Assessing Green Suppliers using MCDM Tool

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ABSTRACT

The green supplier selection is becoming an indispensable and continuous Multiple Criteria Decision Making (MCDM) system that became a potential turf of examen for several years have gone past. Quite a lot of handling ways have earlier been forestalled by experimenters and experts to appraise sustainable suppliers. Of all the practices of MCDM, the Analytic Hierarchy Process or AHP can be the most effective approach due to its strong competence to prioritise and rank the suppliers either in terms of a strategic or sustainable environment. AHP makes it conceivable to specify the best seller in a more systematic style that has integrity and fairness. This work also highlights that a better choice of suppliers can improve the supply chain system of any business. Here few factors have been identified from the various published article to establish the assessment approach to complete the study This work has been done for infrastructural project development or construction organisation. The work will help to rank the suppliers for homogeneous supplying organizations for better implementation of a supply network.

Keywords: Analytical Hierarchy Process, Green supplier selection, MCDM, Ranking of the green supplier, Supplier selection for the green initiative

A. Introduction

Choosing an applicable supplier has a bigger impetus on supply chain management procedures. It has been seen that the entire Supply chain operation is separated into multiple functions, same as Planning, Procurement, Production, Marketing and Finance. Supply Chain Management is to bind all the functions with the torrent of information. At present, for the immeasurable globalised combative business atmosphere, an effective approach for sustainable supplier selection method is always crucial for any business enterprise as well as which will maintain the ecology and environment. The Sustainable supplier selection process is primarily aiming to lessen threats and make the most of the overall output value for the organisation simultaneously maintaining the climate and ecology as well as creating some social impact. Picking up the appropriate seller is always challenging for the purchasing person. To implement a proper and fruitful supply chain network an event of effective supplier evaluation is highly desirable. The global challenge has responded in reduced costs, upgraded sensitiveness, enhanced quality of production and finally better service towards the customers of the organisation both internally and externally. This challenge has thrown all business units to work on the aforementioned factors. In meeting this challenge, companies are forced to concentrate on their providers of materials and other associated drills, distribution paths and all other associated exercises. Sustainable Supplier selection is measured as a foremost factor of global purchasing. It has the competence to transact with both quantifiable and non-quantifiable data for making decisions. The necessity of proper supplier selection is to ensure the flow of the inputs for the production constantly, as suppliers are the inseparable resources of any enterprise. The major benefit of the supplier evaluation isn't only to defend the deficit of raw materials for production but also, it'll help to maintain the buyer-vendor bond and other business aspects.

B. Literature Review

The understanding of a greener approach, impacting how both tangible and intangible products are shaped and distributed to their clientele based on sustainability approaches are improved significantly in the past thirty years. Pointedly, the notion of the sustainable supply chain caught the attention of both academicians and industrialists as well as in both Government and non-Government institutes (Mariouli & Abouabdellah, 2019), Büyüközkan, Gülçin, 2011). Supplier selection is a critical premeditated decision. Experts argue that almost 60 per cent of the cost of production cost relies on material suppliers (Arabsheybani et al., 2018), for which the fiscal state of any enterprise can be impacted. The proper suppliers can strengthen a company's societal and monetary portfolio by lessening costs and authenticating the continual satisfaction of the customers (Zimmer et al., 2016). Organisations have to choose suitable suppliers to comprehend the competitive advantage and increase the adequacy of their organisation(Pradhan & Routroy, 2018). The upgrading knowledge of sustainability, strict administrative involvement, in addition upward civic standards has raised enterprises' responsibility in bearing in mind sustainability in several occupational units (Luthra et al., 2017). Sustainability streamlines effectualpurchase through collaborating monetary, ecological, and community attributes (Gold & Awasthi, 2015). Equally Government and non-government agencies both are participating in the sustainability practices for creating better supply chain operation network design (Jauhar & Pant, 2017). For meeting the organisational demand to achieve sustainability, electing green suppliers all along the material flow line is needed (Zimmer et al., 2016).

Suppliers show a noticeable influence for maintaining sustainability by enforcing green conditions along with societal and economic expectations (Kannan et al., 2015,Luthra et al., 2017). The economic, environmental and social dimensions are required immense attention for sustainable supplier choice (Amindoust et al., 2012,Gören, 2018,Zimmer et al., 2016). Opting for the right suppliers may be a sensitive duty for the buying decisiontakers in support of their organisation(Spekman, 1988). Supplier selection is taken into account as a number one element of worldwide purchasing. In a suitable selection practice, the demand for evolving a scientific supplier selection process of feting then ordering applicable conditions and assessing the immutability between specialized, profitable and act standards (Hassan et al., 2015). AHP could be a feted supplier selection instrument for times (Narasimhan, 1983,Nydick & Hill, 1992,Partovi et al., 1990) because it has robust competence in addressing measurable and indeterminate measures of the supplier evaluation or selection problem.

The supplier assessment method not only aids to defend any scarcity of materials for processing but also helps to maintain a healthy seller-buyer association with proper preservation of climate and ecology and the social aspects from the corporate point of view. Supplier evaluations constantly maintain a stiff and organized style supported by a comprehensive check performed in the industry (Hassan et al., 2015). A combined approach of AHP modified by rough sets proposition and MOMIP (multi-objective mixed integer programming) has been proposed to concurrently regulate the number of sellers to use along with the volume of orders allocated for supplies for the case of collaborative procurement when several goods, employing numerous conditions and with suppliers production limitations would be considered (Xia & Wu, 2007). For discount based on quantity feature to lessen the whole buying expenditure a united model of AHP and non-linear integer program was anticipated to recognize the appropriate supplier and optimum order volume determination (Kokangul & Susuz, 2009). Still, it is very much convenient that by an analytical style suppliers can be selected in a fuzzy environment and the BOCR (benefit, opportunity, cost and risk) concept can be encountered through Fuzzy AHP methodologies which will properly judge every possible aspect of suppliers. An approach based on ANN and MADA was another indicative study for supplier selection where authors integrated artificial neural networks and Multi-attribute decision analysis (Kuo et al., 2010). To restrict the failure related to the former DEA approach a fuzzy logic-based approach was proposed to eliminate decision-making unit limitations along with the advancement in supplier evaluation(Chan & Kumar, 2007).

An Analytical Network Process can assess the suppliers and the assessment will look into the associations between supplier selection criteria in a prodigious responsive mechanism (Gencer & Gürpinar, 2007). A model was proposed, where MCGP (multi-choice goal programming), AHP and Taguchi loss functions were combined for the selection of suppliers which was expected to allow the decision architects to exploit multiple goals for the selection purpose (Liao & Kao, 2010). Again there was another approach of FPCA (Fuzzy Principal Component Analysis) was proposed for the problem related to construction materials suppliers (Lam et al., 2010). The fuzzy Neural Network process was another approach that was proposed to develop a smart supplier decision network problem that allowed both qualitative and numerical factors for supplier evaluation problems (Kuo et al., 2010). To highlight optimal order quantity in the case of multiple vendor selection models were proposed to assign the number of optimum orders to the individual seller (Ahmad et al., 2020,Arunkumar et al., 2007). Another model based on the amalgamation of AHP, F-AHP and Genetic algorithms to identify the most effective supplier where non-measuring elements, as well as fuzzy components, needs to be nurtured(Kubat Cemalettin, 2006). Another approach was proposed by merging AHP with the metaheuristics process for supplier evaluation to opt better line of flow(Chakraborty et al., 2011).

C. Methodology

a) Analytical Hierarchy Process

The Analytical Hierarchy Process is one of the most widely used tools for multi-criteria decision-making problems as it can deal with all types of facts and figures. The AHP is a structured practice with a hierarchical representation for showcasing components of the issue. The AHP technique was established (Saaty, 1982, Saaty, 1990). This method can empower the decision-makers to deal with multiple complex and unstructured factors. This is the process which is focusing on a pairwise comparison matrix.

b) Structuring the hierarchy for evaluation

An order will be required to transact with a situation by the AHP method. Generally, three stages or situations will be answered by the AHP method (Saaty, T. L., & Vargas, L. G., 1991, Saaty, 1990).

- Describe an intention for concluding the challenge.
- Describe points for achieving the aim (intention).
- Fix evaluation conditions for every point.

c) Creating the pairwise comparison matrix

Subsequently configuring a grading, the pairwise comparison matrix for every step is made. For calculation in every pairwise evaluation a nominal scale will be deployed as follows (The scale of relative importance was originated by SaatySaaty, T.L. and Vargas, L.G. (2000))

Intensity of importance	Explanation
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong
9	Extreme importance
2, 4, 6, 8	For the transitional values

d) Calculation of weights of criteria and consistency inspection

In this step weights or priorities will be identified for each criterion. To move forward consistency checking should be done at each step of the calculation. For checking consistency, Consistency index (CI), Random Consistency Index (RI) and Consistency Ratio (CR) will be required.

It is at all times appreciable that the value of CR should be lesser than or equal to o.1 or 10 %, then it will consider that the matrix, as well as the result, is consistent. To finish the calculation, the Overall preference matrix will be created. Here all the weights are multiplied with the features, and then the result of multiplication between weight and elements is composed so that the composite score of each factor can be attained.

e) Identified Criteria

In this work, the parameters are primarily, selected based on a detailed literature survey and then those parameters were furthermore authenticated by the industry experts for a better outcome. The selected parameters are listed underneath:

- Cost (C1): This criterion represents the procurement cost, and taxes together.
- Quality (C2): It determines the worthiness of the product and simultaneously describes the working environment of the suppliers' organization.
- Delivery (C3): It describes the delivery policies.
- Transportation mode and cost (C4): This dealt with the decision related to logistics while considering the freight charges.
- Pollution Control (C5): This criterion will determine the ability and willingness of the supplier regarding their pollution control measures.

- Use of renewable energy (C6): This is to identify whether the suppliers are using renewable energy for their units.
- Environmental audit and certification (C7): Whether the organisationis regularly checked their procedures to maintain the environment's friendliness.
- Information sharing (C8): This criterion dealt with the transparency of the organisation.
- Health and safety of the worker (C9): It is also a considerable fact that the supplier's initiative about the measures for their employees' safety and satisfaction.
- CSR (C10): How they create the good things for the society for living better.

f) Hierarchical Approach to the Problem

Refer Figure 1.

g) Determination of the weights for individual criterion

The analysis has been done by using the Ms Excel application for creating all the pair-wise comparison matrices and consistency checking and finally obtaining the table for Composite score for identifying the ranks of the suppliers.

Step 1: Pairwise comparison matrix for identifying the priority or weightage for individual criteria.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Wt.
C1	1	0.14	0.33	3	3	3	5	3	6	5	**0.13**
C2	7	1	3	9	5	9	7	9	6	8	**0.36**
C3	3	0.33	1	1	5	3	3	1	5	3	**0.13**
C4	0.33	0.11	1	1	5	3	3	1	3	5	**0.10**
C5	0.33	0.2	0.2	0.2	1	1	1	1	1	1	**0.04**
C6	0.33	0.11	0.33	0.33	1	1	1	0.5	0.33	0.33	**0.03**
C7	0.2	0.14	0.33	0.33	1	1	1	0.2	0.33	0.25	**0.03**
C8	0.33	0.11	1	1	1	2	5	1	1	3	**0.07**
C9	0.17	0.17	0.2	0.33	1	3	3	1	1	1	**0.05**
C10	0.2	0.13	0.33	0.2	1	3	4	0.33	1	1	**0.05**

Consistency ratio =9.7 % (Less than 10%)

From the above table it is seems that the criterion Quality got the highest weightage while environmental audit and certification got the least priority in this work.

h) Determination of priorities of the suppliers based on each criterion

Step 2.1: Pairwise comparison matrix for suppliers against the criterion cost

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	0.3300	4.0000	3.0000	**0.3500**
SUPPLIER 2	3.0000	1.0000	3.0000	3.0000	**0.4109**
SUPPLIER 3	0.2500	0.3300	1.0000	1.0000	**0.1983**
SUPPLIER 4	0.3300	0.3300	1.0000	1.0000	**0.1189**

Consistency ratio=7.6 % (Less than 10%)

From the above calculation, it has been found that for the criterion cost Supplier 2 got the highest weight.

Step 2.2: Pairwise comparison matrix for suppliers against the criterion quality

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	3.0000	5.0000	3.0000	**0.5185**
SUPPLIER 2	0.3333	1.0000	2.0000	0.5000	**0.1545**
SUPPLIER 3	0.2000	0.5000	1.0000	0.3300	**0.0859**
SUPPLIER 4	0.3300	2.0000	3.0000	1.0000	**0.2411**

Consistency ratio=2.2% (Less than 10%)

From the above calculation, it has been found that for the criterion Quality Supplier 1 got the highest weight.

Step 2.3: Pairwise comparison matrix for suppliers against delivery

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	3.0000	5.0000	3.0000	**0.5409**
SUPPLIER 2	0.3300	1.0000	0.5000	0.3300	**0.1109**
SUPPLIER 3	0.2000	0.2000	1.0000	0.5000	**0.0891**
SUPPLIER 4	0.3300	3.0000	2.0000	1.0000	**0.2591**

Consistency ratio=6.5% (Less than 10%)

From the above calculation, it has been found that for the criterion cost Supplier 1 got the highest weight.

Step 2.4: Pairwise comparison matrix for suppliers against transportation mode and cost

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	9.0000	5.0000	2.0000	**0.5238**
SUPPLIER 2	0.1111	1.0000	0.3300	0.1667	**0.0487**
SUPPLIER 3	0.2000	3.0000	1.0000	0.2500	**0.1096**
SUPPLIER 4	0.5000	6.0000	4.0000	1.0000	**0.3179**

Consistency ratio=2.4% (Less than 10%)

From the above calculation, it has been found that for the criterion transportation mode and cost Supplier 1 got the highest weight.

Step 2.5: Pairwise comparison matrix for suppliers against pollution control

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	2.0000	1.0000	1.0000	**0.2734**
SUPPLIER 2	0.5000	1.0000	0.5000	0.2500	**0.1140**
SUPPLIER 3	1.0000	2.0000	1.0000	0.5000	**0.2280**
SUPPLIER 4	1.0000	4.0000	2.0000	1.0000	**0.3846**

Consistency ratio=2.2% (Less than 10%)

From the above calculation, it has been found that for the criterion pollution control Supplier 4 got the highest weight.

Step 2.6: Pairwise comparison matrix for suppliers against the use of renewable energy

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	9.0000	3.0000	3.0000	**0.5393**
SUPPLIER 2	0.1111	1.0000	0.2500	0.3300	**0.0553**
SUPPLIER 3	0.3300	4.0000	1.0000	3.0000	**0.2622**
SUPPLIER 4	0.3333	3.0000	0.3300	1.0000	**0.1432**

Consistency ratio=4.6% (Less than 10%)

From the above calculation, it has been found that for the criterion renewable energy Supplier 1 got the highest weight.

Step 2.7: Pairwise comparison matrix for suppliers against environmental audit and certification

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	2.0000	1.0000	7.0000	**0.3934**
SUPPLIER 2	0.5000	1.0000	0.5000	3.0000	**0.1884**
SUPPLIER 3	1.0000	2.0000	1.0000	4.0000	**0.3434**
SUPPLIER 4	0.1429	0.3300	0.3300	1.0000	**0.0748**

Consistency ratio=1.2% (Less than 10%)

From the above calculation, it has been found that for the criterion environmental audit and certification Supplier 1 got the highest weight.

Step 2.8: Pairwise comparison matrix for suppliers against information sharing

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	3.0000	5.0000	1.0000	**0.4160**
SUPPLIER 2	0.3333	1.0000	2.0000	0.5000	**0.1610**
SUPPLIER 3	0.2000	0.5000	1.0000	0.3300	**0.0908**
SUPPLIER 4	1.0000	2.0000	3.0000	1.0000	**0.3321**

Consistency ratio=1.2% (Less than 10%)

From the above calculation, it has been found that for the criterion information sharing Supplier 1 got the highest weight.

Step 2.9: Pairwise comparison matrix for suppliers against the health and safety of the employees

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	3.0000	5.0000	0.5000	**0.2900**
SUPPLIER 2	0.3333	1.0000	4.0000	0.1700	**0.1336**
SUPPLIER 3	0.2000	0.2500	1.0000	0.1700	**0.0590**
SUPPLIER 4	2.0000	6.0000	6.0000	1.0000	**0.5175**

Consistency ratio=7% (Less than 10%)

From the above calculation, it has been found that for the criterion health and safety Supplier 4 got the highest weight.

Step 2.10: Pairwise comparison matrix for suppliers against CSR

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4	Weight
SUPPLIER 1	1.0000	3.0000	4.0000	0.5000	**0.3147**
SUPPLIER 2	0.3300	1.0000	2.0000	0.3300	**0.1387**
SUPPLIER 3	0.2500	0.5000	1.0000	0.2000	**0.0796**
SUPPLIER 4	2.0000	3.0000	5.0000	1.0000	**0.4670**

Consistency ratio=2.1% (Less than 10%)

From the above calculation, it has been found that for the criterion CSR Supplier 4 got the highest weight.

Step 3: Composite score and ranking matrix

	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	SUPPLIER 4
C1 (0.13)	0.35	0.4109	0.1983	0.1189
C2 (0.37)	0.3321	0.2366	0.1194	0.3119
C3 (0.13)	0.364	0.2945	0.2949	0.0467
C4 (0.10)	0.518	0.0424	0.2906	0.149
C5 (0.04)	0.2764	0.4086	0.1689	0.1461
C6 (0.03)	0.518	0.0424	0.2906	0.149
C7 (0.03)	0.364	0.2945	0.2949	0.0467
C8 (0.07)	0.3321	0.2366	0.1194	0.3119
C9 (0.05)	0.3321	0.2366	0.1194	0.3119
C10 (0.05)	0.1733	0.5377	0.1462	0.1428
COMPOSITE SCORE	0.3541	0.2646	0.1838	0.2074

RANK	**1**	**2**	**4**	**3**

D. Conclusion

Green supplier selection encompasses the interface of numerous subjective aspects or measures. Conclusions are often complex and many even express inconsistency. In this study, it was detected that Quality consideration was the most important factor (priority = 0.3652) for the Supplier selection followed by Cost (priority =0.1333). From the four alternatives of suppliers, supplier1 was the most appropriate in consideration of all ten factors in this process. Unlike the traditional approach to supplier selection, AHP makes it possible to select the best supplier in a more scientific manner that preserves integrity and objectivity. The model is transparent and easy to comprehend and apply by the decision-maker. For selecting a supplier the AHP model is exclusive in its identification of various characteristics, nominal data prerequisite and nominal period utilization.

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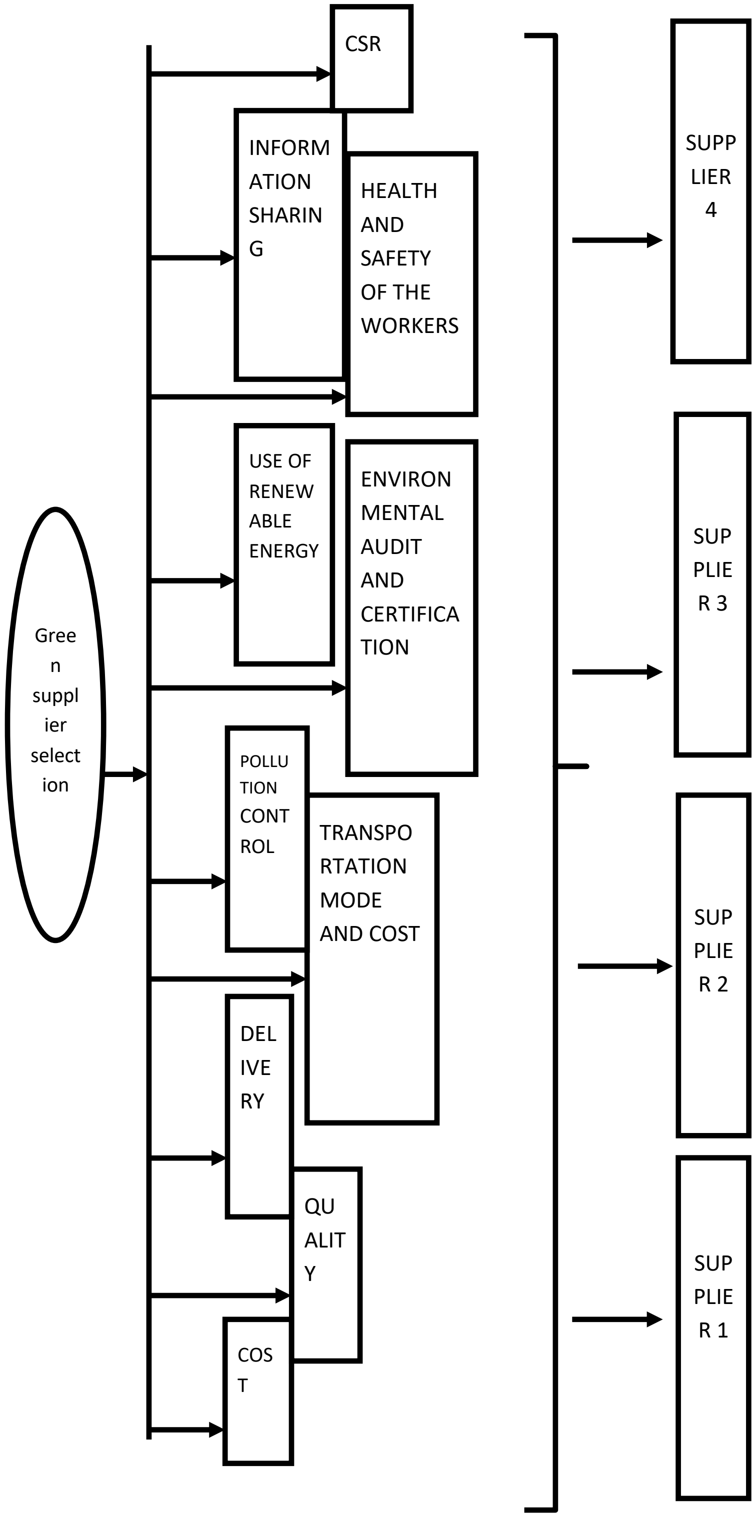

Figure 1: The hierarchical approach for supplier evaluation