Green Supplier Selection in Sustainable Supply Chain Management using AHP

Sudhir Barange[1], Sachin Agarwal[2]
[1]M.Tech Student, Department of Mechanical SAIT Indore, [2]Asst. Professor, Department of Mechanical SAIT Indore

Abstract – A sustainable supply chain management is primarily concerned with the efficient integration of suppliers which are providing eco-friendly environment for suppliers. In SCM Green supplier selection is the most important process for sustainable supply chain management. Green supplier selection relies on green criteria, so determination of suitable set of criteria will help environmental directly. This paper is present environmental and green criteria for supplier selection. Subsequently a decision model based on the analytic hierarchy process (AHP) is applied.

Keywords - Sustainable Supply chain management, Green supplier development, Analytical hierarchy process.

1. INTRODUCTION

Supply chain management deals with linking the organizations within the supply chain in order to meet demand across the chain as efficiently as possible. Supply chain management works for different department like manufacturing, logistics and services. For eliminating environmental pollution issue accompanying industrials development should addressed along with supply chain management, thus contributing to Green supply chain management System (GSCM) [1]. GSCM is generally understood to involve screening suppliers based on environmental performance and then doing business only with those that meet certain environmental regulations or standards [2].

Supplier development is the process of working with certain supplier on a one-to-one basis to improve their performance for the profit of buying organization. Supplier development involves embracing supplier expertise and aligning it to the buying organization's business need, and where appropriate vice versa. The markets in which firms compete are increasingly influenced by international competitors, demanding customers, rapid technological change and shorter product life cycles [3]. In order to maintain a pool of qualified suppliers many companies carefully evaluate and select their suppliers. Additionally some companies have started to strategically improve their supplier's capabilities and thereby their supply base's competitiveness through knowledge transfer or buyer involvement [4].

Green supplier development interacts with green procurement insofar that it adds activities with suppliers that encourage and enable green performance such as

(1) Developing instead of terminating suppliers in case of improvable green performance,

(2) Visiting supplier plants and helping them to improve environmental performance,

(3) Timely and frequent communication on green performance matters, and

(4) Acknowledging green supplier performance e.g. through awards, and close collaboration with suppliers on green matters [5].

Green supplier development increases the cooperation with the suppliers through support and feedback mechanisms that jointly improve supplier performance [4]. Moreover, it also helps supply partners to work together in making supply-side ecological improvements [6].

2. LITERATURE REVIEW

While supplier development has become a well-researched topic, few articles mention relevant criteria for the supplier selection. Based on a literature survey Krause and Ellram [4] identify elements that appear to be critical to the success of a supplier development effort from the buying firm's perspective. Krause and Handfield [3] investigate supplier development in terms of its use for buying companies by comparing supplier development efforts across countries and industries. They depict assessment and rationalization of the supply base as first step in supplier development, but do not provide an extensive list of criteria that could be taken into account.

Lusch and Brown [7] suggest that when firms jointly try to solve their common problems and attempt to improve the relationship as a whole, they will be able to achieve superior performance benefits. Accordingly,

developing actions can ultimately facilitate the formation of idiosyncratic interaction routines that can enable the understanding of strengths and weaknesses of the supply partners [8]. Such an increased understanding of green strengths and weaknesses of the supply partner can enable firms to better accommodate the ever-changing needs of supply-side environmental prowess on a very short notice [9]. Additionally, inter-organizational developing behavior can dramatically reinforce suppliers' trust in the buying firm, and norms like trust could in turn work as complements to enhance performance. Green supplier development can thus result in establishing deeply-embedded capabilities that are tacit, relationship-specific, and not easily replicated by competition [6]. Hence, following the tenets of the resource-based view that propose long-term competitive advantage to be directly related to the ability of firms to create strategic resources and capabilities that are hard to imitate, green supplier development could be envisioned to result in significant competitive advantages to not only the buyer firm, but also the supplier firm.

It is noted that the literature focusing on green supply development activities lacks in-depth frameworks on how to select appropriate green supply development activities out of the many choices available to achieve the desired results. Therefore, there is a research gap to establish the direct or indirect impact of selective green supply development activities on suppliers' green environmental competence, green design and green image innovation, and how these development activities in turn link with improvements in the buying firm's performance. Buying firms would then better understand which green supply development activity is required to achieve particular outcomes and which supplier activities they need to focus on to acquire excellence.

3. METHODOLOGY

The analytic hierarchy process is a theory of measurement through pairwise comparisons that relies on the judgments of experts to derive priority scales for criteria. First relevant criteria for the selection decision are grouped in a hierarchy and criteria weight is then derived by pairwise comparison of criteria. For the specific situation, the process for developing the model was slightly modified. It was developed by Thomas L Saaty in 1970.

AHP method is applied on selected criteria with respect to green supplier development. There are four selected criteria with having three alternative suppliers to achieve decided goal. Pair wise comparisons have been done of those alternatives satisfying the criteria. Then check consistency index of criteria has been calculated with respect to goal. The individual priority of the alternatives was calculated and after calculating their weightage finding the green supplier, who having highest priority is selected.

4. STRUCTURE OF HIERARCHY

The structure of hierarchy can be drawn as the following

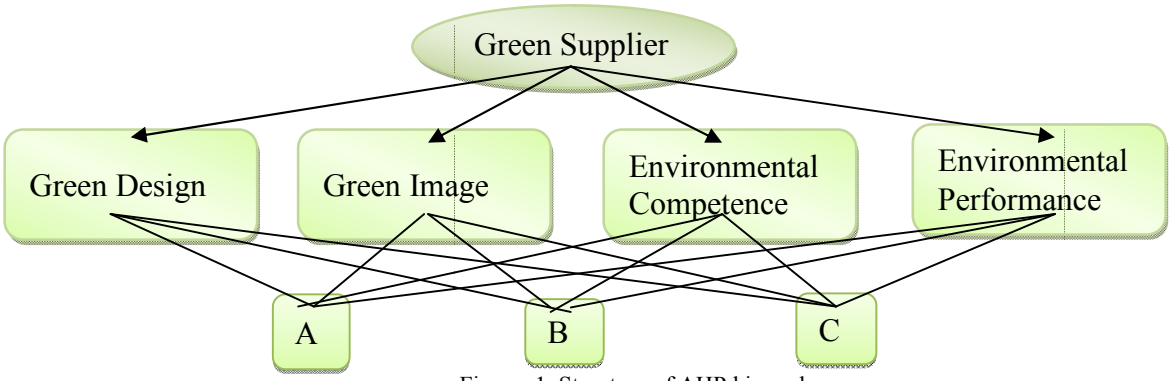

Figure: 1. Structure of AHP hierarchy

Green Supplier is our main goal of the analysis. Next level includes Multi criteria that consist of several factors or alternative choices. The line between of them shows relationship between alternative and green supplier. Make reciprocal matrix correspondent to pairwise comparison. Gives individual priority and check their consistency ratio, which is comparison between consistency index and random consistency index using following formula

$$Consistancy\ Ratio = \frac{Consistancy\ Index}{Random\ consistancy\ Index}$$

Where,

$$Consistancy\ Index\ CI = \frac{\gamma_{max}-n}{n-1}$$

γ_{max} = Calculated with help of priorities

n = no of alternatives

Random consistency index generated reciprocal matrix using scale and get random consistency index to check if it is about 10% or less. This table proposed by prof. Saaty Thomas L is given below

Table: 1. Random consistency index

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Now make calculation and find alternative for achieve goal.

5. CASE STUDY

Table: 2. Criteria for green supplier selection

Sr. No	Criteria	Reference
1	Green Design	Humphreys et al., (2004)
2	Green Image	Humphreys et al., (2004)
3	Environmental competence	Humphreys et al., (2004)
4	Environmental performance	Humphreys et al., (2004)

Table: 3. Comparison matrix for the green alternatives

From / To	Green Design	Green Image	Environmental competence	Environmental performance	Priority
Green Design	1	3	5	7	55.79 %
Green Image	$\frac{1}{3}$	1	3	5	26.34%
Environmental competence	$\frac{1}{5}$	$\frac{1}{3}$	1	3	12.18 %
Environmental performance	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{3}$	1	5.689 %

$$\gamma_{max} = \frac{176}{105}[0.5579] + \frac{68}{15}[0.2634] + \frac{28}{3}[0.1218] + 16[0.0589] = 4.1769$$

Check Consistency Index $= \frac{\gamma_{max}-n}{n-1} = 0.0589$

Random consistency Index according to number of 4 alternative take values from table no 1.

Then Consistency ratio = $\frac{CI}{RI} = \frac{0.0589}{0.9}$ = 6.55 % < 10%, thus it is acceptable.

Table: 4. Comparison matrixes between suppliers for green design

From/To	A	B	C	Priority
A	1	5	3	63.34 %
B	$\frac{1}{5}$	1	$\frac{1}{3}$	10.62 %
C	$\frac{1}{3}$	3	1	26.04 %

$$\gamma_{max} = \frac{23}{15}[0.6334] + 9[0.1062] + \frac{13}{3}[0.2604] = 3.055$$

Consistency Index $= \frac{\gamma_{max}-n}{n-1} = 0.0276$

And Consistency ratio = $\frac{CI}{RI} = \frac{0.0276}{0.58}$ = 4.77 % < 10%, thus it is acceptable.

Table: 5. Similarly Comparison matrixes between suppliers for green image, Environmental competence, Environmental performance

From/To	A	B	C	Priority
A	1	3	$\frac{1}{5}$	19.31 %
B	$\frac{1}{3}$	1	$\frac{1}{7}$	8.34 %
C	5	7	1	72.35 %

$$\gamma_{max} = \frac{19}{3}[0.1931] + 11[0.0834] + \frac{47}{35}[0.7235] = 3.017$$

Consistency Index $= \frac{\gamma_{max}-n}{n-1} = 0.0557$

And Consistency ratio = $\frac{CI}{RI} = \frac{0.0557}{0.58}$ = 9.60 % < 10%, thus it is acceptable.

We can do the same for paired comparisons with respect to environmental competence and environmental performance. However the weight of both environmental competence and environmental performance are very small (from table no. 3 again), therefor we can assume the effect of leaving them out from further consideration is negligible. We ignore these two weights as set them as zero.Adjusted weightage for green design = $\frac{55.79\ \%}{55.79\ \% + 26.34\ \%}$ = 0.679

Similarly, Adjusted weightage for green image = 0.320

And, now we compute the overall composite weight of each alternative choice based.

A = (0.679) (63.34%) + (0.32) (19.31%) = **49.26 %**

B = (0.679) (10.62%) + (0.32) (8.34%) = **9.90 %**

C = (0.679) (26.04%) + (0.32) (72.35%) = **40.84 %**

6. RESULT

Final result shows the sum priorities of supplier A is 49.26 % for supplier B is 9.90 % and for supplier C is 40.84 %. It means supplier A is satisfying all the criteria up to maximum level. After the supplier A, B and C are fulfilling the criteria. Therefore we can suggest that supplier A may be considered as a best supplier for green supplier development. After supplier A we choose supplier C and B. according to sum priority percentage.

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AUTHOR'S PROFILE

Sudhir Barange has received his Bachelor of Engineering degree in Mechanical Engineering from RGTU Bhopal in the year 2009. At present he is pursuing M.Tech with the specialization of Industrial Engineering and Management in SAIT Indore.

Sachin Agarwal has received his Master of Engineering degree in Industrial Engineering and Management from RGTU Bhopal in the year 2013. He is working as an Assistant Professor at SAIT Indore from 2009. His areas of interests are decision making, supply chain management.