Evaluating Supply Chain Management Performance for Plastic Waste Suppliers Using the Analytical Hierarchy Process

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Abstract

***Purpose*:** The purpose of this study was to determine how to manage the capability level for fulfillment of plastic waste as a raw material for the manufacture of plastic chips by the supplier by using a hierarchical analysis process (AHP).

***Design/methodology/approach*:** The research is described how the process of information that occurred beginning with the purchase of raw materials, production, storage and sales of plastic chips to the end buyer. The research will determine the sequence of supplier performance in terms of providing raw material by using a hierarchical analysis process (AHP).

***Findings and Originality/value*:** The results of the analysis process hierarchy matrix obtained that the order of supplier which can meet the demands of the manufacturer is a supplier 1, 3, 2 and 4, in which the first supplier has the highest value. The sequence is a reflection of the most give contribution for satisfaction and fulfilling production needs required by manufacturers at this moment. Criteria for the assessment on a transaction of this plastic waste are: the type of plastic waste, price, color, quality, quantity and time delivery.

***Research limitations/implications*:** The research is performed in one district in Aceh province, Indonesia, which will be much difference to another district. Wider scale should be conducted in the future.

***Practical implications*:** This research can help the manufacturer the better decision that they can manage in the future to run the manufacturer business of plastic waste conversion.

Originality/value: This paper contributes to help the plastic waste business such as manufacturer, suppliers, others related to this activity.

Keywors: Matrix Analysis Hierarchy Process, suppliers, industrial processing waste plastics and plastic chips.

1. **INTRODUCTION:** The process of formation the supply chain and management plays a very important role and can be seen as an organizational transformation of the conventional system to the new system. A lot of research that conducting a

review of the supply chain with a different levels of success and, more important that it has a positive impact on implementation of supply chain activities to the company's in overall activities. Supply chain and logistics activities can help the development of strategies to minimize the risk, helping to improve the supply chain which has encountered problems, and can avoid complicated and inefficient problems which can certainly impacted to the greatest losses for the company.

Industrial processing of waste plastics into semi-finished products or finished products is classified relatively simple industry and does not require high technology. To support the processing of plastic products it takes a lot of sources of plastic waste which is in fact many are in the middle of society and at the environment, whether community life up until the end of waste disposal/garbage in the city and its surroundings. Nevertheless, industrial processing of plastic waste into plastic chips is common and there are many in Aceh. Along with this, waste collection activities, especially plastic waste is something that we often see in the surroundings of our environment and also in the places where garbage collection and final disposal (landfill).

The chain process of collecting the plastic waste is tiered from scavengers either using collectors sack or basket at the back or scavengers simple pedicabs every day to collect the plastic waste and subsequently sold to the collectors who in this activity is referred to as the collecting agent. The collectors are also divided ranging from small-scale of collectors, medium, up to large scale or in a chain of activities is also a small collector is further selling plastic waste collected to the large agency or sold to other manufacturers for processing into chips.

Besides that, after the chips, plastic products produced by local manufacturer and then sold to other larger manufacturers and of course a large manufacturer of plastic chips will then process it into finished plastics products that have higher sale value. All activities are initiated from the collection, storage, sale and subsequent processing and distribution at the same time is a chain of important events that have sustained economic value. Of course, these activities from the supplier to the consumer until the end of the industrial chain of activities which are integrated into a networking activity, namely the supply chain, or better known as supply chain management.

2. LITERATURE REVIEW

2.1. Supply Chain Management

In supply chain is known by the term of supply chain management. Supply chain management is an activity that is mutually integrated or interconnected through the

planning, coordination and control of the entire process and business activity in the supply chain to get the superior value of the consumer with the lowest cost to the customer. Supply chain more emphasis on the material and information flow series, while supply chain management emphasis on collection combines supply chain (Vorst 2004). Based on such understanding, then some of the models that have been developed include Korpela et al. (2002) using the Analytic Hierarchy Process (AHP) for the allocation of production capacity, Aghezzaf (2005) uses relaxation Langrangian for the plant site selection and planning capacity, Jung et al. (2004) used a simulation technique and many varieties of methods used to solve problems in supply chain management.

Beamon (1999), Supply Chain is an integrated process that performed by many of entrepreneurs (such as Suppliers, Manufacturers, Distributors and Retailers), which further conduct cooperation in order to meet the needs of raw materials, and then converts the raw material into a final product predefined and distribute the final product to the retailer.

Supply chain management is more focused on the integration and management of the flow of goods and services and the flow of information through the supply chain to make it more responsive to customer needs while lowering the total cost by Russell and Taylor (2006: 12). According to Li Ling (2007: 5), the supply chain is a set of activities and decisions are interlinked with each other to integrate suppliers, manufacturing, warehouse, transportation services, retailers and consumers more efficiently. It can be concluded that the goods and services can be distributed in the amount, timing and precise location to minimize costs in order to meet the needs of the end consumer.

Distribution activities are one of the keys to success and an important thing to be considered by the company because it will directly affect the distribution cost of the supply chain and consumer needs. The proper distribution network can be used to achieve various objectives of the supply chain, ranging from low cost to high response against customers requested (Chopra 2010: 86).

To be a serious concern in the business sector against the impact of the increase in the competitive market environment and the types of adaptive strategies needed to succeed in a dynamic business environment and continue to undertake the changes. Success in a competition will be determined by the level of success in building and maintaining cooperation and alliances (Morgant and Hunt, 1994), it is a basic concept in supply chain management. In a supply chain management will greatly depend on

coordination between enterprise and business interactions related products, services, financial resources and information. The objective of supply chain management is to coordinate relations between actors in the supply chain, which is in this case means creating an organized manner in the supply chain to interact with one another. The scope of the supply chain will depend on the consensus of the actors involved in building relationships in the supply chain system.

With the increasingly competitive business environment and high uncertainty, the required design an adaptive supply chain and it is able to respond to the market environment which is easy to change. To manage the supply chain possibility may not continue, if only considering the efficiency, value-added and competition. Therefore, the supply chain must also develop the capacity to adapt to environmental changes.

In addition, there are similarities and differences between logistics management and supply chain management. The equation of the two, namely: (1). Concerning both the management of the flow of goods or services, (2). Both are concerned about the management of the purchase, movement, storage, transportation, administration, and distribution of goods and (3). Both involve efforts to improve the efficiency and effectiveness of the management of goods.

2.2. Analytical Hierarchy Process

Saaty (1986), the basis of the Analytic Hierarchy Process (AHP) is a concept that restricted to the scope of the environmental problem, which using a mathematical approach as the basis of this concept and also use a structured by using a consistent matrix approach and associated with eigenvector's and generate the corresponding weights, Merkin, (1979); Saaty (1980).

The application of analytical hierarchy process (AHP) has been widely used in making decisions to solve various problems, which this approach by using multiple criteria in a system consisting of various levels (Liu and Hai, 2005). This method has the ability to resolve the various problems with complex structure, multi-person, multi-attribute, and the problem of multi-period hierarchical (Yusuff, Poh Yee & Hashmi, 2001). In addition, the AHP is very useful in making decisions that complicated and complex where at times the goal to be taken were conflicting and differently to arrive at a consensus decision (Tam & Tummala, 2001). AHP method can help in make a

decision to resolve the various problems such as supplier selection, in which case they are to choose the optimal combination of suppliers (Yu and Jing, 2004).

Omkarprasad and Kumar (2006), the AHP approach are the method that provides the criteria ranked according to the needs of buyers who also leads to more informed decisions on supplier selection. Some of the main advantages of using the AHP method are where buyers get a good overview of the performance of suppliers using criteria hierarchy and evaluating suppliers.

According to Yahya and Kingsman (1999), The AHP method was introduced by Saaty used for decision-making to determine priorities in choosing a supplier. AHP application can be widely used in making a variety of decisions, in which involve multivel criteria in a system of various levels. From AHP feature, then generates a numerical priority of subjective knowledge expressed in the pairwise comparison matrix estimates. This method is also used and is very useful in evaluating the weight of suppliers in the field of marketing activities or in providing its ranking. Nevertheless, it is still considered to be difficult to determine the weight and the corresponding sequence of each alternative.

In the AHP application, also requires the use of data based on the experience, knowledge and subjective judgment on a decision by the decision maker. There are some disadvantages of using this method is that this method does not consider the risks and uncertainty of the ability of suppliers Yusuff et al., (2001).

Analytic hierarchy process (AHP) is a measurement theory to handle the quantitative and intangible criteria that have been applied to various fields of science, such as decision theory and conflict resolution L. Vargas, (1990). AHP is a problem-solving framework and have a systematic procedure to represent the elements of each issue, TL Saaty (1983). AHP is based on three main principles, namely: decomposition, comparative assessment and synthesis of priorities. In AHP begins by describing a complex, multi-criteria problem into a hierarchy in which each level consists of elements that are managed by some of the decomposed into a set of elements, Y. Wind (1980). The second step is to use a measurement methodology for setting priorities among the elements in each level of the hierarchy. The third step in using AHP is to synthesize the priority elements to build the overall priority to get an alternative decision. AHP is different from the conventional decision analysis methodology which does not require decision-makers to be able to guess the numerical development as a subjective assessment be easily included in the process and judgment can be made entirely in the verbal mode, EH Forman (1985).

2.3. Logistic Performance and The Criteria For Supplier selection

Initially the management of supply chain management and logistics operations are defined similarly, as both focus on the effective performance of the activities related to the optimization of the distribution and manufacturing and accelerate the flow of inventory and information through a channel system, DJ Ross (1998). Therefore, a lot of writers who have used the words of logistics and supply chain management as a synonym. For example, Thomas and Griffin define SCM as materials management and information flow in the form of facilities, such as vendors, manufacturing and assembly plants and distribution centers, SR Clinton (1997).

Rapid changes occurring in almost all markets, where suppliers must be flexible enough to restructure their logistics network in a very short time. Therefore, business process reengineering (BPR) has earned its position among the important approach when restructuring or fix a variety of problems such as the supply chain. According to a survey of the European Logistics Association permanent need for re-engineering of logistics processes has been accepted by the leaders of European logistics and other manufacturers that will follow the trend in the future, G. Roux (1997).

Fawcett et. al., (1997) representation of the performance of the logistics company's size is about key factors such as cost, quality, delivery, flexibility and innovation. It is not an easy decision to do because there are many different criteria for a good partner. Criteria to develop partnerships with organization members of the supply chain is usually driven by expectations of quality, cost efficiency, dependency shipping, volume flexibility, and customer service information (Olhager and Selldin, 2004; Motwani et al, 1998;. Li et al, 1997 Choi; and Hartley, 1996). Among the different companies, it has special requirements different in terms of vendor evaluation. For example, in the automotive industry (European), logistics, supplier performance measurement functions include strategy formulation and clarification, information management, communication, motivation suppliers, coordination and alignment, decision-making and priority, and learning (Schmitz and Platts, 2004).

3. RESEARCH METHODS

Research methods and problem-solving approach in which the stages of research to be conducted in this study are as follows:

1. Supply chain activities that began with the collection of plastic waste, is collected by agents and distributors (collector) and then sold to the manufacturer to be processed and then sold to the final buyer is the other major manufacturers (plastic conversion industry) to be processed into

various types of plastic end products. So that is part of this activity is the collection starts from the beginning until the end of processing and sales, including in this case the transportation service to deliver logistics to its destination.

2. Suppliers (distributor) of plastic waste are a plastic waste collection either small scale and large scale collectors is sometimes referred to as agents collecting plastic waste. Sometimes the scavengers may also act to become a distributor if a certain amount they can collect the waste in a relatively large amount and there is an agreement between the manufacturer with the suppliers (including scavengers).
3. The raw material intended is plastic waste that comprises of various types, colors, quality and price which would then be used as a material for processing plastic waste.
4. Products intended in this research that the plastic chips resulting from the processing (production) by using a grinding machine.
5. There are many types of plastics waste are sold by the supplier, but the type that interest of buyers in the market is the type of PP cup and PP injection (polypropylene), PET bottles (Polyethylene Terephthalate) and HDPE (High Density Polyethylene), and others. All raw materials (waste plastic) are made from plastic waste of various kinds of products and consists of a wide range of colors.
6. Model approach is using Analytic Hierarchy Process (AHP) with a decision matrix that is used as a tool for decision making on suppliers (distributors) raw material of plastic waste that the best one which will be helping manufacturers to make decision in purchasing.
7. Supply chain intended in this research is described how the process of information that occurred beginning with the purchase of raw materials, production, storage and sales of plastic chips to the end buyer. To be better at explaining how the information flow of the supply chain will be described the flow of the supply chain data information.

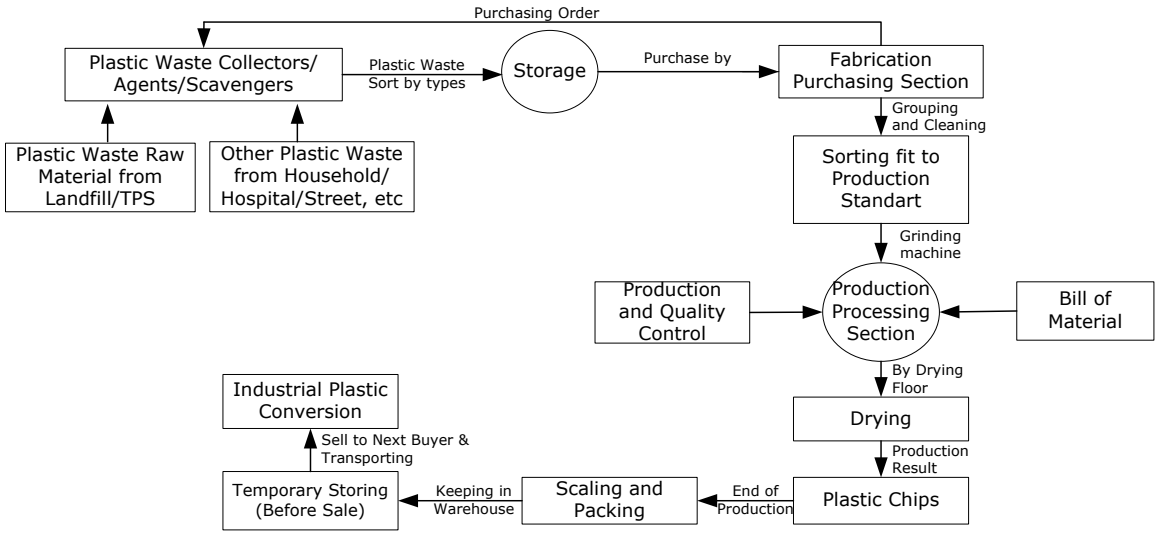
4. DISCUSSION AND ANALYSIS

4.1. Supply Chain Mapping (Raw Material Waste Plastics into Chips Plastic)

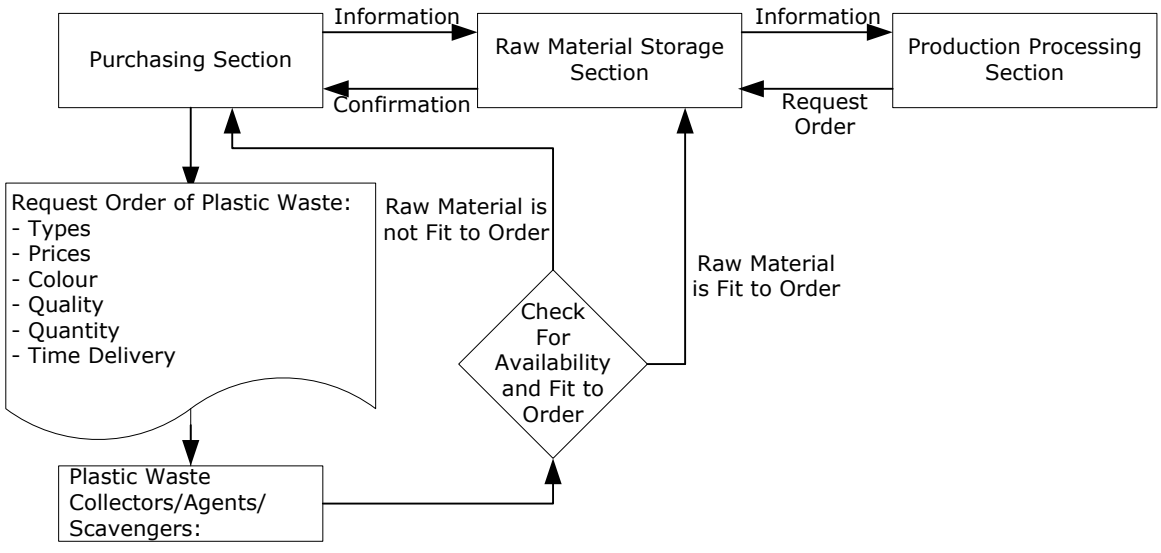
To look at the behavior of the supply chain system in the industrial processing of plastics waste processing into plastic chips (in manufacturers) which in this case

Palapa Plastic Recycle Lhokseumawe become a reference in this study, then it is necessary to know first the flow of data and material (feedstock) in clearly and detail. Therefore, it is necessary to do the mapping of data and information flow of raw material in several levels. The first level illustrates the flow of data and materials in the system in general. The second level illustrates a more detailed flow, and so on until the flow is completed detailed or can not be specified again.

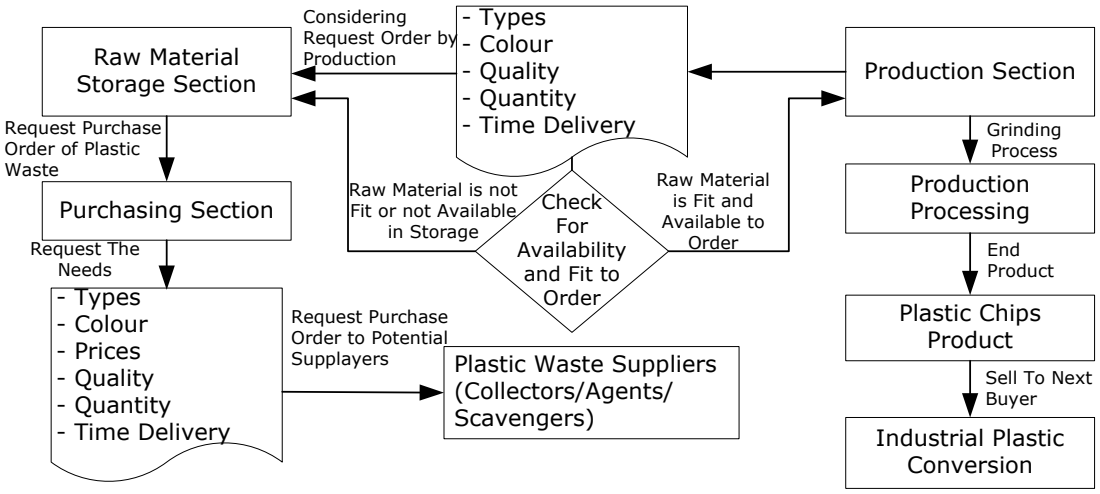
a. Information flow and Plastic Waste Data General



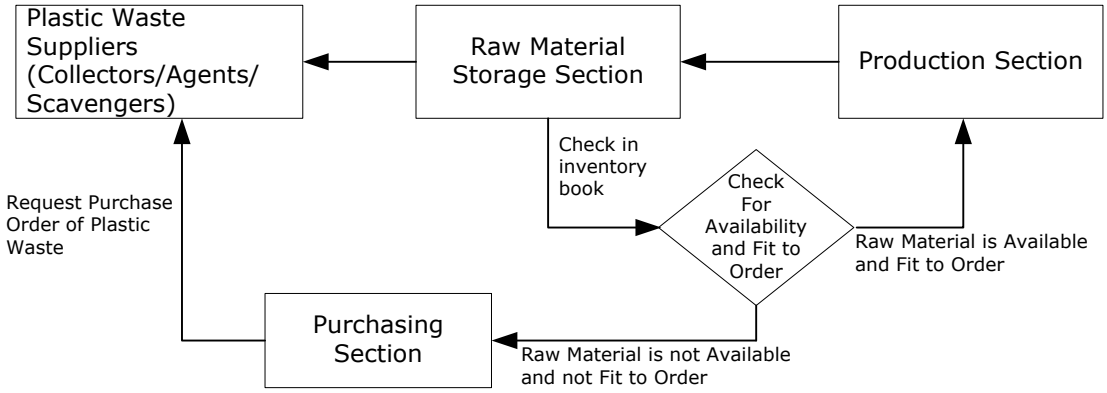
b. Data Information Flow and Plastic Waste Purchase



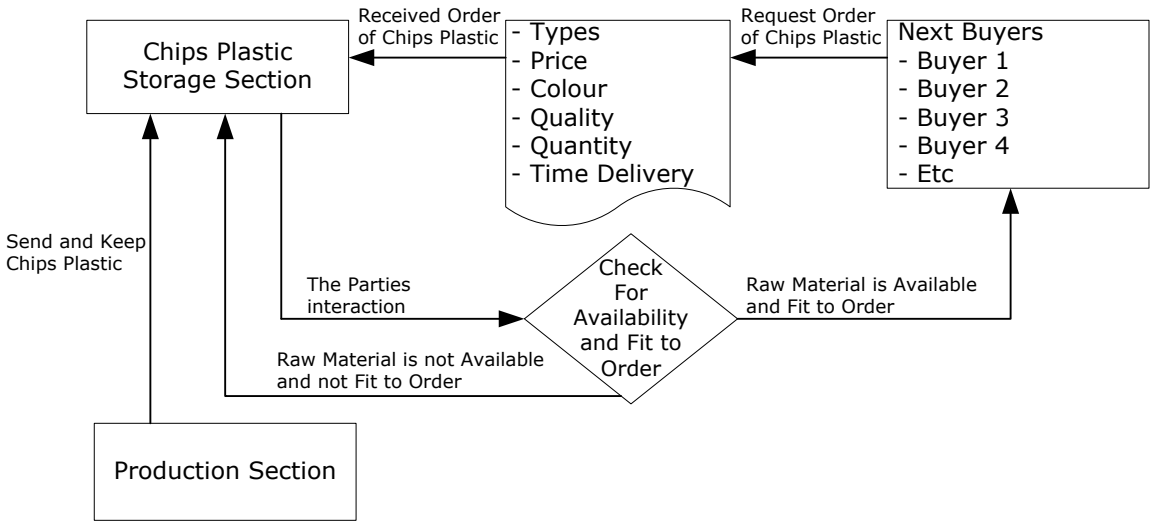
c. Information Flow of Plastic Waste (Raw Material) at Production Level



d. Data Information Flow and Plastic Waste (Raw Material) Inventories



e. Data Information Flow and Plastic Chips Inventories



4.2. Plastic Waste Suppliers

Industrial processing of plastic waste into plastic chips is relatively classified simple industry. Suppliers of plastic waste in the waste business and the processing industry are composed of collecting agent (distributor). Waste plastics obtained from them will be collected in gunny sacks to take home before the sale, sorting and cleaned first. In general, collection agency activity does not have a formal business entity except the plastic waste processing industry had a business entity such as UD, cooperatives or other governmental agencies. Therefore, in order to easier to the assessment or scoring, then to group these suppliers will be coding with (S1, S2, S3 and S4), the coding is abbreviated such a way with the aim in order to easier to conduct the scoring.

4.3. Plastic Waste Supplier Assessment

Plastic waste supplier assessment criteria in the supply chain activities are one of the criteria used as a reflection of supply chain activities. Criteria for the assessment on a transaction of this plastic waste are: the type of plastic waste, price, color, quality, quantity and delivery time. Typically consideration of industrial / manufacturing in the purchase and the transaction is different from one manufacturer to another manufacturer.

4.4. Provision Weight For Each criteria and Sub-Criteria

The model that will be used in the processing of this data is by using AHP (Analysis Hierarchy Process), which this assessment will be given the weighting of criteria and sub-criteria. The AHP model is appropriate to be applied to cases that are relatively difficult decision-making and complex by using several assessment criteria.

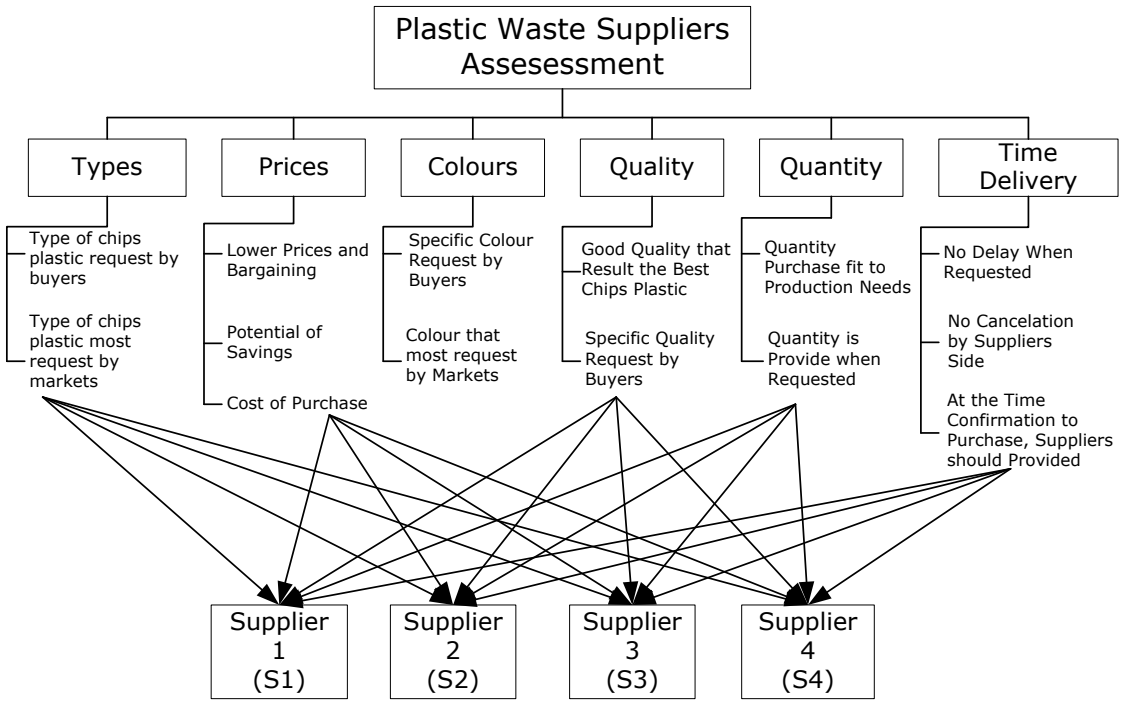


Figure 1. Criteria and Sub-Criteria Assessment of Plastic Waste Suppliers With Approach Analysis Hierarchy Process (AHP) Structure

At the AHP structure, assigning weights to each criterion, namely by way of comparison in pairs. Wherein if the comparison between the two criteria considered equally important as it is rated 1 for both criteria, whereas when there is a difference which one is more important, these criteria are given greater value than the others, namely 3, 5, 7, or 9, in accordance with level of importance of the other criteria into comparison.

Table 1: Pairwise comparisons Of Plastic Waste (Raw Materials) Supplier Selection

	Types	Prices	Colors	Quality	Quantity	Time Delivery
Types	1.00	1.00	3.00	1.00	3.00	2.00
Prices	1.00	1.00	2.00	1.00	2.00	2.00
Colors	1.00	0.50	1.00	0.50	2.00	1.00
Quality	0.50	0.33	1.00	1.00	2.00	3.00
Quantity	0.33	0.20	0.33	0.33	1.00	0.50
Time Delivery	0.50	0.33	0.33	1.00	0.33	1.00
Total	4.33	3.37	7.67	4.83	10.33	9.50

At this stage compares the criteria for the purchase of raw materials of plastic waste and assessment of the level of priority (comparative) or which become more

important relative to one another criterion, namely the criteria of the type, price, color, quality, quantity and time of delivery of the raw material of plastic waste

Table 2: Weight Calculation Of Each Criterion

	Types	Prices	Colors	Quality	Quantity	Time Delivery	Weight
Types	0.23	0.30	0.39	0.21	0.29	0.21	0.27
Prices	0.23	0.30	0.26	0.21	0.19	0.21	0.23
Colors	0.23	0.15	0.13	0.10	0.19	0.11	0.15
Quality	0.12	0.10	0.13	0.21	0.19	0.32	0.18
Quantity	0.08	0.06	0.04	0.07	0.10	0.05	0.07
Time Delivery	0.12	0.10	0.04	0.21	0.03	0.11	0.10

From the table above, obtained weighting of each criterion are sequenced: 0.27; 0.23; 0.15; 0.18; 0.07 and 0.10.

4.5. Weight calculation Of Suppliers, Plastic Waste (Raw Materials)

Supplier assessment undertaken by the buyer in this case is plastic waste processing industry (manufacturers). Assessment of waste plastics that purchased by the manufacturer that is with consideration of the type of plastic waste, price, color, quality, quantity and delivery time. After the manufacturer doing consideration of such criteria, the manufacturer will consider buying plastic waste

The next step is to calculate the weight value of each supplier. The value is obtained by summing the results of multiplication of the weight of each sub-criterion is concerned.

Table 3: Final Suppliers Assessment

Criteria/Sub-criteria	**Weight**	**Supplier 1**	**Supplier 2**	**Supplier 3**	**Supplier 4**
Types	**0.27**				
(T1)	0.18	0.345	0.125	0.255	0.275
(T2)	0.09	0.277	0.156	0.334	0.233
Prices	**0.23**				
(P1)	0.10	0.637	0.124	0.135	0.104
(P2)	0.08	0.267	0.276	0.176	0.281
(P3)	0.05	0.231	0.311	0.323	0.135
Colors	**0.15**				
(C1)	0.08	0.313	0.215	0.357	0.115

(C2)	0.07	0.274	0.197	0.276	0.253
Quality	**0.18**				
(Q1)	0.07	0.471	0.211	0.216	0.102
(Q2)	0.11	0.383	0.276	0.139	0.202
Quantity	**0.07**				
(Qt1)	0.02	0.376	0.219	0.212	0.193
(Qt2)	0.05	0.289	0.319	0.201	0.191
Time Delivery	**0.10**				
(TD1)	0.02	0.211	0.321	0.187	0.281
(TD2)	0.04	0.342	0.253	0.231	0.174
(TD3)	0.05	0.365	0.183	0.234	0.218
Final Weight Value		**0.359**	**0.205**	**0.235**	**0.201**

As shows in the table supplier assessment above, the supplier 1 has the highest value of 0.359, followed by the supplier 3 with a value of 0.235, supplier 2 with a value of 0.205 and suppliers 4 with a value of 0,201.

5. CONCLUSION

Based on analysis by using scorecards and gap analysis models it can be concluded as follows:

1. Base on supplier performance appraisal by using Analytical Hierarchy Process and model of supplier evaluation form to rank several suppliers based on several criteria, thus the obtained sequence of raw material suppliers of plastic waste in accordance with the amount of weight gained. The order of suppliers based weights that provide/meet most demand in accordance with the manufacturer that is supplier 1, 3, 2 and 4, in which the first supplier has the highest value of 0.359, followed by the supplier 3 with a value of 0.235, supplier 2 with a value of 0.205 and suppliers 4 with a value of 0.201. The sequence is a reflection of the most satisfying and fulfilling production needs required by manufacturers currently.
2. Some of the problems in obtaining raw materials at this moment are fluctuating and competitive prices between one supplier to another supplier. In addition, the raw material of plastic waste is sometimes hard to be obtained because of competition with buyers from Medan (large collection agents or industrial conversion of plastic or plastic end products maker),

where the buyers from Medan are ordered directly to the collecting agency in Aceh. Such conditions would create a tight competition and be potential for disruption of the stability of the supply of raw material available in the area of Aceh. This is certainly very disturbing chain of supply, especially for industrial processing plastic waste into plastic chips that exist in the province of Aceh at this moment.

3. To meet the need for raw materials, manufacturing (industrial processing plastic waste into plastic chips) undertake cooperation with several suppliers to get some kind of plastic waste that is required by the manufacturer where the request is a reflection of the demand for buyers in the plastics converting industry into end plastic products, it is conducted in order to keep the needs (capacity) factory production both short-term and long-term.
4. Loyalty of suppliers sometimes is a problem because in this case the effect of market mechanisms, where the highest bidder (the best) will obtain raw materials more quickly. It is sometimes the case where buyer Medan more play a role in these conditions.

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