International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 04 | Apr-2016 www.irjet.net p-ISSN: 2395-0072

Green Supplier Selection for Indian Cement Industry: AHP based approach

Deepesh Giri Sharma[1], A. M. Rawani[2]

[1]*Mechanical Engineering Department, Central college of Engineering and Management, Raipur (C.G.), 492 099, India*

[2]*Mechanical Engineering Department, National Institute of Technology,* Raipur (C.G.), *492 001, India*

Abstract - *Green Supplier Selection (GSS) is an important procurement activity. Selecting suppliers considering the green criteria is known as Green Supplier Selection. Environment consciousness in manufacturing has moved the procurement of materials, good and services towards adopting green practices. Analytical Hierarchy Process (AHP) is multi criteria decision making technique which has been applied for solving many complex problems in decision making. Research studies have focused in incorporating many relevant and new criteria for decision making in manufacturing environment using AHP. This research paper incorporates Analytical Hierarchy Process in developing GSS model. The developed model is applied in selecting the suppliers considering the relevant Green, Corporate Social Responsibility (CSR) and Safety criteria.*

Key Words: Analytic Hierarchy Process, Green Criteria, Green Supplier Selection.

1. INTRODUCTION

Green Supplier Selection (GSS) process ensures that buyer is purchasing the products with no harmful impacts on the environment. The word 'Green' has become synonyms of environmental considerations. In manufacturing industries, there is always a want for innovative practices to retard the competition and to satisfy the appetite of growth. GSS is one of the innovative practices in the procurement function of the production industries. Incorporation of green criteria in supplier selection is due to many reasons and not limited to profits. Some of them are legal and social bindings. Green activities of the suppliers, along with safe business practices and CSR activities have been considered as GSS criteria in this research paper. Cement manufacturers of India are facing challenges in the supply of raw materials. The Granulated Blast Furnace Slag (GBFS) is one of such raw material. In this research paper model for Green Supplier Selection has been proposed and applied in selecting the suppliers of the Granulated Blast Furnace Slag for the two Indian cement manufacturing industries namely ACC Limited and Ambuja Cement Limited.

2. LITERATURE REVIEW

Any of the decision making related with supplier selection starts with identifying the factors which affects this decision making considerably. Dickson in his study has identified twenty three factors that should be considered for selecting the suppliers [1].

Sustainability related factors in the analysis of the supply chain have been considered by Wood DJ [2]. While, Gupta [3] suggests that, the environmental issues have become important factors for the manufacturing industries for managing its supply chain. According to them, organizations are now at the advanced stage of managing their supply chain; in which environmentally conscious firms, mainly larger companies, are developing environmental programs aimed at organizing their supply chains. Integrating environmental management techniques along the supply chain is an appropriate method of improving the environmental performance of an industry. Over the last few years, organizations have responded to this challenge by implementing a number of programs [4]. The word environment at this advanced stage has changed and popularly accepted as 'Green'. The supply chain management considering environmental issues is being known as Green Supply Chain Management and the supplier selection considering the environment related factors are being known as Green Supplier Selection.

The purchasing and supply management is a very important activity in a supply chain. There are limited numbers of focused studies in the field purchasing and supply management and this area will be of high potential in the coming ten years [5]. The green parameters in the purchasing and supply management help to convert the supply chain management into green supply chain management.

The supplier selection is a multiple criteria decision-making problem affected by several conflicting factors [6]. Great environmental challenges, such as global warming, have demanded greater organisational concern regarding their environmental management [7]. In order to improve their relations with the environment, organizations must contribute towards a reduction in environmental impacts from their supply chains, by demanding improvements in their supplier's environmental performance [8]. Supplier selection and evaluation is the process of finding the

appropriate suppliers who are able to provide the buyer with the right quality products and/or services at the right price, in the right quantities and at the right time [9].

Traditionally, companies have considered factors such as price, quality, flexibility, etc. while evaluating suppliers. However, environmental pressures urge them to consider green issues. Competitive advantages associated with supply chain management philosophy can be achieved by strategic collaboration with suppliers and service providers. The success of a supply chain is highly dependent on its suppliers and, thus, the supplier selection problem has been a major research area [10].

There are various techniques for supplier selection but the few have focused on the green supplier selection. For example, Kuo et al. [11] developed an integrated green supplier selection model and used data envelopment analysis (DEA) and analytic network process (ANP). Yeh and Chuang [12] developed an optimal mathematical planning model for green partner selection which involved different objectives.

Perhaps the greatest significance of any good multi criteria procedure is that it provides a structural model to guide the decision maker through a complex decision process. Supplier selection criteria and methods will continue to be the focus in the research fields. However, there are various criteria for the supplier selection, some new criteria to reflect the whole supply chain performance should be included in the process of supplier selection [13]

Lin et al. [14] modeled a green purchasing system considered criteria like energy saving, pollution reduction etc. for green supplier selection. Mukherjee K et al [15] have enlisted different supplier selection methods along with models and techniques which deal with the selection and evaluation of suppliers. The need of including the environment related issues along with social and sustainability parameters for supplier selection has been mentioned in their research studies.

The corporates have started incorporating green sustainability criteria by including some new criteria in addition to other supplier selection criteria. There are very few companies emphasize social criteria by mandating health and safety mechanisms in supplier selection [16].

The above literature review identify that, there are limited number of studies that have addressed green concerns in supplier selection problems. There is a scope of incorporating AHP in GSS problem. Literature reveals that, CSR activities of suppliers and Safety have never been considered as the criteria for selecting the supplier along with Green Criteria. Therefore there is an urgent need to address the green supplier selection problem for Indian cement industries considering theses relevant criteria.

3. GREEN SUPPLIER SELECTION (GSS)

Sharma and Rawani [17] in their study identified criteria and sub criteria for the Green Supplier Selection process and have mentioned need for development of a suitable model for GSS in Indian cement manufacturing industries. The criteria identified in their work are given in the TABLE 1.

Table-1: Criteria and Sub Criteria for GSS

S. No.	Criteria	Sub-Criteria
1	Quality	Quality of incoming lots
		Consistency
2	Cost	Delivery cost
		Cost of quality
		Measurement and assessment cost
3	Services	Timeliness
		Personnel services
		Customer complaints
4	Green activities	Environmental norms and policy
		Environment friendly products
		ISO 140001 Certifications
5	Safety	Safety norms and policy
		OHSAS 180001 certification
		Safe business practices
6	CSR activities	Social image
		Mutual trust and ease of communication

A list of the prospective suppliers of Granulated Blast Furnace Slag (GBFS) has been prepared in consultation with the procurement experts working in ACC and Ambuja Cement limited. The procurement of Granulated Blast Furnace Slag (GBFS) in 2015 has been taken into consideration for the development and application of the Green Supplier Selection (GSS) model. The quotations were called for the supply of Granulated Blast Furnace Slag (GBFS) in this year. Seven steel manufacturing companies specializing in supplying the GBFS participated in this activity. The list of the prospective suppliers of Granulated Blast Furnace Slag (GBFS) is given in the TABLE 2.

Table-2: List of the prospective suppliers of GBFS

S. No.	Name of the suppliers
1	Steel Authority of India Limited (SAIL)
2	Tata Steel Limited (TSL)
3	Rastriya Ispat Nigam Limited (RINL)
4	Jindal Steel and Power Limited (JSPL)
5	Jindal Steel works (JSW)

6	Uttam Galva Limited (UGL)
7	Sun Flag Limited (SFL).

Above identified criteria/sub criteria and list of suppliers are used in developing a decision hierarchy for green supplier selection using AHP. Structure of the decision hierarchy contains four levels: the goal, criteria, sub-criteria and the suppliers. The goal of our problem is to select green suppliers for Indian cement manufacturing industries, which is at the first level of the hierarchy. The second and third level of the hierarchy contains six criteria and their respective sub criteria. The lowest level of the hierarchy contains the suppliers that the cement manufacturing firm wishes to evaluate. The decision hierarchy for green supplier selection is given in Fig. 1.

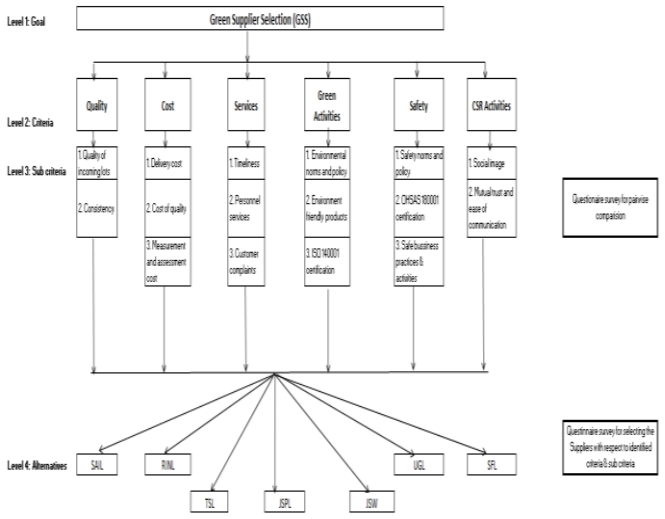

Fig-1: Decision Hierarchy for Green Supplier Selection

The quantitative data collection was done with the help of a questionnaire survey. The questionnaire for this purpose was designed to collect the pair wise judgments from all the participating respondents of cement manufacturing industries. The respondents are mainly purchase managers and from the other functions affecting the process of procurement. The summary of the respondents are given in the TABLE 3, 4 and 5.

Table 3: Statistics of Obtained Responses

Category	No. of Plants Participated	Responses obtained	Percentage of Total Responses obtained
ACC Limited	9	152	54.68 %
Ambuja Cement Limited	3	126	45.32 %
Total	**12**	**278**	**100 %**

Table 4: Respondent's Designation and Numbers

Designation	ACC Limited	Ambuja Cement Limited
General Manager	11	7
Deputy General Manager	23	13
Chief Manager/Managers	32	33
Deputy /Asst. Manager	54	46
Executives	32	27
Total	**152**	**126**

Table 5: Respondent's Experience and Numbers

Total Experience	ACC Limited	Ambuja Cement Limited
Above 21 Years	27	27
15 to 20 Years	43	33
10 to 15 Years	60	46
Below 10 years	22	20
Total	**152**	**126**

Online software tool of Prof Klaus Goepel (bpmsg.com) is used for collecting the responses and data analysis. The questionnaire was distributed in two links through mails. The first link was to conduct the pair wise comparison of the criteria and sub criteria. Once the comparison of the criteria/sub criteria is over from all the respondents, the second link were sent to the same respondents for the purpose of evaluating the suppliers. Online software tool (bpmsg.com) taken the responses from the respondents directly and analyzed them in order to find out the local and global weights of the criteria and sub criteria.

The consistency ratio (CR) was used to determine and justify the inconsistency in the pair-wise comparison made

by the respondents. Based on empirical suggestion C.R. = 0.10 is acceptable, it is concluded that the foregoing pair-wise comparisons to obtain attribute weights are reasonably consistent. In our research work the CR values were less than < 10. There was no need to repeat the comparisons. In some cases it was more and the respondents were asked to modify the responses and all such cases were modified by the respondents.

The local and the global weights are calculated by the online software based on the collected responses. The local and global weights of all the criteria/sub criteria are given in TABLE 6.

Table 6: Global priority weights of the all criteria and sub-criteria

Criteria	Local Priority	Sub Criteria	Local Priority	Global Priority
Quality	0.2433	Quality of incoming lots	0.7255	0.176
		Consistency	0.2745	0.067
Cost	0.2315	Delivery cost	0.6291	0.146
		Cost of quality	0.2158	0.05
		Measurement and assessment cost	0.1551	0.036
Services	0.0598	Timeliness	0.5836	0.035
		Personnel services	0.1849	0.011
		Customer complaints	0.2315	0.014
Green Activities	0.1544	Environmental norms and policies	0.462	0.071
		Environment friendly products	0.403	0.062
		ISO 140001 certification	0.135	0.021
Safety	0.246	Safety norms and policy	0.4173	0.103
		OHSAS 180001 certification	0.1466	0.0356
		Safe business practices and activities	0.436	0.107
CSR Activities	0.065	Social image	0.3527	0.023
		Mutual trust and ease of communication	0.6473	0.042
			Total	1.0

The consolidated result of the pair wise comparisons for sub criteria is shown in Fig. 2 as captured from the 'result screen' of the software.

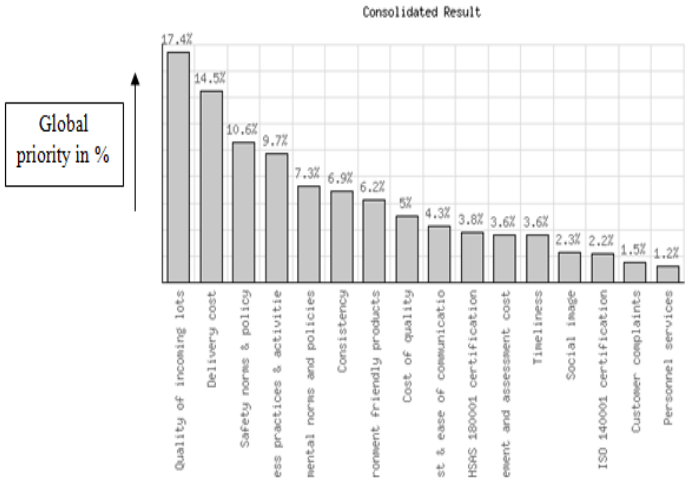

Fig-2: Consolidate results of the pair wise comparisons of sub criteria

Once priority weights of the criteria and sub criteria are calculated, the next step is evaluation of the suppliers. This is done by comparing suppliers against each other with respect to the criteria and sub criteria. As soon as comparison of criteria/sub criteria is done by all the respondents, online software tool (bpmsg.com) generates a link for supplier evaluation and selection. This link was sent to the same respondents and they were asked to do the comparison of the suppliers. The result of the supplier evaluation is given in TABLE 7.

Table 7: Summary of priority weights of each supplier

Criteria and its weights	Sub-Criteria and its weights	Global Priorities	SAIL	RINL	TSL	JSPL	JSW	UGL	SFL
Quality (0.2433)	Quality of incoming lots (0.7255)	0.176	0.0425	0.0338	0.0260	0.0212	0.02	0.0153	0.0148
	Consistency (0.2745)	0.067	0.0161	0.0125	0.0099	0.0085	0.0083	0.0069	0.0067
	Delivery cost (0.6291)	0.146	0.0343	0.0281	0.0223	0.0175	0.0169	0.0133	0.0125
Cost (0.2315)	Cost of quality (0.2158)	0.05	0.0124	0.0093	0.0077	0.0063	0.0058	0.0045	0.0043
	Measurement and assessment cost (0.1551)	0.036	0.0083	0.0067	0.0055	0.0045	0.0043	0.0034	0.0033
Service (0.0598)	Timeliness (0.5836)	0.035	0.0082	0.0066	0.0055	0.0047	0.0044	0.0035	0.0033
	Personnel services (0.1849)	0.011	0.0027	0.0021	0.0017	0.0015	0.0015	0.0012	0.0011
	Customer complaints (0.2315)	0.014	0.0034	0.0027	0.0022	0.0019	0.0017	0.0013	0.0013
Green activities (0.1544)	Environmental norms and policies (0.462)	0.071	0.0162	0.0136	0.0114	0.0093	0.0089	0.007	0.0069
	Environment friendly products (0.403)	0.062	0.0148	0.0121	0.0097	0.0076	0.0071	0.0054	0.0053
	ISO 140001 certification (0.135)	0.021	0.005	0.0040	0.0032	0.0027	0.0026	0.0020	0.0020
Safety (0.246)	Safety norms and policy (0.4173)	0.103	0.0237	0.0191	0.0154	0.0138	0.0133	0.0104	0.0102
	OHSAS 180001 certification (0.1466)	0.0356	0.0085	0.0070	0.0057	0.0049	0.0047	0.0037	0.0036
	Safe business practices and activities (0.436)	0.107	0.0220	0.0171	0.0146	0.0125	0.0119	0.0096	0.0095
CSR activities (0.065)	Social image (0.3527)	0.023	0.0050	0.004	0.0033	0.0029	0.0028	0.0023	0.0023
	Mutual trust and ease of communication (0.6473)	0.042	0.0090	0.0076	0.0063	0.0056	0.0055	0.0045	0.0043
Total		1.0	0.232	0.186	0.151	0.126	0.12	0.094	0.092

The consolidated results of the green supplier selection as captured from the 'result screen' of the online software are shown in the Fig. 3.

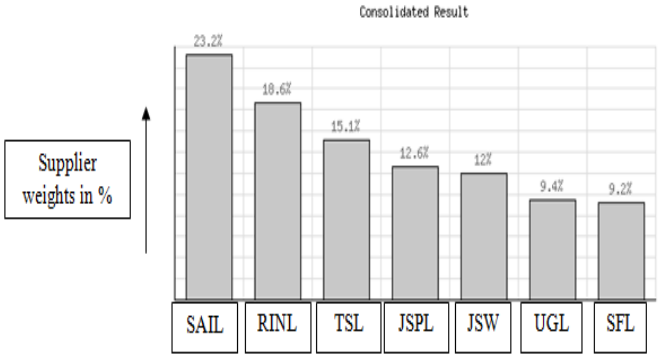

Fig-3: Consolidate results of the Green Supplier Selection

4. RESULT AND DISCUSSION

The consolidate results in Fig. 2 indicates that the top five sub criteria are the quality of incoming lots, delivery cost, safety norms and policy, safe business practices and activities and Environment norms and policy. While the Social image of the supplier and mutual trust are among the important sub criteria. The relevancy of the Green, CSR and Safety criteria in the green supplier selection process is clearly evident from the results. The results indicate that Green activities of the suppliers, Safety and CSR activities are among the important criteria during the green supplier selection. The consolidated results analysis in Fig. 3 shows that Steel Authority of India Limited is most preferred supplier of the granulated blast furnace slag, while the second important supplier is Rastriya Ispat Nigam Limited followed by Tata Steel Limited, Jindal Steel and Power Limited, Jindal Steel Works, Uttam Galva Limited, and Sun Flag Limited.

5. CONCLUSIONS

The issues of green supplier selection have attracted the interest of many researchers. This research paper has successfully achieved its objective in developing and applying the green supplier selection model for Indian cement manufacturing industries. The result of the green supplier selection provides priority scores of suppliers along with their ranking. Indian cement industries can use GSS model developed in this paper in selecting the green suppliers. The selection of suppliers using new criteria like Green activities, Safety and CSR activities of the suppliers will add new knowledge to the existing literature. As the future scope of the work, the result obtained from Green Supplier Selection could be properly validated using appropriate technique. Furthermore, technique to split order quantity in selected supplier can be evolved and optimum order allocation can be done using priority scores of the suppliers as obtained from the GSS. It is also suggested that in future other multi criteria decision making techniques such as Analytic network process should be used for

development of GSS model. Occupational health and safety has become the essential requirement for doing business in India. Few more new sub criteria may be included in the developed green supplier selection model.

REFERENCES

[1]. Dickson, G.W. 'An analysis of vendor selection systems and decisions'. Journal of Purchasing and Supply Management, 2 (1), 5–17, 1966.
[2]. Wood DJ. 'Corporate social performance revisited'. Academy of management review, 164, 691-718, 1991.
[3]. Gupta, M. 'Environmental management and its impact on the operations function'. International Journal of Operations and Production Management, 15 (8), 34–51, 1995.
[4]. Humphreys, P.K., Wong, Y.K. and Chan, F.T.S., 2003. Integrating environmental criteria into the supplier selection process. Journal of Materials Processing Technology, 138 (1–3), 349–356.
[5]. Ogden, J.A., et al. 'Supply management strategies for the future: a Delphi study'. Journal of Supply Chain Management, 41 (3), 29–48, 2005.
[6]. Gunery, A.F., Yucel, A., Ayyildiz, G. 'An integrated fuzzy-LP approach for a supplier selection problem in supply chain management'. Expert System with Application, 36, 9223–9228, 2008.
[7]. Cruz, J.M. and Matsypura, D. 'Supply chain networks with corporate social responsibility through integrated environmental decision-making'. International Journal of Production Research, 47 (3), 621–648, 2009.
[8]. Verghese, K., Lewis, H. 'Environmental innovation in industrial packaging: a supply chain approach'. International Journal of Production Research, 45 (18), 4381–4401, 2007.
[9]. Zhang, D., et al. 'A novel approach to supplier selection based on vague sets group decision'. Expert System with Applications, 36, 9557–9563, 2009.
[10]. Vahdani, B., Zandieh, M. 'Selecting suppliers using a new fuzzy multiple criteria decision model: the fuzzy balancing and ranking method. International Journal of Production Research, 48 (18), 5307–5326, 2010.
[11]. Kuo, R.J., Wang, Y.C., Tien, F.C. 'Integration of artificial neural network and MADA methods for green supplier selection'. Journal of Cleaner Production, 18 (12), 1161–1170, 2010.
[12]. Yeh W-C, Chuang M-C. 'Using multi-objective genetic algorithm for partner selection in green supply chain Problems'. Expert Systems with Applications, 38, 4244–4253, 2011.
[13]. A Hadi-Vencheh. 'A new nonlinear model for multiple criteria supplier-selection problem'. International Journal of Computer Integrated Manufacturing, 24(1), 2011, 32-39, 2011.
[14]. Lin C-T, Chen C-B, Ting Y-C. 'A Green Purchasing Model by Using ANP and LP Methods'. Journal of Testing and Evaluation, 2, 40, 2012.
[15]. Mukherjee, K., Sarkar, B. And Bhattacharyya, A. 'Supplier selection by F-compromise method: a case study of cement industry of NE India'. Int. J. Computational Systems Engineering. 1(3), 162–174, 2013.
[16]. Mani.V, Rajat Agrawal, Vinay Sharma. 'Supplier selection using social sustainability: AHP based approach in India', International Strategic management Review, 2, 98–112, 2014.
[17]. Deepesh Giri Sharma, A.M. Rawani. 'Identification of the criteria and sub criteria for the green supplier selection in Indian cement industries'. International Journal of Advanced Technology in Engineering and Science, 4(3), 278-286, 2016.

BIOGRAPHIES

Deepesh Giri Sharma is Assistant Professor in Mechanical Engineering at Central College of Engineering and Management, Raipur. He has ME in Production Engineering from BIT, Durg. He has 14 years of teaching and industrial experience in various organizations including ACC Cement Limited.

Dr. A.M. Rawani is Professor in Mechanical Engineering and Dean (Academic) at National Institute of Technology, Raipur. He has received his M.Tech. in Industrial Engineering and Management from IIT, Kharagpur and Ph.D. from I.I.T. Delhi. He has more than 29 years of teaching/research and administrative experience in Govt. Engg.Colleges /NIT.

5.