Identifying the Success Factors of Green Supply Chain Management in Indian Manufacturing SMEs and Prioritizing using fuzzy AHP

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***Abstract*— Green issues are arises continuously so that they requires a continuous study to understand the problems because this problems are affected to organizational supply chain.so that new idea has generated for conservation of environment and natural resources is known as GSCM. Manufacturers are recently focuses on GSCM due to pressure from the government and environmental knowledge among the customers. In this paper fuzzy analytical hierarchy process (Fuzzy AHP) is used for the selection and prioritization of success factors of GSCM. Because these type of various MCDM tools has been widely used by academicians, researchers and practitioners. By this method we can remove the vagueness of judgments of decision makers. Here fuzzy logic is to be used for pairwise comparison. The purpose of this paper is to identify the current literature base Success factors for GSCM Implementation and also this paper prioritize the success factors of GSCM in Indian manufacturing SMEs**

***Keywords*— Green supply chain management (GSCM), success factors of GSCM, Fuzzy AHP**

I. INTRODUCTION

From the past decade we have seen that environmental degradation worldwide and no. of environmental problems are arises continuously. From which some of the problems (i.e. air, water, soil etc.) are generated by various industries.so that these problems are affected to organizational supply chain either externally or internally. So that these problems requires a continuous study to understand the problems. As a result of that simultaneously, new idea has generated for conservation of environmental quality due to limited resources and increasing population, is known as green supply chain management (GSCM). The word "supply chain management" was first introduced by Oliver & Webber in the early 1980s.according to them SCM has known as a "process of converting raw materials into useful final products which will then be transferred to the end users."

SCM has become more critical in today's globalization in which green issues & sustainability have become an important element in business practices. Due to global competition, enterprises are continuously looking for strategies to improve their supply chain systems for improving quality, productivity and sustainability.

Eliminating the ill effects caused by the industries by their traditional supply chain management practices is one of the major objectives of all the nations and environmental regulatory bodies.one of the best and most effective ways to achieve this objective is by integrating the traditional supply chain practices with environmental friendly practices, which results in a novel concept named green supply chain management (Gandhi et al., 2015).

What is GSCM?

• GSCM is an integrative environmental thinking into supply chain management from product design to the delivery of the final product to the consumers and also involves end of life management after its useful life (Chin et al., 2015).

• GSCM= Green Purchasing + Green Manufacturing/Material Management + Green Distribution/Marketing + Reverse Logistics.

Why GSCM is required?

The government gives pressure on manufacturer to improve quality of life of their citizen. Manufacturing sectors consumes lots of energy & other resources and emits large amount of greenhouse gases which arises environmental problems like global warming, climate change etc. so that for solution of this problem GSCM is required.(Kumar et al., 2012).GSCM is useful for improving competitive advantage, performance of organization and company brand image.

It is require for minimization of natural resources, global warming and waste management issues (Raja et al., 2015).A successful implementation of GSCM is important to increase economic environmental performances and to ensure sustainability(Gandhi et al., 2015). It is require for fulfilment of requirement of the environmental regulations and customer demand. (Mithiyazhagan et al., 2015).GSCM has gained special attention of many industries are now interested in adopting brand image, capturing more market share & to win trust of the customer (Sharma et al., 2017).

Difference between Traditional Supply Chain & Green Supply Chain Management

Traditional supply chain is defined as an integrating philosophy of the total flow of distribution channel from the point of origin to the point of consumption. So that in traditional supply chain only supply the material to the end user.

All parties involves directly or indirectly in fulfilling a customer request is known as traditional supply chain. (Ref. Supply chain management by Sunil Chopra).

While green supply chain management is defined as an environmental thinking into supply chain management including product design, manufacturing processes, delivery of the final product to the customers and end of life management after its useful life (chin et al., 2015).
GSCM is useful for improving the performance of organization and company brand image.
In this paper proposes extended fuzzy AHP method based on the combination of the fuzzy AHP and triangular fuzzy number for ranking the success factors of GSCM implementation. The significance level of criteria has been determined by using the fuzzy AHP method. In this proposed method the weights of the success factors are derived from the triangular fuzzy number. Thus the proposed method allows a more reasonable solution of the decision making process and reflects the thinking style of human. Fuzzy AHP is the most popular and validated method for finding weight. Fuzzy set theory is to be used for remove the vagueness in uncertain environments and subjectivity of the human judgment process.
The reset of this paper is organized as follows.
Section 2 presents brief literature reviews on success factors of GSCM implementation in Indian small and medium scale manufacturing industries. Empirical study is conducted and described in section 4.futhermore discussion is described in section 5.finally conclusions are presented in section 6.

II LITERATURE REVIEW OF THE ENABLERS OF ERP IMPLEMENTATION IN INDIAN INDUSTRIES.

TABLE I: Summary of literature review

Main criteria	**Criteria code**	**Sub criteria**	**References**
Environmental perspectives	E1	Eco labelling	Ghazila et al.,2015
	E2	Pollution control	Gruels et al.,2015
	E3	Waste reduction	**Tyagi et al.,2015**
	E4	Reduction of hazardous waste	Tseng et al.,2012
	E5	Environmental friendly materials	Gruel et al.,2015
In-house development factors	ID1	Training of employees	Ghazila et al.,2015
	ID2	Top management commitment	Gandhi et al.,2015
	ID3	Adoption of clean technology	Mittal et al.,2015
	ID4	Environmental management	Sharma et al.,2015
	ID5	Training of suppliers	Ghazila et al.,2015
Green practices	G1	Green manufacturing	Chin et al.,2015
	G2	Green packaging.	Kumar et al.,2015
	G3	Green purchasing	Rostanzadeh et al.,2014
	G4	Green transportation	Rostanzadeh et al.,2014
	G5	Green design	Kumar et al.,2015
	G6	Green information system	Chin et al.,2015
	G7	Green innovation	Chin et al.,2015
Customer relation factors	C1	Customer requirements	Larry et al.,2012
	C2	Cooperation with customers	Sharma et al.,2017
	C3	Customer awareness of GSCM	Tyagi et al.,2015
	C4	Competitiveness	Mittal et al.,2014
	C5	customer environmental collaboration	Ozer vvygun et al.,2016
	C6	Supplier environmental collaboration	Ozer vygun et al.,2016
Social perspectives	S1	Conservation of natural resources	Mittal et al., 2015
	S2	Social responsibility	Ghazila et al.,2015
	S3	Environmental related training & seminar	Tyagi et al.,2015
Regulatory norms	R1	ISO 14001	Larry et al.,2012
	R2	Government regulations & standards	Gandhi et al.,2015
	R3	Hazardous and toxic regulations	Ghazila et al.,2015
Green strategic factors	GS1	Reuse	Chin et al.,2015

	GS2	Recycling	Rostanzadeh et al., 2014. Chin et al.,2015
	GS3	Reverse logistics	Sharma et al.,2017 Ozen vygun &Ayse Dede.,2016
	GS4	Remanufacturing	Kumar et al.,2015 Ciang wu et al., 2012.
	GS5	Reduce	Chin et al.,2015 Ozen vygun &Ayse Dede.,2016

III FUZZY AHP METHODOLOGY

The AHP is a flexible multi criteria decision making method which can be used to effectively synthesis the judgments given by a team of experts in order to make better decisions in complex problems, where both tangible and intangible criteria must be considered (Satty 1990). It a powerful decision making methodology for determining the priorities among different criteria. First, the fuzzy theory is discussed before the development of fuzzy AHP as follows. The fuzzy AHP method in the decision making process can be applied to many different areas due to its accuracy. Fuzzy AHP gives both qualitative and quantitative results into the decision model.

3.1 Fuzzy set theory

Fuzzy set theory is suitable for dealing with the uncertainty and impression associated with information concerning various parameters. Human decision is generally characterized by vague language, like 'equally important', 'moderately important', 'strongly important', 'very strongly' and 'extremely important'. The fuzzy sets are defined by the membership functions.
It represents the grade of any element x of X that have the partial membership to A. The fuzzy set theory allows the membership functions to operate over the range of real numbers [0, 1].A fuzzy set contains elements that have different degrees of membership in it. A triangular fuzzy number denoted as M= (a, b, c) is to be used in this method. This type of membership functions are proposed by Buckley (1985).A character '~' is placed above a number represents a fuzzy set.

3.2 Fuzzy AHP procedure

The step by step procedure of fuzzy AHP has discussed bellows.

- Build the structural hierarchy model.
- Defining scale of relative importance used in the pairwise comparison matrix
  The five triangular fuzzy numbers are defined with the corresponding membership functions as shown in table.

Table II: The fuzzy linguistic scale for criteria weight

Intensity of Importance	Fuzzy No.	Definition	Membership Function
1	$\tilde{1}$	Equally Important	(1,1,3)
3	$\tilde{3}$	Moderately Important	(1,3,5)
5	$\tilde{5}$	Strongly Important	(3,5,7)
7	$\tilde{7}$	Very strongly Important	(5,7,9)
9	$\tilde{9}$	Extremely Important	(7,9,11)

- Develop a fuzzy comparison matrix (FCM).
- Estimating the degree of optimism for fuzzy A.
- Calculate maximum eigenvalue of the matrix by using equation.
- AW = λ W where w is principle Eigen vector of the matrix.
- Check the consistency Ratio (CR).
  The consistency ratio (CR) is calculated in order to determine the consistency of the matrix and to control the results. The CR is used to determine directly the consistency of pairwise comparisons and expressed by the following equation.

  $CR=\frac{CI}{RI}$ where CI is consistency Index
  RI is random index

  $CI= \frac{\lambda \max - n}{n-1}$

If CR< 0.10, then only consistency of matrix is considered as acceptable, otherwise decision maker has to revise the original values in the pairwise comparison matrix.

- Calculate the weight of the criteria
- Prioritize the criteria.

The final weight of each criterion can be obtained by multiplying the ratio weight of sub criteria by major criteria's weight. According to final weight prioritize the criteria.

IV Application of fuzzy AHP

In this study 34 success factors of GSCM implementation in Indian manufacturing SMEs are identified through literature review and discussion with decision group members. These sub criteria are divided into seven main criteria. The goal of decision process is to determine as "Ranking the success factors of GSCM Implementation in Indian manufacturing SMEs."

The results obtained from the calculations based on pairwise comparison matrixes provided in Table-3 to 10.CR values of all the matrixes are less than 0.1. Hence, these matrixes are consistent.

Table III: Pairwise comparison of Environmental perspectives

	E1	**E2**	**E3**	**E4**	**E5**
E1	1	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$
E2	$\tilde{7}$	1	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$
E3	$\tilde{7}$	$\widetilde{1}^{-1}$	1	$\tilde{1}$	$\tilde{1}$
E4	$\tilde{7}$	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	1	$\tilde{1}$
E5	$\tilde{7}$	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	1

Table IV: pairwise comparison of In house development

	ID1	**ID2**	**ID3**	**ID4**	**ID5**
ID1	1	$\tilde{1}$	$\tilde{1}$	$\tilde{7}$	$\tilde{7}$
ID2	$\widetilde{1}^{-1}$	1	$\tilde{1}$	$\tilde{7}$	$\tilde{7}$
ID3	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	1	$\tilde{7}$	$\tilde{7}$
ID4	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	1	$\tilde{1}$
ID5	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{1}^{-1}$	1

Table VI: pairwise comparison of customer Relation factors

	C1	**C2**	**C3**	**C4**	**C5**	**C6**
C1	1	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$
C2	$\widetilde{1}^{-1}$	1	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$
C3	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	1	$\widetilde{7}^{-1}$	$\tilde{1}$	$\widetilde{7}^{-1}$
C4	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	$\tilde{7}$	1	$\tilde{7}$	$\tilde{1}$
C5	$\widetilde{7}^{-1}$	$\widetilde{7}^{-1}$	$\widetilde{1}^{-1}$	$\widetilde{7}^{-1}$	1	$\widetilde{7}^{-1}$
C6	$\widetilde{1}^{-1}$	$\widetilde{1}^{-1}$	$\tilde{7}$	$\widetilde{1}^{-1}$	$\tilde{7}$	1

Table VII: pairwise comparison of Social perspective

CRITERIA	**S1**	**S2**	**S3**
S1	1	$\tilde{1}$	$\tilde{9}$
S2	$\widetilde{1}^{-1}$	1	$\tilde{9}$
S3	$\widetilde{9}^{-1}$	$\widetilde{9}^{-1}$	1

Table VIII: pairwise comparison of Regulatory norms related Success factors

CRITERIA	R1	R2	R3
R1	1	$\widetilde{7^{-1}}$	$\widetilde{7^{-1}}$
R2	$\tilde{7}$	1	$\tilde{1}$
R3	$\tilde{7}$	$\widetilde{1^{-1}}$	1

Table IX: pairwise comparison of green strategic related success factors

CRITERIA	GS1	GS2	GS3	GS4	GS5
GS1	1	$\tilde{1}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$
GS2	$\widetilde{1^{-1}}$	1	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$
GS3	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	1	$\tilde{7}$	$\tilde{1}$
GS4	$\widetilde{7^{-1}}$	$\widetilde{7^{-1}}$	$\widetilde{7^{-1}}$	1	$\widetilde{7^{-1}}$
GS5	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\tilde{7}$	1

Table IX: pairwise comparison of green strategic related success factors

CRITERIA	G1	G2	G3	G4	G5	G6	G7
G1	1	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$
G2	$\widetilde{1^{-1}}$	1	$\widetilde{7^{-1}}$	$\tilde{1}$	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$
G3	$\tilde{7}$	$\tilde{7}$	1	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$
G4	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{7^{-1}}$	1	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$
G5	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{7^{-1}}$	$\widetilde{1^{-1}}$	1	$\widetilde{7^{-1}}$	$\tilde{1}$
G6	$\tilde{7}$	$\tilde{7}$	$\widetilde{1^{-1}}$	$\tilde{7}$	$\tilde{7}$	1	$\tilde{7}$
G7	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{7^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{7^{-1}}$	1

Table X: pairwise comparison of major criteria

CRITERIA	S1	S2	S3	S4	S5	S6	S7
S1	1	$\tilde{7}$	$\tilde{7}$	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$
S2	$\widetilde{7^{-1}}$	1	$\tilde{1}$	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$	$\widetilde{7^{-1}}$
S3	$\widetilde{7^{-1}}$	$\widetilde{1^{-1}}$	1	$\tilde{1}$	$\widetilde{7^{-1}}$	$\tilde{1}$	$\widetilde{7^{-1}}$
S4	$\widetilde{7^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	1	$\widetilde{7^{-1}}$	$\tilde{1}$	$\widetilde{7^{-1}}$
S5	$\widetilde{1^{-1}}$	$\tilde{7}$	$\tilde{7}$	$\tilde{7}$	1	$\tilde{7}$	$\tilde{1}$
S6	$\widetilde{7^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{1^{-1}}$	$\widetilde{7^{-1}}$	1	$\widetilde{7^{-1}}$
S7	$\widetilde{1^{-1}}$	$\tilde{7}$	$\tilde{7}$	$\tilde{7}$	$\widetilde{1^{-1}}$	$\tilde{7}$	1

Table XI: Final priority of success factors of green supply chain management Implementation in Indian manufacturing SMEs

SR. NO.	MAIN CRITERIA	MAJOR CRITERIA WEIGHT	SUB CRITERIA CODE	RATIO WEIGHT	FINAL WEIGHT	RANK
1	Environmental Perspectives	**0.3068**	E1	0.0334	0.0102	21
			E2	0.2939	0.0901	3
			E3	0.2551	0.0782	4
			E4	0.2226	0.0682	6
			E5	0.1946	0.0597	8
2	In-house Development Factors	**0.0474**	ID1	0.3474	0.0164	13
			ID2	0.30124	0.0142	18
			ID3	0.2638	0.0125	19
			ID4	0.4684	0.0222	11
			ID5	0.04038	0.0019	31
3	Green Practices	**0.04315**	G1	0.0658	0.0028	26
			G2	0.06	0.0025	27
			G3	0.3812	0.0164	14
			G4	0.0545	0.0023	28
			G5	0.0491	0.0021	30
			G6	0.3447	0.0148	15
			G7	0.044	0.0018	32
4	Customer Relation Factor	**0.03895**	C1	0.2755	0.0107	20
			C2	0.2443	0.0095	22
			C3	0.0351	0.0013	33
			C4	0.2181	0.0084	23
			C5	0.031	0.0012	34
			C6	0.1954	0.0076	25
5	Social Perspectives	**0.2766**	S1	0.5282	0.1461	1
			S2	0.4197	0.1160	2
			S3	0.0518	0.0143	16
6	Regulatory Norms	**0.0348**	R1	0.0659	0.0022	29
			R2	0.5204	0.0181	12
			R3	0.4134	0.0143	17
7	Green Strategic Factors	**0.2517**	GS1	0.2939	0.0739	5
			GS2	0.2551	0.0642	7
			GS3	0.2226	0.0560	9
			GS4	0.0334	0.0084	24
			GS5	0.1946	0.0489	10

V RESULTS AND DISCUSSION OF FUZZY AHP

By developing a comprehensive hierarchy based model to support the effective green supply chain collaboration. The seven main success factors of GSCM are found critically important based on literature review and expert opinions. The expert interview has conducted to prioritize all success factors of GSCM.

The criterion weights for seven major criteria are summarized as environmental perspectives having weight of (**0.3068),** In-house Development Factors (**0.0474),** green practices (**0.04315),** Customer Relation Factors (**0.03895),** Social Perspectives (**0.2766),** Regulatory Norms (**0.0348)** and Green Strategic Factors having weight of (**0.2517).**

From the fuzzy AHP result, it can be concluded that 'environmental perspectives ' having highest priority weight **(0.306927)** and social perspectives having **(0.276681)** highest weight seems to be a most significant success factors among all selected success factors followed and remaining are seems to be least significant success factors.so that for implementation if management considers this priority of environmental perspectives success factors of GSCM then results are bound to be fruitful in terms of organizational performance.

From above table no: XI can be concluded that the social perspectives namely 'conservation of natural resources' and 'social responsibility' and environmental perspectives related 'pollution control' and 'waste reduction' and green strategic factors related 'Reuse' are having highest rank. These five factors having highest weight are consider as most significant factors and remaining are less significant factors.so that if industrial management considers these factors then results will bound to be successful for the performance of organization.

VI CONCLUSION:

From the literature review 34 success factors of GSCM were identified. These success factors have been prioritize based on their final weight of each success factors with the help of FAHP methodology. From the results of FAHP environmental perspectives and social perspectives having highest weight seems to be most important major criteria among other major criteria. According to sub criteria weight social perspectives namely 'conservation of natural resources' and 'social responsibility' and environmental perspectives related 'pollution control' and 'waste reduction' and green strategic factors related 'Reuse' are having highest rank. These five factors having highest weight are consider as most significant factors and remaining are less significant factors from all selected criteria. If industrial management considers these success factors then results are fruitful for increasing performance of organization. In future from the results of this study can be analyze and ranking of other factors taken into account for modelling. It can be performed analyze to investigate the influence of criteria weights on ranking of success factors. Also barriers of GSCM can be identified & ranking performed in future. This type of analysis can be used with the help of other MCDM techniques and hybrid tool so that making model very closer in real life. This type of study will be extended in large scale industries also.

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