THE APPLICATION OF AHP METHOD FOR SUPPLIER SELECTION OF BANGLADESH'S JUTE INDUSTRY: FROM THE PERSPECTIVE OF BOTH PUBLIC AND PRIVATE SECTORS

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ABSTRACT

In the competitive global business market, selection of the best supplier plays a vital role for the survival of any manufacturing company. The selection of a good supplier can make it possible for a company to reach the top position in the market. On the other side, the selection of a poor supplier can lead a company to a lower market position or even shutdown. As a developing country, Bangladesh has many very small and extremely large manufacturing companies where supplier selection is not seriously considered. These companies are selecting suppliers in the traditional way by giving priority to cost and quality, which acts as an impediment to their development. In this paper, the Analytic Hierarchy Process (AHP) method is applied in order to find the best supplier for the jute industry in Bangladesh. The study compares the application process of the method from both the public and private sector perspectives. For this purpose, the data are collected from a government factory named "Jessore Jute Industries Ltd" and a private factory named "Ahyan Jute Mills" and their present strategies are compared. This paper recommends to these jute industries that the use of the AHP method in selecting the best supplier can be effective and efficient.

Keywords: supplier selection; Analytic Hierarchy Process (AHP); Multi Criteria Decision Making; jute mills

1. Introduction

In recent years, increased supply chain profitability is the prime concern for the management of any company. In the case of a manufacturing factory, the success of upstream supply chain management is solely dependent on how good the selected supplier is. This is because supplier selection affects the product quality and is directly or indirectly related to customer satisfaction. Day by day the transmuting of customer postures, incrementing varieties of customer demands, advances of

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information technologies, product proliferation, competition in the international environment, increases in governmental regulations, short product life cycles and environmental consciousness have coerced all types of companies to fixate on supply chain management (Digalwar et al., 2014).

Supply chain is a sequential chain of sundry participants such as sub-suppliers, suppliers, manufacturers and distributors which culminates with customers who authentically integrate value with the products. The raw materials not only flow through the chain and are converted into a final product, but ultimately reach the customers. The main objective of each participant in the chain is to provide the right products to the customers at the right time. Moreover, the goal of supply chain management which involves the manager and those participants is to build the most optimal chain (Aktepe & Ersoz, 2011). The supplier is considered the first stage of this chain. It is always very arduous for the companies to select the right suppliers. Recently, supplier selection has become the most consequential quandary because every supplier has both strengths and weaknesses. Selection of suppliers requires several criteria to be considered which turns the quandary into a multi-criteria decision-making problem (Tahriri et al., 2008).

In Bangladesh, jute products have a valuable contribution to the economy of the country. Therefore, the importance of jute products in Bangladesh cannot be ignored (Shakil et al., 2013). Evaluation and selection of suppliers lead to the prosperity of any jute product factory whether government or private. The quality and cost of jute products are directly cognate to the purchased raw materials (Koul & Verma, 2011). Traditionally, the jute industries in Bangladesh select their supplier predicated on the cost and quality and sometimes consider the distribution schedule (Tahriri et al., 2008). There are several supplier selection methods available such as different MCDM approaches, linear weighting models etc. (Digalwar et al., 2014). Bangladeshi jute industries are failing to meet product demand worldwide (Akter, 2015). The selection of the right supplier increases productivity. This supplier selection process is composed of four phases: the initial quandary definition, the formulation of criteria, the qualification of potential suppliers, and the final selection among the eligible suppliers (Khan et al., 2015).

This paper analyzes the current supplier selection system of "Jessore Jute Industries Ltd" as a sample of regime industry, and "Ahyan Jute Mills" as a private sector representative. It compares them utilizing the Analytic Hierarchy Process (AHP), a multi-criteria decision-making approach, to select the right supplier.

The rest of the paper is structured as follows: Section 2 provides a brief review of related previous works. In section 3, the scenario of supplier selection in the jute industry is presented and discussed. The selection methodology using AHP is conducted in Section 4. Section 5 provides key results of the study with discussion. Section 6 concludes the paper.

2. Literature review

Supplier selection for an organization is a process in SCM for evaluating the eligible suppliers and selecting the right supplier who can meet the organization's requirements. The supplier selection process requires considering a number of criteria. Dickson (1966) in his seminal work suggested 23 consequential criteria which are utilized for the evaluation and selection of suppliers (Dickson, 1966). In his

work, he suggests, "From the purchasing literature, it is fairly facile to abstract a list of at least 50 distinct factors (characteristics of vendor performance) that are presented by sundry authors as being consequential to consider in a vendor selection decision" (Dickson, 1966). A vast amount of research has been done concerning supplier criteria.

Charles (1991) reviewed 74 publications about supplier selection from 1966 to 1991 and showed that more than 63% of them were in multi-criteria environments (Weber, et al., 1991). Davidrajuh (2000) reviewed some papers and published a paper which accentuates the paramount criteria and their invariability (Davidrajuh, 2000) Bross & Zhao (2004) concluded on their review that the most valuable supplier selection criteria are cost, quality, accommodation, relationship, and organization. Because of these many criteria, supplier selection has become a multi-criteria decision-making quandary which consists of both qualitative and quantitative metrics. Since it is the most consequential and indispensable part of a company, an abundance of studies and investigations has been published on supplier selection. Alehashem et al. (2013) mentioned 13 paramount criteria for supplier selection in his work. He additionally suggested applying the Analytical Hierarchy Process (AHP) method to identify and evaluate the supplier selection.

Since supplier selection is a multi-criteria decision-making process, it consists of a number of valuable criteria. Many studies have already been done to find these criteria, which usually affect the supplier (Vaidya & Kumar, 2006). After consulting with jute experts and reviewing some research papers, the authors have identified the important factors which are considered as criteria for selecting a supplier such as price (cost), quality and delivery, responsiveness to customer needs, relationship and business effort, technical support, product appearance, productivity, flexibility, direct cost, trust, responsibility, discipline, financial, warranty, performance history, location, long term relationship, reliability etc. (Shakil, Ullah & Lutfi, 2013; Rajesh, & Malliga, 2013; Dursun & Karsak, 2013; Verma, 2013; Yusuff et al., 2001; Khan & Islam, 2014; Liu & Hai, 2005; Ghorabaee et al., 2017) Mohammad Abdolshah, 2013, Thiruchelvam & Tookey, 2011, Ellram, 1990 and Stamm and Golhar (1993) mentioned 60, 42, 36, 18, and 13 criteria for supplier selection, respectively in their study. Weber et al. (1991) reviewed 47 articles on supplier criteria and recommended that the most important criteria are price, quality, delivery, production capacity, and localization.

The AHP method was first proposed by Saaty in 1980. Since then, a large volume of work using the AHP has been carried out that is available in the literature (Kazempoor et al., 2015; Ramlan & Qiang, 2014). Among them, the number of works related to the supplier selection problem that use the AHP model is not trivial (Tahriri et al., 2008; Alehashem et al., 2013; Kazempoor et al., 2015). The Analytic Hierarchy Process has been a practical implement in the hands of decision makers and researchers, and it is one of the most widely used multiple criteria decision-making implements (Vaidya & Kumar, 2006). The authors used the AHP approach to cull and evaluate suppliers for jute industries. By applying the AHP to supplier assessment in a multi-criteria environment, the authors were able to solve the supplier quandary. The AHP method may integrate multiple criteria in the subjective environment of the decision-making process for supplier selection.

Rather than AHP, several other paradigms have also been used over the last three decades such as Fuzzy Analytic Hierarchy Process, Data Envelopment Analysis,

Commixed Integer Programming, TOPSIS, Fuzzy TOPSIS, Fuzzy QFD, AHP QFD, Analytic Network Process and Expert Systems (Tahriri et al., 2014; Tas, 2012; Ayhan, 2013; Ahmady et al, 2012; Hu et al., 2016; Sasi & Digalwar, 2015; Gurung & Phipon, 2016; Kilie, 2012; Dursun & Karsak, 2013; Rajesh & Malliga, 2013; Gupta et al, 2015; Sadeghi et al, 2012; Sanayei et al, 2010).

The selection of suppliers for jute industries requires considering a number of subjective factors. In this situation, the Analytic Hierarchy Process (AHP) provides an effective tool to deal with these subjective factors that may come from multiple sources (Yusuff et al., 2001). Khan & Islam (2014) proposed an incipient model for selecting suppliers for jute industries in a competitive environment. Liu & Hai (2005) have found widespread applications of the Analytic Hierarchy Process (AHP) in intricate decision-making quandaries involving multiple criteria in systems of many calibers. Ghorabaee et al. (2017) reviewed a total of 339 publications and some book chapters from 2001 to 2016 and concluded that the AHP and TOPSIS methods are the most popular approach for multi attribute decision-making (MADM) as well as supplier selection.

Although, a large volume of work exists on the supplier selection problem, there is still no work within the jute industry. In Bangladesh, the jute industry has been facing a serious problem with raw materials supply for the past decade. This problem results in higher jute prices, longer lead-times, supply uncertainty and poor relationships between industries etc. For these reasons, this sector has not seen any profit for a long time. Selection of the right supplier can mitigate a large portion of this problem. Therefore, there is a need for a work that seeks to find a systematic way of supplier selection for the jute industry in Bangladesh. The current research is intended to develop a systematic process of supplier selection for the jute industry using the AHP model.

3. Present selection procedure of jute suppliers

Suppliers are an essential part of business for both government and private jute factories. The current supplier selection systems for both types of factories are discussed below.

3.1 Private industry

Private factories like Ahyan Jute Mills conventionally produce various types of jute products. As a jute product-producing factory, they need to have a supplier for collecting raw materials. Unfortunately, only 20% of the jute is supplied by the supplier and the remaining 80% of the jute is purchased by their own people.

(1) In the 20% jute obtained from suppliers only 5-7% of the suppliers are permanent and others are short-lived. These suppliers are selected mainly based on personal relationships.
(2) For purchasing the jute, each of the factories sends their experienced employees to the local markets that are selected by the top management. They buy the jute from the local market and carry it back to the factory in their own trucks.

When the jute is purchased, the buyers customarily consider some criteria such as price, quality, distribution etc. However, they do not utilize any method or valuable

implementation for decision-making. They give priority to feelings rather than facts and logic when buying jute, which is one of the main obstacles for business.

3.2 Government industry

Government factories, like Jessore Jute Industries Ltd., customarily use perpetual suppliers. Firstly, jute officers customarily contact all the suppliers who are interested in working with these industries. Then they ask them about the criteria, which have been previously selected. Their considered criteria are price, quality, distribution, reliability etc. After getting the answer from the suppliers, the jute officers arrange an internal meeting with the experts and top management. This group discusses and selects the supplier. They are not utilizing any decision-making method, but still utilizing expert opinion.

4. Research methodology

The first and most important instruments of this research are interviews with the purchase managers of the jute factories. These interviews were carried out by the authors. Next, the interviews were analyzed and the unnecessary data was eliminated. Then the data was summarized and interpreted into an easily understandable form. The next step was to input the data into Microsoft Excel for further analysis and pairwise comparisons were calculated. The final stage involved synthesizing judgments and checking for consistency to make sure that the judgments were accurate. Saaty, in 1980, suggested that this calculation would be adequately consistent if the consistency ratio (CR) is less than 0.1(10%). The methodology can be summarized in 4 steps.

- Step 1: Collect data through interviews
- Step 2: Analyze and eliminate unnecessary data
- Step 3: Summarize data into easily understandable form
- Step 4: Calculate data using AHP method
- Step 5: Make a decision

The summary of AHP model is that it compares different alternatives (i) against different attributes (j) through an n×n judgment matrix as follows:

Comparision Matrix	Geometric mean	Normalized weigh
J 1 2 Λ Λ k Λ Λ n 1 1 a_{12} Λ Λ a_{1k} Λ Λ a_{1n} 2 a_{21} 1 Λ Λ a_{2k} Λ Λ a_{2n} M M M M M M M M M M M M M M M M M M i k a_{k1} a_{k2} Λ Λ 1 Λ Λ a_{kn} M M M M M M M M M M M M M M M M M M n a_{n1} a_{n2} Λ Λ a_{nk} Λ Λ 1 Sum = y_1 y_2 Λ Λ y_k Λ Λ y_n	$\begin{bmatrix} b_1 \\ b_2 \\ M \\ M \\ b_k \\ M \\ M \\ b_n \end{bmatrix}$	$\begin{bmatrix} x_1 \\ x_2 \\ M \\ M \\ x_k \\ M \\ M \\ x_n \end{bmatrix}$

Where, i and j are alternatives or attributes to be compared, and a_{ij} is a value which represents the comparison between alternatives/attributes i & j.

In the matrix $y_k = \sum_{i=1}^{n} a_{ij}$, where k= 1, 2…n and j = 1, 2 ….n (1)

Geometric mean is calculated as follows:

$$b_k = [(a_{k1}) \cdot (a_{k2}) \Lambda \Lambda (a_{kn})]^{1/n} \quad (2)$$

Normalized weights are calculated as follows:

$$x_k = \frac{b_k}{\sum_{k=1}^{n} b_k} \quad (3)$$

Consistency Index (C.I.) is calculated as follows:

$$C.I. = \frac{\lambda_{\max} - n}{n-1}, \text{ where } \lambda_{\max} = y_1 x_1 + y_2 x_2 + \Lambda \Lambda + y_n x_n = \sum_{k=1}^{n} y_k x_k \quad (4)$$

Table 1
Consistency index (R.I.)

Some randomly generated consistency index (R.I) values are,

N	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Then consistency ratio (C.R.) is found by using the following equation:

$$C.R = \frac{C.I.}{R.I.} \tag{5}$$

If C.R. ≤ 10%, the alternatives accepted. Otherwise, it is rejected.

The authors have identified the most important criteria of suppliers for jute industries which are shown in the Table 2,

Table 2
Most important identified criteria by researchers

	Price	Quality	Delivery	Reliability	Capacity	Relationship	Performance	Time	Service	Organization
Dickson(1966)	✓		✓				✓			
Welber, Current and Benton (1991)	✓	✓	✓		✓					
Tullous and Munson (1991)	✓	✓	✓			✓		✓	✓	
Pullman (1998)	✓	✓	✓					✓		
Zhang, Lei, Cao, Ng (2003)	✓	✓	✓							
Bross and Zhao (2004)	✓	✓		✓					✓	✓
FarzadTahriri (2008)	✓	✓	✓				✓			
Om Pal (2013)	✓	✓	✓				✓			
Dr. Devendra Singh Verma (2013)	✓	✓	✓							

From the above table and more analysis of supplier criteria, the authors find that the six most important criteria for jute industries suppliers are price, quality, delivery, performance, reliability and availability.

After discussions with management and experts, the authors have considered four alternative suppliers. Figure 1 shows the hierarchical structure of supplier selection problem considering six evaluation criteria.

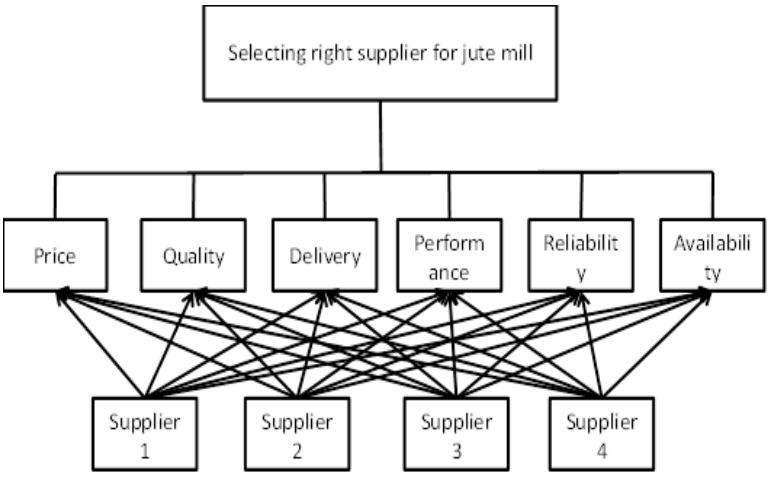

Figure 1 Hierarchical structure of the evaluation criteria and suppliers

Now the pairwise comparison matrix has been prepared using a "scale of relative importance". This shows the relative importance of one option using grades ranging from 1-9. The scale range is described in Table 3.

Table 3
Scale of relative importance

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it.

Next, the pairwise comparison matrices are analyzed and augmented for the criteria and alternative suppliers in order to obtain the following results. The authors have calculated Tables 4-11 using Equations 1-5 (shown above).

Evaluation of selected criteria:

Table 4
Comparison and judgment for criteria
Comparison matrix and judgment for criteria to find the normalized weight

Criteria	Price	Quality	Delivery	Performance	Reliability	Availability	Geometric mean	Normalized weight
Price	1	1	2	7	6	5	2.7365	0.3429
Quality	1	1	3	5	4	7	2.7365	0.3429
Delivery	1/2	1/3	1	2	1/2	3	0.8909	0.1116
Performance	1/7	1/5	½	1	1	1/2	0.4389	0.0549
Reliability	1/6	1/4	2	1	1	1	0.6609	0.0828
Availability	1/5	1/7	1/3	2	1	1	0.5167	0.0647
Sum	3.009	2.926	8.833	18	13.5	17.5	7.9804	
n = 6 λ_{max} = 6.2591				C.I. = 0.05182 C.R. = 4.179% <10%				
Consistency ratio (C.R.) is less than 10%, so accepted.								

Evaluation for alternative suppliers:

Table 5
Evaluation for price
Comparison matrix and judgment table for price

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	2	1/3	1	0.9036	0.20952
Supplier 2	1/2	1	1/2	1	0.7071	0.16395
Supplier 3	3	2	1	2	1.8612	0.43156
Supplier 4	1	1	1/2	1	0.8408	0.19495
Sum	5.5	6	2.333	5	4.3127	
n = 4 λ_{max} = 4.1176			C.I. = 0.0389 C.R. =3.92% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 6
Evaluation for quality
Comparison matrix and judgment table for quality

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	1/8	4	1/4	0.59460	0.09701
Supplier 2	8	1	9	1	2.91295	0.47529
Supplier 3	¼	1/9	1	1/8	0.24274	0.03960
Supplier 4	4	1	8	1	2.37841	0.38807
Sum	13.25	2.236	22	2.375	6.12870	
n = 4 λ_{max} = 4.1409			C.I. = 0.04699 C.R. = 5.22% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 7
Evaluation for delivery
Comparison matrix and judgment table for delivery

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	3	1	5	1.96798	0.41017
Supplier 2	1/3	1	1	6	1.18920	0.24785
Supplier 3	1	1	1	3	1.31607	0.27430
Supplier 4	1/5	1/6	1/3	1	0.32466	0.06766
Sum	2.533	5.167	3.333	15	4.79791	
n = 4 λ_{max} = 4.247			C.I. = 0.0824 C.R. = 9.16% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 8
Evaluation for performance
Comparison matrix and judgment table for performance

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	4	9	6	3.83365	0.60615
Supplier 2	1/4	1	7	4	1.62657	0.25718
Supplier 3	1/9	1/7	1	1/3	0.26970	0.04264
Supplier 4	1/6	1/4	3	1	0.59460	0.09401
Sum	1.52	5.39	20	11.33	6.32452	
n = 4 λ_{max} = 4.225			C.I. = 0.07516 C.R. = 8.35% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 9
Evaluation for reliability
Comparison matrix and judgment table for reliability

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	1/4	2	1/3	0.63894	0.13222
Supplier 2	4	1	2	1	1.68179	0.34803
Supplier 3	1/2	1/2	1	1/6	0.45180	0.09349
Supplier 4	3	1	6	1	2.05976	0.42624
Sum	8.5	2.75	11	2.5	4.83229	
n = 4 λ_{max} = 4.1749			C.I. = 0.05831 C.R. = 6.47% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 10
Evaluation for reliability
Comparison matrix and judgment table for availability,

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Geometric mean	Normalized weight
Supplier 1	1	4	1	2	1.68179	0.37537
Supplier 2	1/4	1	1/2	1	0.59460	0.13271
Supplier 3	1	2	1	3	1.56508	0.34931
Supplier 4	1/2	1	1/3	1	0.63894	0.14261
Sum	2.75	8	2.833	7	4.48041	
n = 4 λ_{max} = 4.0819			C.I. = 0.02731 C.R. = 3.03% <10%			
Consistency ratio (C.R.) is less than 10%, so accepted.						

Table 11
Evaluation and ranking of supplier
Based on the result of above matrices, an overall evaluation is performed using the calculated weights of the alternative suppliers and five measuring criteria, as follows:

Alternative suppliers	Criteria and their weights						Composite weights ($\sum x_k$ *of criteria* × x_k of alternative)	Over-all ranking
	Price	Quality	Delivery	Performance	Reliability	Availability		
	0.3429	0.3429	0.1116	0.0549	0.0828	0.0647		
Supplier 1	0.20952	0.09701	0.41017	0.60615	0.13222	0.37537	0.21939	4
Supplier 2	0.16395	0.47529	0.24785	0.25718	0.34803	0.13271	0.29837	1
Supplier 3	0.43156	0.03960	0.27430	0.04264	0.09349	0.34931	0.22485	3
Supplier 4	0.19495	0.38807	0.06766	0.09401	0.42624	0.14261	0.25714	2

5. Results and discussion

In Table 10, it is observed that supplier 2 has the highest composite weight and is marked as rank 1. Supplier 4 is marked as rank 2 and supplier 1 has the lowest composite weight which is marked as rank 4 Thus, the decision is to select the supplier with the highest composite weight which is supplier 2. The application of the

suggested AHP method has been discussed, and the existing methods of both public and private sectors of jute factories are listed and compared below.

Government industry vs. private industry system:

1. During supplier selection, the purchase manager of the government jute industry discusses with experts and top management, which is genuinely time consuming. (Recently BGMEA has become the controller of the jute supply). However, in the private jute industry, factories purchase most of their raw materials (especially jute) by their own hand.
2. Private jute industries purchase their raw materials for one year at a time because it requires an astronomically immense amount of area/space to store them. However, government industry uses supplier storage. They can inductively authorize their raw materials when they are required. They do not need any extra area/space.

Analyzing the above-discussed problems, the authors recommend that both industries use any MCDM approach to select suppliers. As an example, the AHP method was applied to both private and government industry to select the suppliers.

Application of AHP in Private Sector:

- AHP is a multi-criteria decision-making method. It accumulates all of the paramount criteria which are essential for a supplier. Therefore, it is possible to select the optimum supplier by utilizing this method. However, it is not possible in the current system to select the optimum supplier for the private industry.
- In the current system, the private industry is responsible for obtaining the raw materials. However, when utilizing AHP, the supplier will be responsible.

Application of AHP in Government Sector:

- AHP decision-making model is more appropriate than the current "discussion method" which is currently practiced because not all criteria are considered in these discussions.

Here, supplier selections of two jute sectors have been compared and the application of AHP for both sectors has been shown. Both companies can benefit by applying AHP in their supplier selection.

6. Conclusion

In this paper, the authors have used the AHP approach, as an example of a MCDM approach, to select the best supplier for jute industries in Bangladesh, and made a comparison with the present method of both government and private industries. There are some other techniques such as TOPSIS, FUZZY, ANP, ELECTRE, DEMATEL, PROMETHEE etc. that could also be used for this system. The authors have studied the AHP approach because it allows the decision makers of jute industries to rank alternative suppliers predicated on their subjective judgments regarding the attributes that are paramount. While studying both government and private jute industries, the authors have found that neither industry utilizes any modern decision-making method

to select their supplier. They are failing to select the right suppliers for their industries, which has a negative effect on the success of their business. In this method, the supplier is selected based on some criteria and if the selection criteria can be increased, the result would be more fruitful. This is the limitations of the study. The other MCDM approaches could be applied in this sector to select the right supplier. A comparison analysis could be performed of these methods (TOPSIS, ELECTRE, DEMATEL, etc.) with the AHP in a supplier selection decision-making problem.

This paper recommends that both private and government jute industries utilize the AHP for supplier selection and evaluation. It would allow the organization to reduce costs, ascertain excellent quality, procure authentic-time distribution, optimum lead-time, mitigate peril, increment and smooth engenderment flow and receive better accommodation of raw materials.

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