GSCM Performance Evaluation of Indian Manufacturing Industry using Analytical Hierarchy Process (AHP)

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Abstract

Many manufacturers are striving to increase the productivity and sales volume, but at the same time ignoring the issue of sustainability of their organisations is to be motivated for greening their supply chain. The present study is focused upon the assessment of awareness about the GSCM. The study included a sample of manufacturing SMEs, for assessing the awareness about GSCM among the SMEs. Analytical Hierarchy Process (AHP) was used to calculate GSCM performance index. A comprehensive questionnaire was formulated and qualitative data was collected, the same was analysed. The results of the study revealed that the SMEs with higher values of GSCM performance index have a higher awareness level of GSCM practices.

Keywords - GSCM-Green supply chain Management, SMEs-Small and medium enterprises, AHP-Analytical Hierarchy Process, GPI-Green performance Index.

Introduction

The GSCM has played a key role in advancing cleaner production in manufacturing industry. Many manufacturers which utilize environmental regulatory compliance tend to advance GSCM by screening suppliers for their environmental performance and then by doing business with only those who meet the environmental regulations. With the implementation of GSCM, manufacturers anticipate benefits such as improvement of a corporation's image, reduction of liability and improvement of business continuity and to take a competitive position in the market.

Literature

An environmentally conscious supply chain, also called a green supply chain, is a new concept appearing in recent literatures. Although this environmental issue has been realized very important for business, its introduction to supply chain management has only been developed recently. The literature about environmentally conscious supply chain is very limited."Sustainable Development" was the key concept of the Earth Summit (1992& 2012) at Rio de Janeiro, Brazil where the governments of various nations and international organizations committed themselves to take action to protect the environment as in integral part of long-term sustainable economic development. Environmentally-responsible production is seen as an essential part of the strategy to improve environmental quality, reduce poverty and bring about economic growth, with resultant improvements in health, working conditions, and sustainability. In particular, organizations were called upon to exercise leadership in the promotion of environmentally sound goods and services. Qinghua *et al.* (2004; 2006) studied Green supply chain management: pressures, practices and performance within the Chinese automobile industry in which they observed that increasing pressures from a variety of directions have caused the Chinese automobile supply chain managers to consider and initiate implementation of green supply chain management (GSCM) practices to improve both their economic and environmental performance. Expanding on some earlier work investigating general GSCM practices in China, authors explores the GSCM pressures/drivers (motivators), initiatives and performance of the automotive supply chain using an empirical analysis of 89 automotive enterprises within China. Hsu *et al*. (2008) studied the Green supply chain management in the electronic industry in which they mentioned various approaches for implementing green supply chain management practices. Authors used the fuzzy analytic hierarchy process method to prioritize the relative importance of four dimensions and twenty approaches among nine enterprises in electronic industry. The findings indicate that these enterprises would emphasize on supplier management performance as a crucial role of implementing green supply chain management. Fengfei (2009) studied on the Implementation of Green Supply Chain Management in Textile industry in which the Green supply chain management is a sort of modern management tool, comprehensively consider the environmental influence and resource utilization efficiency in the whole supply chain and implement it in special industrial operations. In another study, Ninlawan *et al*. (2012) works on the Implementation of Green Supply Chain Management Practices in Electronics Industry in which they aims to survey the current green activities in computer parts' manufacturers in Thailand in order to evaluate Green supply chain, 11 manufacturers provided in-depth interview about green procurement, green manufacturing, green distribution, and reverse logistics. To evaluate green supply chain management, the questionnaire related to investigate GSCM practices, measure GSCM performance, and explore GSCM pressure/ driver within Thai electronics industry is used to obtain survey results and to develop GSCM practices in electronic industry. Benjamin *et al*. (2010) introduced Green Transportation Costs in Supply Chain Modeling in which they thinks that escalating environmental concerns with prevalent transportation modes has lead to an increased interest in the adoption of green /sustainable practices in supply chain management. As a part of green supply chain strategy, the amount of carbon emissions resulting from the transportation element of a supply chain is a growing concern for supply chain managers and the authors tries to review methods for quantifying carbon emissions and estimating the cost of going green in supply chain optimization.

Green performance index (GPI)

Green performance Index (GPI) is a direct measure of the negative environmental impact based on Performance assessment. It expresses the total environmental load of a product or process. For industrial sectors without their own environmental monitoring systems, the Green performance Index (GPI) can be useful for working out where there is a need for action in environmental policy making and its management. Each indicator can be linked to well-established policy targets. The GPI relies on 33 indicators that capture the best possible data.

Green performance Index (GPI) gives you an in-depth sector-wise ranking of Indian manufacturing industries through the various performance indicators based on which ranking has been given. GPI is a comparative analysis of environmental achievements, challenges and priorities among Indian manufacturing sectors. So based on the cost and profit, factors responsible for green supply chain profitability were derived. Using these factors a Green performance index (GPI) was developed. This index is useful to evaluate the sustainable performance of the organisation based upon these green factors in supply chain. GPI also indicate the status of sustainability among the various manufacturing sectors. It helps to indicate the factors where the industries lack in implementation of GSCM practices. The comparison among various SMEs in manufacturing was done w.r.t their GSCM performance and practices. It can compare the GSCM performance with any other sector like textile; electronics;

automobile etc Thus, an in-depth analysis was done through GPI and also indicate the driving/lagging factors in a particular industrial sector or organisation.

Table 1: Green performance index (GPI).

Index	Objectives (Level 0)	Indicators (Level 1)	Sub–indicators (Level 2)
Green Performance index (GPI)	Green sourcing & Procurement.	(A1) Substitute for hazardous materials	(A11) Employ eco-design and eco-friendly product lifecycle management in sourcing strategy
		(A2) Improved quality & Minimal usage of raw material	(A21) Use of electronic processes/state of art machinery for higher efficiencies
		(A3) Supplier development	(A31) Embed "sustainability" into supplier relationships (A32) Work with suppliers on green SCM guidelines (A33) Audit suppliers for green SCM compliance
		(A4) Reduced resource consumption	(A41) Reduce use of paper/e-procurement (A42) Localised sourcing for JIT (A43) others
	(B) Green production & manufacturing	(B1) Process design	(B11) Recycling programs for raw materials (B12) Recycling programs for reusable components parts (B13) Implementing ongoing assessment to measure and ensure Green SCM compliance (B14) Reducing carbon emissions in manufacturing processes/Cleaner development mechanisms
		(B2) Product design	(B21) Include recycling in new product design (B22) Increase product robustness in product design (B14) Reducing carbon emissions in manufacturing processes/Cleaner development mechanisms
		(B3)Increased efficiency	(B31) Measuring your company's carbon footprint (B32) replacing outdated processes, methods (B33) utilization of fuel efficient tools & machinery (B34) Other

	Green sourcing & Procurement.	(B4) Employee satisfaction	(B41) Improved Labour management/eco-trainings
	(C) Green warehousing	(C1) Reduction of energy consumption	(C11) Reducing energy consumption through solar panels and green roofing options etc. (C12) Reducing inventory and handling of product
	(D) Green distribution	(D1) Distribution considerations	(D11) Optimizing location of distribution hubs (D12) Using reusable containers /storage equipment (D13) Implementing order consolidation (decreasing unused space on trucks)
	(E) Green packaging	(E1) packaging material selection and reduce consumption	(E11) Selection of recyclable packaging materials (E12) Reduction in packaging materials
	(F) Green transportation	(F1) Alternative fuels	(F11) Replacing diesel-powered trucks with alternatives fuels (F12) Switching to more fuel efficient modes like shipping or railways
		(F2) Logistics optimization	(F21) Reducing expedited shipping (reducing air freight) (F22) Route optimization(reducing empty miles) (F23) Reducing truck idle time
		(F3) Vehicle maintenance	(F31) Periodical Services of the vehicles at service stations/Timely replacement and repair of spare parts
		(F4) Optimised truck load	(F41) Increasing cube utilization/capacity utilization
		(F5) Employee satisfaction	(F51) Improved labour management/ environment trainings
		(F6) Longer life of vehicles	(F61) Migration to more aerodynamic trucks/avoid overloading

Above index indicates the mapping of GSCM objectives and describes various level of performance. Analytic Hierarchy Process (AHP) is an analytical approach was developed by Saaty (1990) and was originally applied to uncertain problems that involved multiple indicators. The procedure has been widely used in solving problems involving ranking, selection and evaluation. Steps in Analytic Hierarchy Analysis process:

1. Define the decision elements: goal of the decision, the options, and the criteria for determining how well the options meet the goal.
2. Construct decision model.
3. Decompose the decision into smaller parts.
4. Compare importance of criteria in achieving goal. Compare alternatives' abilities to meet the criteria.
5. Make decision or refine the analysis.

Generally, AHP separates complex decision-making problems into elements within a simplified hierarchical system. After constructing AHP model, the next step is to calculate the weight for the indicators and their respective sub – indicators. Various steps to calculate weight are as follows:-

STEP 1- Pair-Wise Comparison

It is observed that the number of comparisons is a combination of the number of things to be compared. Since there are 6 objectives (Green sourcing & procurement, Green production & manufacturing, Green warehousing, Green distribution, Green packaging, Green transportation) thus, there are 15 comparisons. Table below shows the number of comparisons. The scaling is not necessary 1 to 9 but for qualitative data such as preference, ranking and subjective opinions, it is necessary to use scale 1 to 9.

Number of things	1	2	3	4	5	6	7	n
Number of comparisons	0	1	3	6	10	15	21	$\frac{n(n-1)}{2}$

For example of pair 1 is in between (A) Green sourcing & procurement & (B) Green production & manufacturing. Likewise between A&C, A&D, A&E, A&F, B &C, B&D, B&E, B&F, C&D, C&E, C&F, D&E, D&F and E&F. A basic, but very reasonable, assumption is that if attribute A is absolutely more important than attribute B and is rated at 9, then B must be absolutely less important than A and is valued at 1/9. These pair wise comparisons are carried out for all factors to be considered, usually not more than 7, and the matrix is completed. The matrix is of a very particular form which neatly supports the calculations (Saaty, 1990).

Table 2: Rating scale for response.

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience & judgment slightly favour one over the other
5	Much more important	Experience & judgment strongly favour one over the other
7	Very much more important	Experience & judgment very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2,4,6.8	Intermediate values	When compromise is needed

STEP 2 – Making Comparison Matrix

After making paired comparisons in this step, a reciprocal matrix from pair wise comparisons is prepared. In this problem there are six objectives to be compared and the subjective judgment on which objectives is best, like the following by the importance 15 pair wise comparisons are done above. Now, 6 by 6 matrix from the 15 above comparisons is prepared. The diagonal elements of the matrix are always one and need to fill up the upper triangular matrix only.

Table 3: Intensity of importance for various pairs.

No of Pair	Objectives (Left side)	Intensity of importance	Objective (Right side)	No of Pair	Objectives (Left side)	Intensity of importance	Objective (Right side)
Pair 1	A	1	B	Pair 9	B	1	F
Pair 2	A	5	C	Pair 10	C	1	D
Pair 3	A	1	D	Pair 11	C	3	E
Pair 4	A	3	E	Pair 12	C	5	F
Pair 5	A	1	F	Pair 13	D	5	E
Pair 6	B	5	C	Pair 14	D	1	F
Pair 7	B	3	D	Pair 15	E	1/5	F
Pair 8	B	5	E				

There are certain rules to fill up the upper triangular matrix:

1. If the judgment value is on the left side of 1, put the actual judgment value.
2. If the judgment value is on the right side of 1, put the reciprocal value.

Comparing A and B, we assumed both are equally important objective, thus put 1 in the row 1 column 2 of the matrix. Comparing A and C, it is assumed much more important objective A, thus , put 5 in the row 1 Column 3 of the matrix .Comparing A & D, it is assumed both are equally important objectives, thus put 1 in the row 1 column 4 of the matrix 1 Comparing A & E, it is assumed slightly more important objective A , thus put 3 in the row 1 column 5 of the matrix. Comparing A & F, it is assumed both are equally important objective, thus put 1 in the row 1 column 6 of the matrix .

Comparing B & C ,it is assumed much more important objective B , thus we put 5 in the row 2 column 3 of the matrix .Comparing B & D , assumed Somewhat more important objective B , thus put 3 in the row 2 column 4 of the matrix 1 Comparing B & E , assumed Much more important objective B , thus put 5 in the row 2 column 5 of the matrix. Comparing B & F, assumed both are equally important objective , thus put 1 in the row2 column 6 of the matrix.

Comparing C & D , assumed both are equally important objective , thus put 1 in the row 3 column 4 of the matrix. Comparing C & E , assumed slightly favour objective C, 1 thus put 3 in the row 3column 5 of the matrix. Comparing C & F, assumed Much more important objective C, thus put 5 in the row 3 column 6 of the matrix .

Comparing D & E, assumed Much more important objective D, thus put 5 in the row 4 column 5 of the matrix .Comparing D & F, assumed both are equally important objective, thus put 1 in the row 4 column 6 of the matrix .Comparing E & F, assumed Much more important objective F, thus put 1/5 in the row 5 column 6 of the matrix.

To fill the lower triangular matrix, use the reciprocal values of the upper diagonal. If a_{ij} is the element of row i column j of the matrix, then the lower diagonal is filled using this formula; $a_{ji} = 1/a_{ij}$.

Now, the complete comparison matrix is:

$$\textbf{Green Supply Chain management (GSCM)} = \begin{array}{c} \\ A \\ B \\ C \\ D \\ E \\ F \end{array} \begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{bmatrix} 1 & 1 & 5 & 1 & 3 & 1 \\ 1 & 1 & 5 & 3 & 5 & 1 \\ 1/5 & 1/5 & 1 & 1 & 3 & 5 \\ 1 & 1/3 & 1 & 1 & 5 & 1 \\ 1/3 & 1/5 & 1/3 & 1/5 & 1 & 1/5 \\ 1 & 1 & 1/5 & 1 & 5 & 1 \end{bmatrix} \end{array}$$

Notice that the entire element in the comparison matrix are positive, or . ($a_{ij} > 0$)

STEP 3 – Priority Vector

Next step is how to use this matrix. There is 6 by 6 reciprocal matrix from paired comparison and the sum of each column of the reciprocal matrix is to be done.

$$\textbf{Green Supply Chain management (GSCM)} = \begin{array}{c} \\ A \\ B \\ C \\ D \\ E \\ F \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{bmatrix} 1 & 1 & 5 & 1 & 3 & 1 \\ 1 & 1 & 5 & 3 & 5 & 1 \\ 1/5 & 1/5 & 1 & 1 & 3 & 5 \\ 1 & 1/3 & 1 & 1 & 5 & 1 \\ 1/3 & 1/5 & 1/3 & 1/5 & 1 & 1/5 \\ 1 & 1 & 1/5 & 1 & 5 & 1 \end{bmatrix} \\ \begin{array}{cccccc} 4.53 & 3.73 & 12.53 & 7.2 & 22 & 9.2 \end{array} \end{array}$$

Then, divide each element of the matrix with the sum of its column, it has normalized relative weight and consequently the sum of each column is one.

Table 4: Normalized Relative Weights for various Criteria.

Criteria	A	B	C	D	E	F
A	0.22075055	0.26809651	0.3990423	0.13888889	0.13636364	0.10869565
B	0.22075055	0.26809651	0.3990423	0.41666667	0.22727273	0.10869565
C	0.04415011	0.0536193	0.07980846	0.13888889	0.13636364	0.54347826
D	0.22075055	0.08847185	0.07980846	0.13888889	0.22727273	0.10869565
E	0.07284768	0.0536193	0.02633679	0.02777778	0.04545455	0.02173913
F	0.22075055	0.26809651	0.01596169	0.13888889	0.22727273	0.10869565
	1	**1**	**1**	**1**	**1**	**1**

The normalized principal Eigen vector can be obtained by averaging across the rows.

$$GSCM = \frac{1}{6}\begin{bmatrix} 1.27183754 \\ 1.64052441 \\ 0.99630866 \\ 0.86388813 \\ 0.24777523 \\ 0.97966603 \end{bmatrix} = \begin{bmatrix} 0.211973 \\ 0.273421 \\ 0.166051 \\ 0.143981 \\ 0.041296 \\ 0.163278 \end{bmatrix}$$

The normalized principal Eigen vector is also called priority vector. Since it is normalized, the sum of all elements in priority vector is 1. The priority vector shows relative weights among the things that are compared. In our example above objective, A is 21.19%, B is 27.34%, C is 16.60%, D is 14.39%, E is 4.12 %, and F is 16.32 %. Thus, most preferable objective is B, followed by Objectives A, C, F, D, and E.

The relative weight is a ratio scale that we can divide among them. It is observed that GSCM relies on objective B ,1.29 (=27.34/21.19) times more than objective A; objective B, 1.65 (=27.34/16.60) times more than objective C; objective B, 1.89 (= 27.34/14.39) times more than objective D; objective B, 6.62 (=27.34/4.13) times more than objective E and objective B, 1.67 (=27.34/16.32) times more than objective F.

Aside from the relative weight, we can also check the consistency. For that, Principal Eigen value is obtained from the summation of products between each element of Eigen vector and the sum of columns of the reciprocal matrix.

$$\lambda_{max} = \frac{1}{A11} * 1.27183754 + \frac{1}{B22} * 1.64052441 + \frac{1}{C33} * 0.99630866 + \frac{1}{D44} * 0.86388813 + \frac{1}{E55} * 0.24777523 + \frac{1}{F66} * 0.97966603 = 6.093644$$

STEP 4 – Consistency Index and Consistency Ratio

Saaty (1990) had proved that for consistent reciprocal matrix, the largest Eigen value is equal to the size of comparison matrix, or $\lambda_{max} = n$. Then he gave a measure of consistency, called Consistency Index as deviation or degree of consistency using the following formula $CI = \frac{\lambda_{max}-n}{n-1}$ Knowing the Consistency Index, the next question is how do we use this index? Again, the author proposed that we use this index by comparing it with the appropriate one. The appropriate Consistency index is called Random Consistency Index (RI).He randomly generated reciprocal matrix using scale 1/9,1/8,1/7,1/6 ....1 , 2,3, ...8,9. And get the random consistency index to see if it is about 10% or less. The average random consistency index of sample size 500 matrices is shown in the Table 5.

$$CI = \frac{\lambda_{max}-n}{n-1} = \frac{6.093644- 6}{6-1} = 0.0187288, \text{ where n=6 number of comparison matrix}$$

Table 5: Random Consistency Index (RI).

n	1 2	3	4	5	6	7	8	9	10
RI	0 0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Then, the author defined Consistency Ratio, which is a comparison between Consistency Index and Random Consistency Index, or in formulae , $CR = \frac{CI}{RI}$. If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment. For n= 6, RI = 1.24, thus $CR = \frac{0.0187288}{1.24} = 0.01510387 = 1.51\ \% < 10\%$

Thus, green supply chain subjective evaluation about his measurement of performance objective preference is consistent. So far, in AHP we are only dealing with paired comparison of criteria of Level 1 only. In the final analysis this formula was utilized in order to check the consistency of the survey results using all levels of AHP.

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Table 6: Paired comparison matrix level 1 with respect to the goal i.e. green supply chain measurement of performance as an objective.

Criteria	A	B	C	D	E	F	Priority Vector
A	1	1	5	1	3	1	21.19729%
B	1	1	5	3	5	1	27.34207 %
C	0.2	0.2	1	1	3	5	16.60514%
D	1	0.33	1	1	5	1	14.39814 %
E	0.33	0.2	0.33	0.2	1	0.2	4.129587 %
F	1	1	0.2	1	5	1	16.32777%
Sum	4.53	3.73	12.53	7.2	22	9.2	100.00 %

λ_{max}=6.093644, CI = 0.0187288 , CR=0.01510387=1.51 %<10% (acceptable)

Now there are several comparison matrices at level 2. These comparison matrices are made for each choice, with respect to each factor.

Table 7: Paired comparison matrix level 2 with respect to objective A.

Criteria	A1	A2	A3	A4	Priority Vector
A1	1	5	1/3	1/5	24.12103 %
A2	1/5	1	5	7	38.85992 %
A3	3	1/5	1	3	19.38689 %
A4	5	1/7	1/3	1	17.63216 %
Sum	9.2	6.342857	6.666667	11.2	100.00 %

λ_{max} = 4.051225, CI = 0.017075, For n = 4, RI = 0.9, CR = 0.0189722 = 1.9 % < 10% (acceptable)

Table 8: Paired comparison matrix level 2 with respect to objective B.

Criteria	B1	B2	B3	B4	Priority Vector
B1	1	5	0.142857	0.2	22.58258 %
B2	0.2	1	7	3	33.06542 %
B3	7	0.142857	1	0.142857	16.28236 %
B4	5	0.333333	7	1	28.06964 %
Sum	13.2	6.47619	15.14286	4.342857	100.00 %

λ_{max} = 4.086918, CI = 0.0289726, For n = 4, RI = 0.9, CR = 0.0321918 = 3.2 % < 10% (acceptable)

λ_{max} = 6.0635658, CI = 0.01271316, For n = 6, RI = 1.24, CR = 0.0102525 = 1.03 % < 10% (acceptable)

Table 9: Paired comparison matrix level 2 with respect to objective F.

Criteria	F1	F2	F3	F4	F5	F6	Priority Vector
F1	1	7	0.333333	0.2	0.333333	0.142857	9.038413 %
F2	0.142857	1	0.333333	0.142857	3	1	8.262457 %
F3	3	3	1	0.333333	5	0.333333	15.74644 %
F4	5	7	3	1	0.333333	5	31.27095 %
F5	3	0.333333	0.2	3	1	0.333333	15.6041 %
F6	7	1	3	0.2	3	1	20.07763 %
Sum	19.14286	19.33333	7.866667	4.87619	12.66667	7.809524	100.00 %

λ_{max} = 4.086918, CI = 0.0289726, For n = 4, RI = 0.9, CR = 0.0321918 = 3.2 % < 10% (acceptable)

λ_{max} = 6.0635658, CI = 0.01271316, For n = 6, RI = 1.24, CR = 0.0102525 = 1.03 % < 10% (acceptable)

Table 10: Calculated Weights of the Various Indicators & their Sub-Indicators.

Index	Objectives (Level 0)	Indicators (Level1)	Sub–indicators (Level 2)
Green Performance index (GPI)	**(A) Green Sourcing and Procurement [0.2197]**	(A1) Substitute for hazardous material [0.5113%]	✓ (A11) Employ eco-design and eco –friendly product lifecycle management in sourcing strategy [0.5113%]
		(A2) Improved quality & Minimal usage of raw material [0.8237%]	✓ (A21) Use of electronic processes/New technologies for higher efficiencies [0.8237%]
		(A3) Supplier development [0.4109%]	✓ (A31) Embed "sustainability" into supplier relationships [0.1370%] ✓ (A32) Work with suppliers on green SCM guidelines [0.1370%] ✓ (A33) Audit suppliers for green SCM compliance [0.1370%]
		(A4) Reduced resource consumption [0.3775%]	✓ (A41) Reduce use of paper [0.1258%] ✓ (A42) Localised sourcing for JIT [0.1258%] ✓ (A43) Others [0.1258%]

Green Performance index (GPI)	**(B) Green production & manufacturing** **[0.2734%]**	(B1) Process design [0.6174%]	✔ (B11) Recycling programs for raw materials [0.154%] ✔ (B12) Recycling programs for reusable components parts [0.154%] ✔ (B13) Implementing ongoing assessment to measure and ensure Green SCM compliance [0.154%] ✔ (B14) Reducing Carbon emissions in manufacturing processes [0.154%]
		(B2) Product design [0.9041%]	✔ (B21) Including recycling in new product design [0.452%] ✔ (B22) Increasing product robustness in product design [0.452%]
		(B3) Higher efficiency [0.4452%]	✔ (B31) Measuring your company's carbon footprint [0.148%] ✔ (B32) Applying carbon off-setting [0.148%] ✔ (B33) utilization of fuel efficient tools & machines [0.148%] ✔ (B34) Other [0.148%]
		(B4) Employee satisfaction [0.7675%]	✔ (B41) Improved Labour management/Eco-trainings [0.7675%]
	(C) Green warehousing [0.1660%]	(C1) Reduction of energy consumption [0. 1660 %]	✔ (C11) Reducing energy consumption through solar panels and green roofing options [0. 8302 %] ✔ (C12) Reducing inventory and handling of product [0. 8302 %]
	(D) Green distribution [0.1440%]	(D1)Distribution considerations [0.1440 %]	✔ (D11) Optimizing location of distribution hubs [0.4799 %] ✔ (D12) Using reusable containers /storage equipment [0.4799 %] ✔ (D13) Implementing order consolidation (decreasing unused space on trucks) [0.4799 %]
	(E) Green packaging [0.4129%]	(E1) packaging material selection and reduce consumption [0.4129%]	✔ (E11) Selection of recyclable packaging materials [0.2065 %] ✔ (E12) Reduction in packaging materials [0.2065 %]

Green Performance index (GPI)	(F) Green transportation [0.1632%]	(F1)Alternative fuels [0.147 %]	✔ (F11) Replacing diesel-powered trucks with alternatives flues [0.7378 %] ✔ (F12) Switching to more fuel efficient modes like boat or rail [0.7378 %]
		(F2) Logistics optimization [0.1349 %]	✔ (F21) Reducing expedited shipping (reducing air freight) [0.4497 %] ✔ (F22) Route optimization (reducing empty miles) [0.4497 %] ✔ (F23) Reducing truck idle time [0.4497 %]
		(F3) Vehicle maintenance [0.2571%]	✔ (F31) Periodically Services of the vehicles at service stations [0.2571 %]
		(F4) Optimised truck load [0.5106 %]	✔ (F41) Increasing cube utilization [0.5106 %]
		(F5) Employee satisfaction [0.2548 %]	✔ (F51) Improved labour management [0.2548 %]
		(F6) Longer life of vehicles [0.3278 %]	✔ (F61) Migration to more aerodynamic trucks [0.3278 %]

Results and Conclusions

As discussed above the weights were calculated for each objective using AHP approach & also finds out the weights for their indicators & various sub-indicator's separately by conducting a special purpose survey based upon the AHP methodology which was supported by various Institute Professors , Researchers , Consultants, managers etc through personal interviews. After the weight calculation the aim was to find out the performance of the manufacturing sectors. Then, the calculation of the scores of the all the industries individually w.r.t their responses was carried out. Although there are no clear normative benchmarks or thresholds for 'good' performance on many of the indicators, scores on each indicator can be ranked from 'best' to 'worst'. The index is constructed on this relative variation within the dataset thus, providing a comparative benchmark for GSCM evaluation in Indian Manufacturing SMEs.

Higher GPI for manufacturing sectors/Industries indicates it has the benefit of better environmental quality and/or policy thus creating the potential to improve its environment in the future. Lower GPI for manufacturing sectors/Industries is an indication of challenges in sustainable development due to higher pollution and degradation and more stress on the ecosystems.

By generating five peer groups of manufacturing sectors/Industries have a better basis for benchmarking their environmental performance in comparison to each other and provides the data for sustainability with respect to GSCM practices, evaluation and implementation. The following below [Table12] shows the sustainability classes/ranges for manufacturing sectors/Industries and Figure1 shows the relative green performance of each cluster across the 6 objectives, 17 indicators & 33 Sub-indicators.

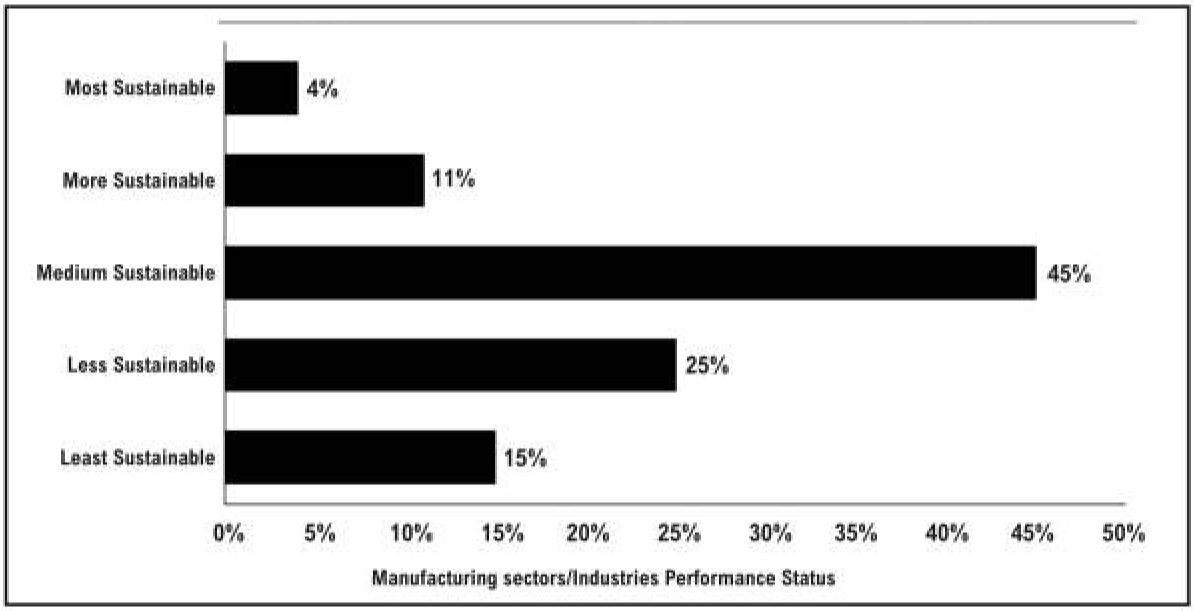

Figure 1: Manufacturing sectors/Industries sustainability Performance Status in supply chain.

Table 12: Summarized Sustainability Range Groups.

Range of GPI Scores Rating	Manufacturing sectors/Industries	Comments
0.00 – 2.00	Least Sustainable	Manufacturing sectors/Industries which face maximum challenge/threat in maintaining their environmental performance in years to come
2.01 - 4.00	Less Sustainable	Manufacturing sectors/Industries likely to experience increasing environmental problems unless appropriate actions taken
4.01 – 6.00	Medium Sustainable	Moderately sustainable manufacturing sectors/Industries
6.01 – 8.00	More Sustainable	Manufacturing sectors/Industries with potential to maintain their environment
8.01 – 10	Most Sustainable	Manufacturing sectors/Industries that are most likely to remain sustainable

Overall Status of GSCM performance of manufacturing SMEs of India

1. 15% out of 114 respondent industries lies in the lagging category towards the sustainability capability.

2. 25% manufacturing industries i.e. ¼ ratio lies slightly above the lagging sectors category towards the sustainability capability in GSCM
3. 45 % industries i.e. nearly half the ratio falls in the middle range category towards the sustainability capability
4. Results of 11 % industries shows slightly better than the middle range category towards the sustainability performance in GSCM implementation
5. It is observed that only 4 % manufacturing SMEs lies in the leading category towards the sustainability capability

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