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Perhimpunan Ahli Teknologi Pangan Indonesia (PATPI) Kalimantan Timur

OPTIMALIZATION OF PALM OIL PLANTATION AND BY PRODUCT'S CARRYING CAPACITY FOR RUMINANTS FEEDSTUFF BY FEED PROCESSING TECHNOLOGY (APPROACH OF SWOT AND ANALYTIC HIERARCHY PROCESS)

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ABSTRACT

Palm oil plantations area in Indonesia increases rapidly in compliance with the increasing volume of Crude Palm Oil (CPO) export which puts Indonesia as the second largest CPO exporter in the world after Malaysia. This favorable condition should be utilized as much as possible by looking for chances on the aspects which have not been properly managed. One of the great opportunities that need to be examined is the waste management of palm oil plantations and its by-products as the source of ruminant feeds by technology application. The problems found in the waste management were very complicated and the integration of livestock as an effort on diversification and optimization of plantation and its waste carrying capacity were very demanding. Thus, appropriate approach using appropriate analysis tool in selecting the best alternative is needed. The combination of SWOT analysis and Analytic Hierarchy Process was expected to be the answer to solve this complex problem. An aggressive policy intended to apply palm oil-livestock integration and utilization of palm oil plantations and processing plant waste as complete feed (CF) using application of technology is strongly needed to optimize the palm oil plantation economic potency.

Keywords: palm oil plantation, strategy-matrix, analytic hierarchy process, palm oil-livestock integration

INTRODUCTION

Indonesia has vast land resources which are very valuable for developing many agricultural commodities. Indonesia land's area reaches 188.20 million ha, consists of 148 million ha dry land and 40.20 million ha wet land. It has various soil type, climate, physiographic and fertile parent materials (volcanic). The land elevation in Indonesia is also varied. This condition makes various type of plants can be grown and utilized in Indonesia. Indonesia's agriculture land area is about 70.20 million ha, and most of it which is about 18.50 million ha is utilized for plantation area, about 14.60 million ha is dry field area, while unused land and rice field area about 11.30 million ha and 7.90 million ha, respectively. The development of agriculture land utilization has not changed in the recent years, especially in rice fields, dry fields and dry rice cultivation. The rice field area even tends to decline due to land conversion (Mulyani and Las, 2008).

Indonesia is now the second largest palm oil producer after Malaysia with a production share of crude palm oil (CPO) is only 28.8 % (Pahan, 2008), while Malaysia leads with 47 % of total world's CPO production. There is about 90% of the world's palm oil export produced in Malaysia and Indonesia (Sumathi *et al.*, 2008). Total area of palm oil plantation in Indonesia is about 4.888 million ha, spread along Sumatra, Java, Kalimantan, Sulawesi, and Papua (Badan Pusat Statistik, 2010). Exclusively in East Kalimantan, one of the steps taken by the government through the estate offices in province and district level is through "The Movement of Million Hectare Palm Oil Planting Program" which has been implemented since 2003 (Riyanto and Munawar, 2005; Tjahjono, 2005; BPS Kaltim, 2011). In addition to the considerable growth in these areas, something more fundamental is the spread, which was originally exist in only three provinces in Sumatra, has now spread at 17 provinces in

Indonesia (Goenadi *et al.*, 2005; Badan Pusat Statistik, 2010).

Livestock development paradigm in the globalization era is the achievement of a healthy, productive, and creative society with strong husbandry based on local resources. The integration pattern of large-scale crop livestock using sustain-able approach with low cost and optimizing the waste utilization or known by the term low external input sustainable agriculture (LEISA) and zero waste, especially took place in the plantation area which utilize local biomass feed. Through the technology innovation, the waste and its by-products could be used as a source of potential ruminant feed for fattening program (Sunarso, 2003; Sunarso, 2008).

Livestock integration system (crops livestock system) is a suitable alternative to develop. Besides its inexpensive cost, it also can improve land and plantation crop fertility which will create sustainable agri-culture. Moreover, it will increase farmers' welfare through increasing income and farm efficiency. The integration of livestock into palm oil plantation is a diversification pattern that could be done. The useful material of livestock that could be used in this matter is the livestock dung. Livestock dung is used as the source of organic fertilizer for soil or plantation crop. On the other hand, the plantation waste and its by-products are used for livestock (Devendra and Sevilla, 2002; Pelitawati, 2006; Mathius, 2008; Sumarsono, 2008; Devendra and Leng, 2011).

One obstacle in developing ruminant husbandry is limited forage both in quality and quantity in adequate amount and its continuity throughout the year. Fluctuation in the availability of forage is influenced by land use and cropping patterns. Forage scarcity usually occurs during dry seasons, while in rainy seasons forage production is high enough to follow the patterns (Sembiring *et al.*, 2002). Feed from palm oil waste and its by-products are cheap and bulky in general, with low protein quality, TDN, palatability, and digestibility. It can be used optimally as basal feed and it had been proven can reduce feed cost and increase livestock productivity. Until now, the best strategy and feed compo-sition applied on the ruminant system in various business locations have not yet been disco-vered. The best strategy was to uncover and prepare potential local feed material into economical product which safe, healthy, being integrated, lawful (halal), and high quality (Kearl, 1982; Sunarso, 2003; Mariyono and Romjali, 2007).

The area of palm oil plantation can be used as the alternative for ruminant husband-dry development by utilizing the vacant area among the crops, besides its by-product ensures abundant feed source. The opportu-nity to acquire new sources of feed materials which are fully used the palm oil plantation resources is enormous. That resource should be used optimally in order to obtain low cost new feed source. The use of plantation waste and its by-products as the complete feed (CF) composition is possible. Various by-products can be used as new feed sources. Processing can be conducted using technology approach to make it edible and create potential feed livestock. Processing can be conducted through physical, biological, and chemical processes with hydrolysis, fermentation, and ammonization (Mathius and Sinurat, 2001; Sunarso, 2008; Sunarso *et al.*, 2011). The development of CF is expected to assist the supply of balanced feed ingredient because of balanced concentrate and nutrition content. CF technology as the alternative for feeding strategy can be widely applied in various location conditions (Mariyono and Romjali, 2007; Mayulu *et al.*, 2009; Sunarso *et al.*, 2011). The problem to solve is how to optimize palm oil plantation as the affordable source of alternative feed for ruminants?

The objectives of this review were to: 1) conduct the inventory of various land resources found in palm oil plantation; 2) conduct the identification to determine suit-able characteristics of plantation integrated with ruminants; 3) collect laboratory analysis results in order to determine nutrient content of palm oil plantation resources; 4) provide initial input in formulating CF made from palm oil resources; 5) stimulate for conduct-ing experimental test CF formula to rumi-nants productivity.

According to literature study and field condition, it is expected to provide informa-tion such as: 1) the design to invent utilization technology of plantation resour-ces; 2) observe the suitable integration model; 3) when it is proven that the complete feed technology based on plantation resources can improve ruminants productivity, the alterna-tive feed for ruminants will be recommend-ded; 4) as the contribution for the knowledge especially in the field of animal husbandry; 5) as the source of information for local government in order to formulate develop-ment policies in agriculture field and animal science.

RESEARCH METHODS

This study is a preliminary study and carried out through exploratory approach with an emphasis on three objects namely: 1) literature study), 2) interview to resource persons, and 3) survey in PTPN XIII in Long Ikis District, Paser Regency, East Kalimantan. Preliminary design of a case study was conducted by observation, interview and collection of documents, which are directly related to the information about internal factors and external factors (Arikanto, 2006; Nasution 2007).

RESULTS AND DISCUSSIONS

Technology Approach

There are several types and techniques in processing the waste and its by-products that can be done to improve potential crude protein digestibility on ruminants. Increasing quantity of parts that can be digested in low quality feed can be done through chemical, physical, and biological processes. Physical process can be conducted through cutting, grinding, pelleting, and others. Biological process using mushrooms (fungi). The process of chemical digestion of planta-tion waste and its by-product can be improved by the addition of alkali and acid. Chemical process which has already been studied were the treatments of NaOH, KOH, $Ca(OH)_2$ and urea. Acidic treatments were HCl and H_2SO_4 (Sutrisno, 2001; Hanafi, 2004).

Physical Process

Physical process aimed to increase the damage and fermentation value in rumen, thereby increasing the value of digestibility and dry matter intake. It is useful for reducing the particle size to increase the surface area exposed to be digested by rumen microbes. It can be achieved by (Sutrisno, 2001; DFID, 2006; Salem and Smith, 2008; Sutrisno, 2009; Wright and Lackey, 2008):

Chopping, chopping does not appear to increase the intake and digestibility. However, it will reduce the selection;

Grinding, relies fully on grinding machines. Feed materials stored by the size 1.5 cm may be an efficient size. To compose CF or concentrate feed smaller particle size is required;

Soaking, in water provides incon-sistent benefits with digestibility improve-ment, however with the pulp shape reduces dust and provides an easy and safe way if the urea is added because it will minimize the risk of poisoning;

Striping, is conducted to improve the palatability of leaves and buds which will be used for feed materials.

Chemical Process

The process of chemical digestion of palm oil waste and its by-products can be enhanced by the addition of alkali and acid. Chemical treatments which already have been studied are the treatment of NaOH, KOH, $Ca(OH)_2$ and urea. One of the common processes is fermentation. Fer-mentation is various metabolism processes with the help of enzyme from microbes to perform oxidation, reduction, hydrolysis, and other chemical reactions, which stimulate chemical changes in the organic substrates producing the material proper-ties. Fermenta-tion can be done in solid and liquid medium; solid medium is a process where the medium used does not dissolve yet it contains adequate amount of water for microorga-nisms, while fermentation using liquid medium is a process which the substrate is dissolved or suspended in liquid phase (Sutrisno, 2001; Hasnudi, 2006).

The silage process

Silage is a preservation method using fermentation process to obtain high quality feed materials and durable so that it can be given to the cattle during periods of feed scarcity. The principle of preservation based on fermentation process in the storage (silo).

Plant cells will temporarily live and use available O_2 inside the silo. If O_2 is no longer available, an aerobic state occurs inside the storage that will not allow the growth of fungus. Acid-forming bacteria will grow rapidly and convert the sugars in forage into organic acid such as acetic acid, lactic acid, and alcohol. The increasing of acidity will inhibit the activity of other bacteria such as decay bacteria. At a certain degree of acidity (pH=3.5), lactic acid bacteria will no longer react and the silage-making process is completed (Hanafi, 2004).

There are three factors which affect in making of silage. *First:* the suitable forage for silage is grass, sugar cane, wheat cobs, corn cobs, sugar cane shoots, pineapple stem and rice straw. *Second:* the addition of additives to improve the silage quality. Several additives used are livestock waste (chicken and swine manure), urea, water, and molasses. The additives are also used to improve protein or carbohydrate content in feed materials. Usually, low-quality of feed needs additives to fulfill livestock nutritional need. *Third:* high water content gives effect in making the silage. Excessive water content results in the rapid growth of fungus and produces undesirable acids such as butyric acid. Low water content results in higher temperature inside the storage and puts the silo in high risk of fire. The successful in making of silage depends on three main factors: 1) the presence and the amount of lactic bacteria; 2) physical and chemical properties of forage used; 3) the ambient condition (Hanafi, 2004).

Table 1. Silage assessment criteria (Hanafi, 2004)

Criteria	Very Good	Good	Medium	Bad
Fungus	Not exist	Very few	Fair	Many
Smell	Acidic	Acidic	Fairly acidic	Decayed
pH	3.2-4.5	4.2-4.5	4.5-4.8	> 4.8
N-NH_3 Content	< 10 %	10-15 %	< 20 %	> 20 %

Ammonization treatment

Ammonization is a form of chemical process that commonly conducted on fibrous feed to improve the digestibility. The mixing process between feed materials and urea was meant to break down the lignin bonds in celluloses to make it more digestible and to enrich nitrogen (N). Thus, the purpose of ammonization processing is to cut-off the chain bonds. In this case, the bonds will be replaced by NH_3 otherwise celluloses and hemicelluloses will be released (Sunarso, 2003; Mayulu *et al*., 2009; Van Soest, 2006).

There are three sources of ammonia which can be used in ammonization process: NH_3 in liquid gas form, NH_4OH in solution form and urea in solid form. The use of NH_3 liquefied gas is relatively expensive. Moreover, it requires a high-pressure resistant tank for storage purpose (minimum pressure 10 bar). Similarly, NH_4OH solution is not only relatively expensive but also difficult to gain resulted in limited use of NH_4OH in laboratory activities. Compare to other chemical processing (NaOH), ammonization has several advantages, such as: 1) simply constructed and harmless; 2) more afford-able and easier to construct than using NaOH; 3) moderately effective to eliminate aflatoxin especially in rice straw; 4) enhan-ce crude protein content; 5) do not pollute the soil. Urea is the only source of NH_3 that is easily obtained and cheap (Hanafi, 2004; Sunarso, 2008).

Ammonization treatment using urea has been proven to have a good effect on feed. Further ammonization process will also give advantages such as enhancing feed digestibility. It occurs after NH_3 is decom-posed into NH_3 and CO_2. Present of water molecule cause hydrolysis process changes NH_3 to NH_4^+ and OH. The p-Ka of NH_3 = 9.26, which means more NH^+ is available in neutral state (pH=7). Thus, ammonization is similar to alkaline treat-ment. The group of OH will break hydrogen bonding between number 2 oxygen carbons of glucose with number 6 oxygen carbon of other glucose in cellulose, lignocellulose, and lingo-hemi-cellulose bond. It is widely known the last two bonds are alkali-labile, or it can be decomposed by alkaline treatment. Therefore, feed will expand and easily digested by rumen microbes. The expansion will dissolve lignin deposits found in the cell walls and the space between cells. It means ammonization treat-ment reducing the amount of feed which is difficult to digest or even undigested by the cattle, which eventually increases feed digestibility (Sunarso, 2003; Hanafi, 2004; Sunarso *et al*., 2011).

The Approach of SWOT Analysis and Analytical Hierarchy Process

SWOT Analysis

The approach of Strength, Weak-ness, Opportunities and Threats (SWOT) involves systematic thinking and thorough diagnosis of the factors related to new production, technology, manage-ment, or planning. It is used extensively in strategic planning, where all influenced environ-mental factors are deeply analyzed (Rangkuti, 2008). Strengths, Weaknesses, Opportu-nities, and Threats (SWOT) analysis is a commonly used instrument which scans internal strengths and internal weaknesses of a product or service industry and highlights the opportunities and threats of the external environment (Pesonen *et al*., 2000; Rauch, 2007). Generally SWOT is a list of statements or factors with descript-tions of the present and future trend of both internal and external environment; the expressions of individual factors are general and brief which describes subjective views. However, SWOT is a convenient and promising way of conducting a situational assessment. The research was designed to test the strengths and weaknesses of palm oil plantation and its waste, also the opportunities and threats both in internal and external environment so that the product can be used as feed source for ruminant husbandry.

The SWOT analysis method is used in early exploration stage to assess the situation regarding palm oil plantation resources and its waste, in order to formulate the strategies to integrate ruminant husbandry and zero waste concept as the final target. SWOT analysis was designed to be used in preliminary step in decision-making, act as the strategic management planning, commonly used by individuals or groups. It is a very effective policy analysis especially in providing clarity, identifying main target factors (Arslan and Er, 2008).

Analysis of SWOT is expected to maximize the strengths and opportunities, minimize the external threats, turn weaknesses into strengths, and provide benefits from the opportunities also minimize the internal weaknesses and external threats. It can be used to internal and external environment analysis to achieve a systematic approach in decision-making. The SWOT analysis will provide: an initial framework to examine and develop strategies for suitable plans; as the basic to assess the actual ability and authority; the proofs and keys to change and success; stimulus to take part in a group experience (Arslan and Er, 2008).

The SWOT analysis is an important tool to support decision-making, commonly used to examine the internal and external environment of an organization systematically. This tool was used to summarize the most important internal and external factors and those which affect the future of an organization – widely known as strategic factors. Internal and external environment consist of inside and outside variables (Yuksel and Dagdeviren, 2007).

Mode of SWOT is an analysis me-thod or environmental analysis method that integrating internal strengths / weaknesses and external opportunities / threats. Analy-sis from internal strengths / weaknesses are based primarily on the evaluations of how a company solve its problems, such as management problems, work efficiency, research and develop-ment of external factor evaluation (EFE) method and internal factors evaluation (IFE) to evaluate the competitiveness of a facility according to its factors. Identifi-cation of the business advantages and the disadvantages is carried out using EFE and IFE. Analysis results are based on quantitative method, which is different from qualitative method according to traditional SWOT analysis method (Kuoliang and Shuchen, 2008). This method is created to make a stable planning for long, medium, or short-term. According to the analysis, several criteria of EFE and IFE can be gained from palm oil plantation carrying capacity and its waste, such as (Rangkuti, 2008):

Strength

Strength is usually located in first quadrant: depicts a favorable situation. Palm oil plantation has opportunities and strengths to utilize existing chances (Table 2). The strategy should be applied in this condition to support integration policy of aggressive growth (Integrated growth oriented strategy).

Weaknesses

Weakness is located in second quadrant: despite facing various threats, palm oil plantation still has internal strengths (Table 2). The applied strategy is using force to exploit long-term opportunities through diversification strategy (product/market).

Opportunity

Opportunity is located in third quadrant: the optimization of plantation to face opportunities, however in the other hand facing several obstacles or internal weaknesses. The condition in third quadrant is similar to Question Mark. Strategy focus that can be pursued is to minimize internal issues to create better opportunities (Table 3).

Threats

Threats is located in forth quadrant: depicts an unfavorable situation, where the optimization of plantation and its waste carrying capacity facing various threats and internal weaknesses (Table 3).

Specifically, SWOT provides opportunities to classify internal factors (strengths, weaknesses) into internal or external analysis (opportunities, threats). One major limitations of this approach is the importance of each factor in decision-making that cannot be measured quantitatively, difficult to assess the most-influenced factors on strategic decisions, errors or suspicious events from both internal and external factors. Further utilization of SWOT is based on qualitative and quantitative analysis from internal and external factors. The SWOT analysis needs to be flexible, the change in situation should be anticipated and a renewed analysis should be made frequently. Furthermore, SWOT analysis does not take long time or creating complications because of its simplicity. The SWOT classifies strength, weakness, opportunities, and threats using pairwise comparisons to achieve the shortest time required in decision-making in situations with multi-variable parameters have temporary characteristics (Table 4). Work activity mostly concentrated on the purposes of SWOT analysis with its four-quadrant (Yuksel and Dagdeviren, 2007).

Table 2. Calculation of internal factor

Evaluation Factors	Weights	Ratings	Weight x Rating	Comments
Strength				
Palm oil area;	0.20	4	0.80	Utilized
Excessive waste;	0.20	4	0.80	Utilized
Concentrated in a location	0.20	4	0.80	Utilized
Applicable for feed;	0.20	3	0.60	Technology needed
Tolerated by ruminants;	0.10	2	0.20	Proof
Affordable	0.10	2	0.20	Proof
Total Strength	**1.00**		**3.40**	
Weaknesses				
Bulky with high crude fiber;	0.20	3	0.60	Technology needed
The approach of application technology is needed;	0.20	3	0.60	Proof
No agreements among stakeholders;	0.20	1	0.20	Find Solution
Low knowledge level of farmers;	0.10	2	0.20	Socialization
The opportunity for integrating plantation to ruminant within the system has not existed	0.20	2	0.40	Cooperativeness
Cattle are still considered as main business disturbance.	0.10	2	0.20	Proof
Total Weaknesses	**1.00**		**2.20**	

Table. 3. Calculation of external factor

Evaluation Factors	Weight	Rating	Weight x Rating	Comment
Opportunities				
Affordable feed source;	0.10	4	0.40	Proof
Technology application to improve nutrient value;	0.10	3	0.30	Proof
Formulating CF as ruminant feed;	0.20	4	0.80	High possibility
Suppressing increasing feed cost;	0.20	3	0.60	High possibility
Creating integrated business diversification with zero waste concept;	0.20	2	0.80	Expected
Improving the farmers' welfare.	0.20	4	0.60	Proof
Total Opportunities	**1.00**		**3.50**	
Threats				
Grand Strategy: livestock development has not yet considered animal protein high priority (animal food as a strategic commodity);	0.20	3	0.60	Paradigm change
High dependency on imported feed;	0.20	4	0.80	Policy change
The policy has not in favor of farmers and tend to partial;	0.20	3	0.60	Adjustment needed
The farmers are in low selling position compare to the plantation owner;	0.20	2	0.40	Paralleled
Technology dissemination to improve nutritional value of low-quality waste;	0.10	2	0.20	Pursued
Requires time and cost.	0.10	2	0.20	Minimized
Total Threats	**1.00**		**2.80**	

Table 4. SWOT Matrix (Strengths-Weaknesses-Opportunities-Threats)

Internal factor / **External factors**	**Strength (S)** S_1 = palm oil area S_2 = excessive waste S_3 = concentrated in a location S_4 = applicable for feed S_5 = tolerated by ruminants	**Weakness (W)** W_1 = bulky and high crude fiber W_2 = limited knowledge W_3 = limited connection between the farmers and the plantation owners W_4 = the absence of applicative technology W_5 = the policy is not yet environmental friendly
Opportunities (O) O_1 = affordable feed source O_2 = application technology O_3 = CF formulation discovered O_4 = suppressing feed cost O_5 = zero-waste diversification	**Strategies (S-O)** 1. Creating integrated regions (S_1,O_1) 2. Discovering application technology (S2,O2) 3. Used as the source of CF raw materials (S3,O3) 4. Increasing revenue by business diversification (S4,O4) 5. Environmental friendly feed	**Strategies (W-O)** 1. The presence of technology (W_1,O_1) 2. Improving farmers' knowledge and skills with application technology (W_2,O_2) 3. Developing the partnership with the use of CF formula (W_3,O_3) 4. Using to invent affordable feed (W_4,O_4) 5. Improving the waste utilization and its by-product through CF (W_5, T_5)
Threats (T) T_1 = Grant strategy T_2 = business dependency T_3 = partial policy T_4 = application technology dissemination T_5 = the decreasing of palm oil price and feed cost is expensive	**Strategies (S-T)** 1. Integration between livestock and plantation (S_1,T_1) 2. Business diversification with the use of CF (S_2,T_2) 3. Land use policy with livestock business(S_3,T_3) 4. Dissemination of application technology using plantation waste as CF (S_4,T_4) 5. Creating a brand new feed source and income (S_5, T_5)	**Strategies (W-T)** 1. Waste optimization (W_1,T_1) 2. Dissemination and utilization of CF application technology (W_2,T_2) 3. Creating partnership between plantation owners and farmers (W_3,T_3) 4. Dissemination of waste-based CF technology (W_4,T_4) 5. Improving farmers' knowledge and business resilience(W_5, T_5)

Since it is used properly, SWOT provides a suitable base for strategy formulation. However, SWOT analysis does have its weaknesses in measurements and evaluations. In conventional SWOT analysis, the magnitude of factors is not measured to determine the effect of each factor in proposed plans or strategies. Specifically, SWOT analysis allows to classify internal factors (strength, weakness) or external (opportunities, threats) in order to make decision-making, so that the comparisons between opportunities-threats and strength-weak-ness are possible. However, the results from SWOT analysis are usually only a list (incomplete qualitative test of internal and external factors). For this reason, SWOT analysis cannot be fully understood to examine strategic decision-ma-king process (Arslan and Er, 2008).

<u>Analytic Hierarchy Process</u>

Basically, the method of Analytic Hierarchy Process (AHP) is simplified a complex situation, unstructured, into its component parts; arranging the part or variable in a hierarchy; giving numeric value on subjective judgment about the importance of each variable; and synthe-sizing various considerations to determine the highest-priority variables and affect the results based on the situation. Solving problems using AHP is done with several basic principles such as decomposition, priority determination, and logical consis-tency (Saaty, 1993; Lee *et al.*, 2009).

Furthermore, AHP is a systematic analysis technique developed for multi-criteria decisions. The output of AHP is a comprehensive rating which indicates the choices for each alternative decision (Lasserre *et al.*, 2009; Lee *et al.*, 2009). Analytic hierarchy process method is commonly used as an effective tool in a structure and in modeling multi-criteria problems because they measure human judgment and omit the other approaches. Analysis of strategic decision-making involves the calculation of values from different choices available for corporations or decision makers (Hughes, 2009).

However, AHP uses pairwise comparisons, calculated a choice among all criteria which mostly rely on some quantitative data and the judgments of experts to derive priority scales. Comparison rating is actually a relative consideration of two elements at a particular level related to the upper level (Yuan and Chiu, 2009).

Criteria and alternatives are assessed through pairwise comparisons. According to Saaty various problems range from scale 1 to 9 is the best scale to express the judgments (Saaty, 1993; Marimin, 2004). The values and definitions of qualitative opinions from comparison scale showed in Table 5.

Analitic hierarchy process consists of three main operations, including hierarchy construction, priority analysis, and consistency verification. Firstly, the decision makers need to break down or specify the complex problems into its component parts in which each decision attribute may be set to double-size hierarchy levels. Afterwards, the decision makers must compare each data in each level according to similar pair based on their own experience and knowledge (Ho, 2008).

Table 5. Pairwise Comparison Scale in Analitic Hierarchy Process

Intensity of Importance	Description
1	Criteria/alternative A is equally important with criteria/alternative B
3	A is moderately more important than B
5	A is clearly more important than B
7	A is strongly more important than B
9	Absolutely more important than B
2,4,6,8	Intermediate values

Analitic hierarchy process proposed by Saaty is a simple term, mathematically based on multi-criteria as the decision-making tools which are related each other in a complex, unstructured, and compli-cated manner. This process was developed by Saaty since 1980 has been extensively studied and used in almost all application related to decision-making in the last 20 years (Ho, 2008). Saaty proposed a further method allowing the decision-makers to associate with the benefits, costs, and risks of a decision. A hierarchy may be consisting of four subhierarchies: give benefits, opportunities, costs, and risks (Lee *et al*., 2009).

Application of AHP in optimizing carrying capacity of palm oil plantation and its waste as the feed source for ruminants through application technology can be conducted by placing plantation waste as an object of exploitation. Possible existing problems are considered as the main targets related to criteria and requirement of success according to the image below (Figure 1).

Weighting of the three criteria are: palm oil waste specification, processing technology and palatability based on the level of importance. Weighting can be conducted using SWOT method or using AHP working principle such as pairwise comparisons, importance, hence whether a criterion which is relative to other criteria can be stated clearly (Saaty, 1993; Marimin, 2004). It is assumed that pairwise comparisons results for three criteria above are shown in Table 6.

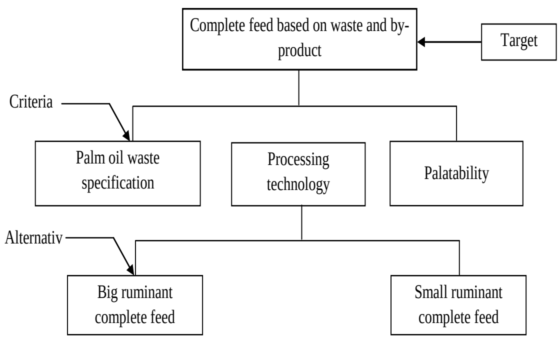

Figure 1. Hierarchy of Optimization on Plantation Waste and By-product as Ruminant Feed

Table 6. Pairwise Comparison Matrix with respect to Importance

	PWS	PT	M
PWS	1/1	1/2	3/1
PT	2/1	1/1	4/1
P	1/3	1/4	1/1

PWS = Plantation Waste Specification *P = Palatibity*
PT = Processing Tewchnology *M = Marketing*

Completion by manipulating matrix was processed to determine the weight of criteria, through determining eigenvector based on the procedures: a) squaring the matrix; b) calculate total value of each row, then normalize; c) the process is terminated when the difference between the sum of two calculations are less than certain limit. The next step was to change the matrix into decimals and squared up to third interaction until the requirements fulfilled when there were no difference to four decimal places and Eigen vectors were obtained. It is shown in Table 7 (Saaty, 1993; Marimin, 2004).

According to the Eigen values, the most important criteria can be discovered to make decisions which criteria that should be the priority. In the matrix above, it can be seen that the Eigen values put the list of processing technology, plantation waste specification, and palatability, respectively. Therefore, the most important criteria were processing technology to improve waste value as the optimization of plantation carrying capacity for ruminant raw materials.

Table 7. Pairwise comparison matrix with Eigen values

	PWS	PT	M	EV
PWS	1,000	0,500	3,000	0,3196
PT	2,000	4,000	4,000	0,5584
P	0,333	1,000	1,000	0,1220

PWS = Plantation Waste Specification *P = Palatibity*
PT = Processing Tewchnology *M = Marketing*
EV = Eigen Value

The approach of AHP-SWOT is combined to support decision-making in forestry. There are two options faced by forestry: 1) make a commitment to create a progress on certified forest issue; 2) the forest remains tin-oriented production. Firstly, the main factors regarding the strategic choices are collected and classified using SWOT analysis. Analitic Hierarchy Process then used to measure the relative importance on SWOT groups (strengths, weaknesses, opportunities, and threats), and considering SWOT factors related to four SWOT standards within the group, which are based on thorough considerations of obtained priority factors (Ho, 2008; Wickramasinghe and Shin-ei, 2009).

Shrestha *et al*. (2004) analyzed the various possibilities to adopt silvopasture in south Florida using a combination of AHP and SWOT approach. Some researchers explained that silvopasture is an agroforestry technology combining the forest with trees and grazing field for livestock. The similar approach was also adopted by Kurttila *et al.* (2000) and Kajanus *et al.* (2004), which AHP was used to measure the relative importance for each SWOT factor.

Analitic Hierarchy Process also provides an effective structure for decision-making in groups by forcing discipline in exchange ideas within the group. The compulsory to deliver numerical value to each problem variable helps the decision makers to maintain cohesive thinking patterns and achieves a conclusion. Furthermore, through the consensus decision making in group improves the consideration consistency and AHP reliability as a mean for decision making (Saaty, 1993).

CONCLUSION

Optimalization of palm oil plantation and by-product's carrying capacity as an alternative feed for ruminant by the approach of feed processing technology was studied. Exploration of palm oil plantation and processing plant potential using SWOT and AHP analysis gave an option that an aggressive policy intended to apply palm oil-livestock integration and utilization of palm oil plantations and processing plant waste as complete feed (CF) using application of technology is strongly needed to optimize the palm oil plantation economic potency.

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