it can use Fuzzy Inference System (FIS) method used to determine the level of rank within the decision making.

## 4.4 Policy Analysis Matrix (PAM) Method

PAM method is an approach for account system "double entry" which is able to be used for analyzing the influence of various policy of government and the effect towards both commodities in the level of farmers, processing, and industry marketing. PAM Method is discovered based on some sets of data which then is explained with some formulas such as calculation in the level of private benefit, calculation of social benefit, and counting the transfer effect as an effect of particular policies [20], such as in Table 2.

**Table 2. PAM Model**

| | Revenue | Cost | | Profit |
|---|---|---|---|---|
| | | Tradeable Input | Domestic Factor | |
| **Private Price** | A | B | C | D |
| **Social Price** | E | F | G | H |
| **Divergence Effect** | I | J | K | L |

Private profit: D = A-B-C

Social profit: H = E-F-G

Output Transfers: I = A-E

Tradable Input Transfers: J = B-F

Domestic factor transfers: K = C-G

Net Transfers: L=D-H or L =I-J-K

## 4.5 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method

TOPSIS method is first introduced by Yoon and Hwang in 1981. Generally, the procedure of TOPSIS follows the steps to make normalized matrix decision, normalized the value, positive and negative ideal solution, distance between alternative value with the positive and negative matrix, and determining the value of preference for each alternative decision. TOPSIS method needs alternative A1 in each criteria C1 which is normalized. [62]–[64], as the operator:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}; \text{with } i = 1,2,\dots,m, \text{and} = 1,2,\dots,n. \quad (3)$$

# 5. RESULTS AND ANALYSIS

## 5.1 Group of Stakeholder Model Research

Based on the last seven years of research, there are several previous studies related to the stakeholder model to approach the clearing of the case of agricultural land with environmental impact. Dechazal et al. (2008) using a model of stakeholders in the decision-making group, this paper used Socio Ecological Systems (SES) method to measure the assessment decisions involving group decision making for land use [39]. The SES model was used for decision-making governance of natural resources using the collective stakeholder model with Fuzzy Logic Cognitive Maps. This model aims to connect between stakeholders assessment based approach to social environment and ecological in decision making [32].

Several studies using MCDA with stakeholder model such as in [33] the results of these studies using the method of Multiple Criteria Analysis (MCA), this model can overcome the problem of environmental management supported 48 stakeholders. MCA models used to analyse the results of the final decision to solve environmental issues. In 2010, Afshar et al. made a decision that involves various stakeholders to overcome the problem of water resources in the reservoir [65]. This research used Fuzzy and Fuzzy Inference System (FIS) technique for assessment and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for large-scale multi-level decision-making. Other MCDA model was used by Silva et al. (2010) to make a decision involving stakeholder groups to support the issue of water resources, so that every member of the decision-making can measure water safety using the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) as a model of assessment decisions [26]. Zerger et al. (2011) made a model inference for planning multi-stakeholder input in decision-making for local biomass energy that can help decision-making in groups of foreign investment in the development of bio-energy feedstock using Analytic Hierarchy Process (AHP) [66].

In 2012, Myllyviita et al. using MCDA models to describe a process of assessment environmental impact from material standard alternative to analyse the impact of biomass production in the rest of the used oil palm plantations for biodiesel [30]. Collier et al. (2014) describes a multi-stakeholder involvement in solving the problem of dredging material that can be solved using a decision model using MCDA [41]. Dredging decision making model is material here is to save environmental resources. AHP technique used in Multi-Criteria Multi-Attribute (MCMA) for the selection of the best agricultural warehouse location. This paper used several attributes such as accessibility criteria area, distance, cost and other parameters used for decision making [29]. Model MCDA was recommended for the determination to manage the environment or land clearing based on the review by Soltani et al. (2015) from several papers related with waste management in the city [37].

Tompkins et al. (2008) describes the process of unification of the stakeholder analysis models for handling the problem of climate change based on the seashore of the various

stakeholder interests. This paper was not related with plantation but it used stakeholder model for environmental impacts and determining the location [38]. In research by Pita et al. (2010) aims to increase the participation of various stakeholders for decision-making on fishery issues that can help management fishery resources using Principal Component Analysis (PCA) [67]. Mianabadi et al. (2011) describe a model of environmental management using Fuzzy Linguistic quantifiers (FLQ) which involves the interests of stakeholders to manage the flow of water resources and environmental impact [35].

Research by Chavez et al. (2012) developed criteria for assessing the diversification of activities and to diversify the different criteria in the case of agricultural land [27]. This research used AHP technique to obtain consistent assessment criteria and the activities of the expert stakeholders. In 2013, Irawan et al. analyzed and provided an assessment of forest damage problem because it came into production forests or plantations such as the occurrence of forest to oil palm plantations management using a method called Opportunity Cost Analysis (OCA) [34]. The important role of stakeholder groups among government agencies, industry, and NGO was analyzed using the model Strengths, Weaknesses, Opportunities, and Threats (SWOT) and AHP on the problem of waste biomass for bioenergy development in Malaysia. This model is expected to analyze factors interests of stakeholders in decision-making based on the SWOT analysis and assessment of AHP [28]. Delgado-Galvan et al. (2014) discussed about the relationship between the stakeholders to other stakeholders in managing natural resources governance in the case of water or river basin using AHP, in order to know the results of the analysis of the level of interest of each stakeholder [31].

In 2014, Missonier and Loufrani-Fedida discussed about stakeholder involvement in decision-making problem projects using network theory perspective approach based on the nature, role until the status relationships between each stakeholders [36]. Model Actor-Network Theory (ANT) is intended to unify the perception of stakeholders in decision-making. The grouping of problems is shown in Table 3.

**Table 3. Literature review of group based on the stakeholder model for decision-making on the approach to growing crops or management environment**

| Citation | Topic Of Environmental Stakeholder | | | | |
|---|---|---|---|---|---|
| | Location | Environmental Impact | Plantation/Palm Oil | GDS | Method *) |
| [27] | √ | √ | √ | √ | AHP |
| [28] | | √ | √ | √ | SWOT-AHP |
| [29] | √ | √ | | √ | AHP/MCDA |
| [30] | | √ | √ | √ | MCDA |
| [31] | | √ | | √ | AHP |
| [32] | √ | √ | | √ | SES, Fuzzy/FCM |
| [33] | √ | √ | | √ | MCA/MCDA |
| [34] | √ | √ | √ | | OCA |
| [35] | √ | √ | | √ | Fuzzy/FLQ |
| [36] | | | | √ | ANT |
| [37] | √ | √ | | √ | MCDA |
| [38] | √ | √ | | √ | SBSE |
| [39] | √ | √ | | √ | SES |
| [41] | √ | √ | | √ | MCDA |
| [65] | | √ | | √ | MCDA-Fuzzy TOPSIS |
| [66] | √ | √ | √ | √ | MCDA-AHP |
| [67] | √ | √ | | √ | PCA |
| [68] | √ | √ | | √ | MCDA-PROMETHEE |
| **Total paper /18** | **13** | **17** | **5** | **17** | |

*) Social Ecology System (SES), Multiple Criteria Analysis (MCA) / Multi-Criteria Decision Analysis (MCDA), Scenario-Based Stakeholder Engagement (SBSE), Principal Component Analysis (PCA), Fuzzy Linguistic Quantifiers (FLQ), Fuzzy-Logic Cognitive Maps (FCM), Fuzzy Inference System (FIS), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Opportunity Cost Analysis (OCA), Strengths, Weaknesses, Opportunities, and Threats (SWOT), Analytic Hierarchy Process (AHP), Actor–Network Theory (ANT).

Based on eighteen papers review which have relevance in stakeholder involvement in decision making related with land clearing, there are four parameters include location problems, environmental impact, plantation / palm oil and group decision support are shown in Table 1. Grouping diagram of model stakeholder involvement is shown in Figure 4.

There is 28% percent of eighteen paper using stakeholder decision model related to the case of oil palm agriculture or plantation problem [27], [28], [30], [34], [66]. Other percentage result of literature review showed that the interrelations other stakeholder model for clearing the environmental impact have data 95%. While the papers that have the relevance to the display location or Geographic Information System (GIS) is 73%. The percentage showed that clearing land or oil palm plantations problems that involve multi-stakeholder decision-making can be developed as open research issues.

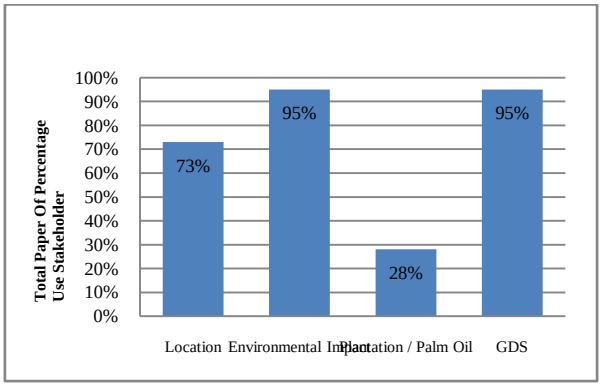



**Figure 4. Several Papers using the stakeholder model for group decision on land clearing Approach**

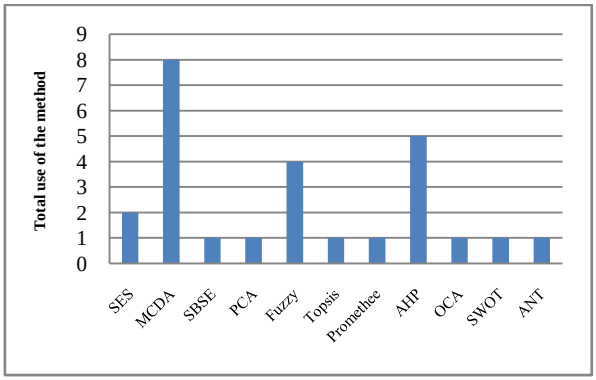



**Figure 5. Total GDS multi-stakeholder involvement methods to approach land clearing**

Figure 5 shows that MCDA is a method that is widely used for decision making in groups of multi-stakeholder involvement in land clearing issues and environmental impact.

## 5.2 Group Of Multi-Criteria Decision Analysis (MCDA) Model

Based on the grouping results shown MCDA method is suitable for decision making that involves multi-stakeholder in the case of land clearing. Grouping of the papers from the last seen years did not find any paper in 2008 that discuss about clearing of plantation land using MCDA.

In 2009, Nekhlay et al. discussed about group decision support for land suitability olive groves, this paper explained that the suitability of land to not to disturb the ecosystem or habitat on the plantation land needed [14]. AHP method was used for the assessment of land criteria in decision-making and GIS method used for visualization of the location into spatial data. Management of water resources and irrigation evaluated national project for group decision support using AHP and MCDA approach to benefits and cost carried [16].

Research by Akinci et al. (2013) discussed about decision support to select agricultural land with AHP method and using GIS visualization [21]. The problem-solving techniques in this paper was to determine the agricultural land suitable for agricultural production in accordance with the type of land to be planted. This paper did not involve groups of decision makers but it used spatial data model to determine the agricultural land.

Multi-criteria decision model to support multilateral environmental agreements and assessment issues of land conservation and plantation forestry was used [15]. ELECTRE methods are used to maintain a model of environmental sustainability in order to maintain continuity of forest. This model can be used to issue the environmental impact of plantations.

In [17] discussed the selection of oil palm fruit using regression-based method for Random Fuzzy multi-criteria decision. This research did not show the problems of clearing land but only discussed how to choose a good oil palm fruit. Balezentiene et al. (2013) developed a methodology fuzzy decision support for selection plant sustainable energy [22]. This method is called Fuzzy Moora, it offers multi - criteria decision support framework priority energy crops which allows to overcome information that is not right. Fuzzy Multi-Objective Optimization by Ratio Analysis (MULTI Moora) method made for data fusion and priority in making criteria parameters. Other fuzzy method also developed [25]. This paper developed Fuzzy Inference System model and involving agricultural experts to measure the development of agriculture in the country, but does not involve other groups in solving the case.

The selection process of industrial plant location was discussed [18]. ELECTRE model was used to evaluate the selected location to assist decision making in groups. This research also used visualization GIS. This model can be used to evaluate the location of the land so it suitable for the development of plantation land clearing models. In the same year Kasivisvanathan et al. made decision model for optimization assessment palm oil mill to be sustainable palm oil in the production management Crude Palm Oil (CPO). Fuzzy optimization method is used to measure uncertainty for maximize CPO production.

Research by Suroso and Ramadan made model of Policy Analysis Matrix (PAM), DSS analytical method used for forecast palm oil needs in the community that can assist the government in decision making of palm oil production [20]. The differences between this paper and [19] was in this paper emphasize to the analysis of the production process that did not involve decision making groups.

Combination System GIS and multi-criteria decision making (MCDM) discussed in the study [23]. This method was to get evaluation placement optimal solar power plants. MCDM methods used to evaluate potential locations on plant solar. Combination methods of analysis and calculation weight factor did by using AHP. Then the alternative assessment according to the degree of adequacy calculated by Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

methods. Giri and Nejadhashemi (2014) used different AHP method for selecting agricultural land in order to become more effective and improve the effectiveness [24]. The method called Best Management Practices (BMP) based on 3 different scenarios, namely the different combinations that environmental, economic environment, and social factors economy environment.

Silva et al. (2014) discussed about how to integrated MCDA methods, GIS, and the Web. Results of the database decision making model namely Web Multi-criteria Spatial Decision Support Systems (WebMC - SDSS) [26]. This MCDA method used ELECTRE III assessment to evaluate the continuation of the development of the environmental sustainability of agriculture. Based on the reviews of several paper, this paper conducted grouped by year sequence and environment MCDA models. It is shown in Table 4.

**Table 4. The literature review of decision support models using non stakeholders MCDA approach palm plantation or farm environment**

| Citation | Topic Of Environmental MCDA | | | | |
|---|---|---|---|---|---|
| | Location | Environmental Impact | Plantation/Palm Oil | GDS | MCDA Method*) |
| [14] | √ | √ | √ | √ | AHP |
| [15] | √ | √ | √ | √ | ELECTRE |
| [16] | √ | √ | √ | √ | AHP-Fuzzy AHP |
| [17] | | | √ | √ | Fuzzy Random |
| [18] | √ | √ | | √ | ELECTRE |
| [19] | √ | √ | √ | √ | Fuzzy Optimization |
| [20] | | √ | √ | | PAM |
| [21] | √ | √ | √ | | AHP |
| [22] | √ | | √ | √ | Fuzzy MOORA |
| [23] | √ | √ | √ | √ | AHP, TOPSIS |
| [24] | √ | √ | √ | √ | AHP |
| [25] | | √ | √ | √ | FIS |
| [26] | √ | √ | √ | √ | ELECTRE |
| **Total paper /13** | **10** | **11** | **12** | **11** | |

*) Analytic Hierarchy Process (AHP), Ehmrlfiatfon Et Cbofx madufsantfa reair'tE (ELECTRE), Policy Analysis Matrix (PAM), Multi-Objective Optimization by Ratio Analysis (MOORA), Fuzzy Inference System (FIS), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

Table 4 showed the related agricultural land clearing non stakeholders in decisions that produce. The related is shown in Figure 6.

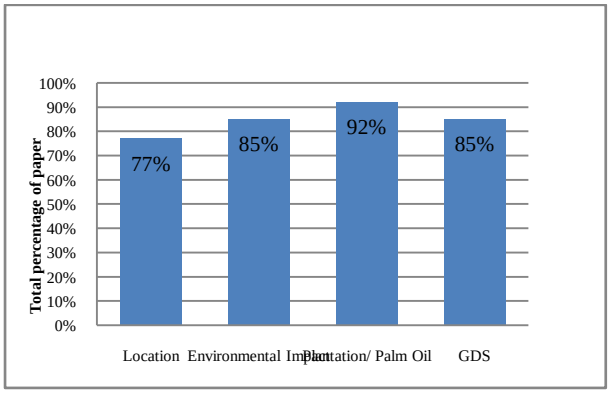



**Figure 6. The number and percentage of the papers using MCDA method for clearing plantation non-stakeholder decision**

Based on the review result from several papers, there are 92% papers use non stakeholders MCDA that have relevance to the issue of plantation land clearing, 85% of papers used environmental impact parameters and GDS and 77% of papers related to the location or GIS. This result indicated that the problem of oil palm plantation land clearing can involve by four parameters (plantation, environmental impact, GDS and location). That can improve multi-stakeholder complicity using MCDA decision model. There are two papers that do not use the model of the GDS [20], [21] and one paper did not discuss about the agricultural problems or palm [18], but still related to the issues of environmental impact and land clearing for decision support.

There are five group of MCDA model based on the different assessment method, namely : AHP, ELECTRE, Fuzzy, PAM and TOPSIS. AHP method was implemented in [14], [16], [21], [23], [24]. The research that used ELECTRE method has been done [15], [18], [25]. The use of fuzzy method was developed [16] used Fuzzy AHP, [17] used Fuzzy Random, [19] used Fuzzy Optimization, [22] used Fuzzy MultiMOORA and [25] used FIS. PAM and TOPSIS methods were implemented sequentially in [20] and [23]. All of this

researches were related with environment impact. The grouping of MCDA model is shown in Figure 7.

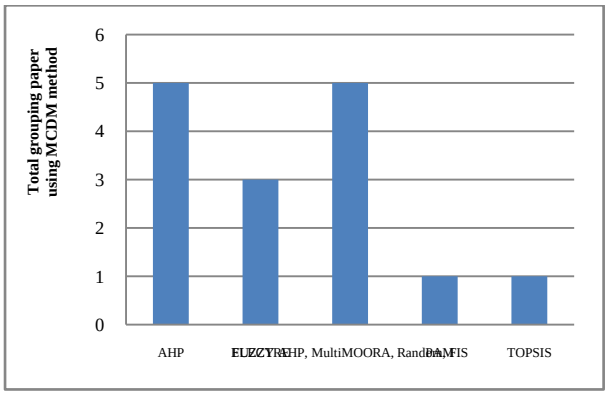



**Figure 7. MCDA methods group in the case of plantation land clearing**

## 6. CONCLUSION

Researches about group decision making for palm plantation land clearing involving stakeholders can still be developed, while the problem of environmental impact of agriculture has been performed using MCDA method. At the clearing of oil palm plantations problems do not involve stakeholders using MCDA with AHP and Fuzzy. The open researches about involving multi-stakeholder with MCDA to group decision support for the clearing of oil palm plantations can still be developed. The clearing of oil palm plantations can be developed by combining methods such as AHP, ELECTRE, Fuzzy, PAM and TOPSIS in the multi-stakeholder involved. Development can be performed by using parameters such as adding GIS parameter and environmental impact in the case of oil palm plantation land clearing to groups decision support.

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