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Analyzing the factors for implementation of green supply chain management

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Abstract
Purpose – In the present context of a globalised economy, market requirements are changing regularly in term of product cost, delivery time, safety and environmental issues. Apart from conventional measures, environmental factors have become an integral part of performance measurement system. This study aims to analyse major barriers and factors in green supply chain (GSC) management implementation.
Design/methodology/approach – The present study has tried to identify barriers and factors for green supply chain management (GSCM) based on literature review. Factors for GSCM have been modelled by interpretive structural modelling (ISM) approach.
Findings – Based on literature review, 12 factors have been identified. It has been observed that top management commitment, integration among supply chain members, vendors' development, environmental friendly packaging and transportation, reverse logistic management and development of a green performance measurement system are major drivers for successful implementation of GSCM.
Research Limitations/implications – Organisations need to follow a proactive approach for taking GSC initiatives. For generalisation of findings, empirical study and some case studies need to be carried out.
Originality/value – Findings of this study will help organisations in strategy formulation for GSCM and successful implementation for sustainable competitiveness.

Keywords Performance, Sustainability, Barriers, Green supply chain management

Paper type Research paper

1. Introduction
In the present context of a globalised market, all organisations are facing a tough scenario to sustain their global competitiveness. Subramanian and Gunasekaran, (2015) have observed that realizing the need to incorporate sustainability and the triple bottom line as part of their strategic intent, companies focus on assessing the economic, environmental and social impacts of their activities and highlighting the relationship between sustainability and performance. Lubin and Esty (2010) have observed that

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sustainability efforts are in firms are driven by innovations in energy efficiency, renewable power, resource productivity and overall green operations. In the present context of globalisation, environmental issues have become very important for organisations to sustain their competitiveness. Therefore, most of the organisations are trying to make their supply chain more efficient and green. Environmental management is gaining interest among researchers in supply chain management. Green supply chain management (GSCM) can be defined as green purchasing, green manufacturing (material management), green distribution (marketing) and reverse logistic. It refers to the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment (Green *et al.*, 1998). Handfield and Nichols (1999) have considered greening of supply chain as a critical issue in the near future scenario. Singh and Sharma (2015) have observed that to make supply chain competitive, organisations need to make their processes energy efficient and sustainable.

Green supply chain (GSC) strategies have become the backbone for many business organisations in today's environmentally sensitive scenario. Effective market coverage and availability of greener products at locations which hold the key to revenue recognition depend upon the effectiveness of GSC strategy. According to Hervani *et al.*, (2005), successful management of a supply chain is influenced by customer needs, globalisation of the market, application of information technology and government and environmental regularisations. Ireland and Webb (2007) have considered strategic supply chain as the medium for creating and sustaining a competitive advantage for an organisation. Fawcett *et al.* (2008) have described various benefits of supply chain management. These include inventory reduction, shorter product development cycles and improved delivery service. Stonebraker and Afifi (2004) have found that the success of a strategic supply chain is dependent on the management's ability to recognise changes in the competitive environment. Therefore, direct and coordinated action is needed across the organisations to utilise resources effectively and meet the demands of the environmental issues (Singh, 2013a, 2013b).

Managers are increasingly giving importance to environmental issues. Van Hoek (1999) has found in his study that 60 per cent managers have considered environmental issues to be highly important and 82 per cent have expected that the importance would further increase in the coming years. GSC has emerged as an important component of the environmental and supply chain strategies for a number of organisations. The GSC encompasses a broad range of practices from green purchasing to integrated supply chains flowing from suppliers to manufacturer to end consumer, and finally to the reverse supply chain, which is "closing the loop" (Zhu and Sarkis, 2006; Rao and Holt, 2005). From a life-cycle perspective, initiatives have been made to achieve the goal of the GSC, a notable environmental and economic gain of the entire supply, are hard to implement successfully without the deep involvement of the supply chain partners. In other words, it is crucial to include suppliers in the supply chain-wide environmental improvement process. Sarkis (2003) has observed that private organisations such as Hewlett-Packard, IBM, Xerox and Digital Equipment Corporation have introduced some form of initiative for greening their supply chains, including the integration of suppliers, distributors and reclamation facilities. According to van Hoek (2002), an environmentally friendly supply chain would need to consider all activities within the chain, i.e. raw material acquisition, inbound logistics, transformation, outbound

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logistics, marketing and after-sales. Agrawal *et al.* (2015) have observed that organisations are not able to optimise their logistic operations effectively for sustainable supply chains. Mangla *et al.* (2015) have observed that operational risks are the most important risks in GSC implementation.

Based on literature gaps, it is observed that many organisations face problems in successful GSCM due to lack of green strategies and improper selection of critical success factors. In contrast to many studies on GSCM in developed countries, there has been a lack of research on GSCM in developing countries such as India (Jayaram and Avittathur, 2012). Therefore, key objectives of this paper are to identify the factors for GSCM on basis of literature review and to develop a structural framework for implementing GSCM successfully. The remaining part of this paper is organised as follows: Section 2 discusses literature review on barriers in GSCM implementation and identification of factors, Section 3 discusses interpretive structural modelling (ISM) methodology, Section 4 discusses results, and finally Section 5 is conclusion.

2. Literature review

The literature review has been done in two parts. First, barriers are analysed, then factors are identified for developing a framework for GSCM implementation.

2.1 Barriers in green supply chain management implementation

Sheu *et al.* (2005) have observed that an increase in environmental concerns during the past decade has grown towards environmental pollution issues. They also felt that implementing industrial development together with supply chain management may contribute to GSCM. Lee (2009) also emphasised the need of greening the supply chains to maintain competitiveness in the global market. Walker *et al.* (2008) have observed that various policies and regulatory regimes formulated by government and public agencies in different countries may act as barriers in greening the supply chain. The rapidly growing population and economic development are leading to a number of environmental issues in India because of the expansion and massive intensification of agriculture, uncontrolled growth of urbanisation and industrialisation and the destruction of forests. Wycherley (1999) have defined fundamental barriers which mainly come across in adopting a GSCM such as increased costs, mistrusted suppliers, lack of information, resources and expertise of suppliers and lack of government policies. Mainly barriers are related to management, technology and environmental degradation, lack of employee involvement and lack of government policies. Several organisations have failed to integrate their supply chain because they have deployed inadequate measures and metrics (Mentzer *et al.*, 2007). Olugu *et al.* (2010), Dey and Cheffi (2013) have suggested that a performance framework for GSC should integrate upstream supply chains, internal operations and downstream customers. Major barriers based on literature review are summarised in Table I.

2.2 Identification of factors for green supply chains

GSCM consists of the activities that include recycling, reuse, reduction and the substitution of materials (Narasimhan and Carter, 1998). According to Van Hock and Erasmus (2000), GSCM has emerged as an important tool for many industries in achieving profit and market share objectives by lowering their environmental risks and by raising their ecological efficiency. According to Sarkis (2012), knowledge and learning management activities are also critical in determining the informational

No.	Barriers	References
1	*Management problems*	
	Material mismanagement	Cox and Blackstone (1998), Agrawal *et al.* (2014)
	Difference in organizational policy	Zhu *et al.* (2005), Mangla *et al.* (2015)
	Geographical and cultural difference	Zhu *et al.* (2005)
	Lack of training	Thakkar *et al.* (2011)
	Ineffective performance framework	Olugu *et al.* (2010), Dey and Cheffi (2013)
2	*Technical problems*	
	Poor and outdated equipment	Clark (2000), Hall (2000)
	Non standardised data	Zhu *et al.* (2005)
	Failure to introduce new and advance technology	Clark (2000), Hall (2000), Agrawal *et al.* (2015)
3	*Environmental degradation*	
	Failure in product recycling	Qian *et al.* (2011), Agrawal *et al.* (2015)
	Less awareness about environment	Clark (2000), Agrawal *et al.* (2015)
	Excessive emission of energy	Zhu *et al.* (2008)
	Failure to prevent pollution and hazardous waste	Beamon (1999)
4	*Lack of employee involvement*	
	Resistance to adopt new procedures	Bhakoo and chan (2011)
	Roles and responsibilities are not distributed evenly	Zhu *et al.* (2005)
	Lack of communication between suppliers and customers	Bowen *et al.* (2001), Theyel (2001), Zhu and Sarkis (2006), Rao and Holt (2005)
5	*Ineffective govt. control*	
	Lack of effective government policy	Zhu *et al.* (2008), Reza *et al.* (2010)
	To many problems are ignored	Cox and Blackstone (1998)
	No monitoring	Wiersma (2009)

Table I. Barriers in GSCM implementation

boundaries for a firm. Collaborative supply chains are applied for knowledge-sharing activities, such as seminars and workshops, which may help in supplier training and development efforts in environmental issues (Bai and Sarkis, 2010; Vachon, 2007). Waste management can be done by adopting various techniques such as land filling or incineration of waste material and then returning useful materials back into the supply chain. Klassen and Vachon (2003) have considered information, process, product or organisational support technology as critical factors for managing a GSC. Material store and management have been considered as essential enablers to improve supply chain performance. It has been found that many companies are switching towards reusable packaging systems. According to Cox and Blackstone (1998), reusable containers can reduce solid waste and product damage during shipping which can further help in eliminating ergonomic and safety problems. Implementation of the 3R – recycle, reuse and recovery – concept can help in product development. 3R should be considered in package design to reduce excess packaging. Laosirihongthong *et al.* (2013) have

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observed that there is less focus on reverse logistics. Organisations can greatly improve business performance by working with suppliers, shippers, distributors and customers to better coordinate GSC activities. Zhu *et al.* (2005) have found that environment-friendly logistic may be used for reducing cost and increasing total production. Buyukozkan and Cifci (2012) have shown that efficient reverse logistics networks can provide lucrative economic benefits and improve organisational competitiveness. Proper training and efficient human resource development are also considered as a necessary part of GSC. Lee *et al.* (2012) found that due to lack of human resources and internal innovation capability, small- and medium-sized enterprises (SMEs) experience difficulties in achieving satisfactory performance in their projects. They further stated that a large number of SMEs are struggling with implementing new requirements of their buying firms mainly because of lack of knowledge, expertise and financial and human resources.

Reduction in hazardous material is considered as an important enabler for an organisation. Every organisation needs to follow and maintain strict standards for their vendors and suppliers to prevent pollution (Beamon, 1999). Laosirihongthong *et al.* (2013) have observed that manufacturers can attain a positive image of their organisations and products in the perceptions of employees, suppliers and customers while, simultaneously, reducing their consumption and air pollution and also complying with environmental standards. Zhu *et al.* (2005) have considered implementation of cleaner production, environmental management systems (EMSs) and eco-efficiency as green management practices. Zhu and Cote (2004) have observed that the approach of GSC systems may help to improve resource recovery just like an eco-industrial development. Seuring (2004) has considered EMSs, life-cycle analysis, industrial ecology, product administration, extended producer responsibility and economic design as the key features of GSCM. Sarkis (2012) has found that instead of disposing these wastes, recycling and reverse logistics network flows can be designed to manage these streams. According to Laosirihongthong *et al.* (2013) environmental performance measures the actual impacts of GSC initiatives, such as compliance with environmental standards, reduced air emissions, decreased resource consumption and lower consumption of hazardous materials. According to Buyukozkan and Cifci (2012), it is important to use environmental- and non-environmental-based measures to evaluate GSCs. Teuteberg and Wittstruck (2012) identified three dimensions of performance – environmental, economic and social. The study also measured economic performance in terms of reduced cost and increased profitability (Green *et al.*, 2012) and environmental performance in terms of reduction in air emission, energy consumption, hazardous material, material usage and compliance to environmental standards (Zhu *et al.*, 2012; Rao, 2002).

Lee (2009) has found that large manufacturers have been adopting environmental audit programmes to control their vendors in an effective manner. Industrial customers with closer supplier relationships may require suppliers to implement organisational and design environmental technologies such as EMS and DFE, to expand the technological capabilities and minimise various transaction hazards (Rosen *et al.*, 2000). The influence of JIT practices has shown variations in environmental implications influencing in a bad way or a good way (Zhu and Sarkis, 2004). Hugo and Pistikopoulos (2005) have observed that facility location and partnership development will be influenced by the geographical constraints associated with managing transportation environmental influences. According to Zhu *et al.* (2005), ISO (14001) certification and GSCM can help developing countries in reducing waste and improve their economic positioning by reducing the environmental burden of both manufacturing and disposal of products. Hsu *et al.* (2013) have found that environmentally proactive organisations often encourage their suppliers to obtain environmental management certification such as ISO (14001). Hines and Jones (2001) have observed that the mentoring role within GSCM is an emerging concept that can provide a significant relationship between the customer and the supplier. Based on literature review and opinion of experts from industry, a total of 12 factors have been identified for GSCM, and they are further summarised in the Table II.

3. Research methodology

For effective GSCM, a strategic framework based on identified factors is very important. For modelling of identified factors and to develop a structural framework among them, the ISM approach has been used in this study.

3.1 Interpretive structure modelling

ISM is a method which can be applied to a system – such as a network or a society to better understand both direct and indirect relationships among the system's components. Warfield (1973) proposed the concept of ISM to analyse the complex socioeconomic systems. Its basic idea is to use experts' practical experience and knowledge to decompose a complicated system into several sub-systems (elements) and construct a multilevel structural model. ISM is often used to provide fundamental understanding of complex situations, as well as to put together a course of action for solving a problem. Warfield (1976) worked on the generic ISM process. Singh (2015) applied this ISM approach for analysing interaction among factors for responsive supply chains. Different steps involved in the ISM are as follows;

- *Step 1*. Variables affecting the system under consideration are listed, which can be objectives, actions and individuals, etc.
- *Step 2*. A contextual relationship is established among variables with respect to which pairs of variables would be examined.
- *Step 3*. A structural self-interaction matrix (SSIM) is developed for variables, indicating pair-wise relationship among variables of the system under consideration.
- *Step 4*. Reachability matrix is developed from the SSIM and checked for transitivity. It helps in developing "final reachability matrix". The transitivity of the contextual relations is a basic assumption made in ISM. It states that if Variable A is related to B and B is related to C, then A will be necessarily related to C.
- *Step 5*. The final reachability matrix obtained in Step 4 is partitioned into different levels.
- *Step 6*. Based on the relationship given in the reachability matrix and determined levels for variables, a directed graph is drawn and transitive links are removed.
- *Step 7*. The resultant diagraph is converted into an ISM by replacing variables nodes with statements.

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No.	Enablers	References
1	Top management commitment	van Hock and Erasmus (2000), Zhu and Sarkis (2004), Hugo and Pistikopoulos (2005), Hamprecht *et al.* (2005)
2	Vendors development	Lee (2009), Singh (2013a, 2013b), Bansal *et al.* (2014), Kannan *et al.* (2014)
3	Materials store and management	Cox and Blackstone (1998), Singh (2013a, 2013b)
4	Effective GSCM	Green *et al.* (1998), Narasimhan and Carter (1998)
5	Pollution prevention and hazardous waste management	Beamon (1999), Agrawal *et al.* (2014)
6	Reverse logistic management	Beamon (1999), Zhu *et al.* (2005), Buyukozkan and Cifci (2012) , Laosirihongthong *et al.* (2013), Agrawal *et al.* (2014)
7	Environmental friendly packaging and transportation	Lamming and Hampson (1996), Singh (2008)
8	Application of advance technology and IT tools	Klassen and Vachon (2003), Vachon (2007), Zhu *et al.* (2005), Sarkis (2012), Bai and Sarkis (2010)
9	Environment management certification (ISO 14000 series)	Hines and Jones (2001), Zhu *et al.* (2005), Hsu *et al.* (2013)
10	Development of green performance measurement system	Beamon, (1999), Rao (2002), Laosirihongthong *et al.* (2013), Buyukozkan and Cifci (2012), Teuteberg and Wittstruck (2012), Green *et al.* (2012), Zhu *et al.* (2012)
11	Development of trained and skilled manpower	Beamon, (1999), Laosirihongthong *et al.* (2013)
12	Integration among supply chain members	Bowen *et al.* (2001), Theyel (2001), Beamon (1999), Laosirihongthong *et al.* (2013), Dey and Cheffi (2013), Singh and Sharma (2015)

Table II.
Enablers of GSCM

- *Step 8*. The developed ISM model is reviewed to check for conceptual inconsistency and necessary modification are made.

3.2 Structural self-interaction matrix

The ISM methodology suggests the use of expert opinions in developing the contextual relationship among the factors. Based on the opinion of experts, a Table III of SSIM is developed. Four symbols are used to denote the direction of relationship between the criterion (*i* and *j*):

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Serial no.	Enablers	1	2	3	4	5	6	7	8	9	10	11	12
1	Top management commitment		V	V	V	V	V	V	V	V	V	V	V
12	Vendors' development			V	V	V	V	V	A	A	V	A	A
13	Material store and management				V	V	V	V	A	A	V	A	A
14	effective GSCM					A	A	A	A	A	A	A	A
15	Pollution prevention and hazardous waste management						A	A	A	A	V	A	A
16	Reverse logistic management							X	A	A	V	A	A
17	Environment-friendly packaging and transportation								A	A	V	A	A
18	Application of advance technology and IT tools									V	V	A	A
19	Development of trained and skilled manpower										V	A	A
10	Environment management certification (ISO 14000 series)											A	A
11	Development of a green performance measurement system												X
12	Integration among supply chain members												

Table III. Structural self intersection matrix

(1) *V*: Criterion *i* will help to achieve criterion *j*.

(2) *A*: Criterion *j* will help to achieve criterion *i*.

(3) *X*: Criterion *i* and *j* will help to achieve each other.

(4) *O*: Criterion *i* and *j* are unrelated.

For developing these relationships, a team of five experts was made. Three experts were from the industry having sound knowledge and experience of GSC issues and applications and two experts were from academia having done wide research in GSCM. The following points would explain the use of the symbols V, A, X and O in SSIM (Table III):

- Enabler 1 helps achieve Enabler 2. This means that the enabler, namely, "top management commitment" will help to achieve enabler "vendors' development". Thus, the relationship between Factors 1 and 2 is denoted by "V" in the SSIM.
- Enabler 2 can be achieved by Enabler 8, i.e. Enabler 8, namely, "application of advance technology and IT tools" would help achieve Enabler 2 (i.e. "vendors' development."). Thus, the relationship between these factors is denoted by "A" in the SSIM.
- Factors 11 and 12 help achieve each other. Enabler 11, namely, "Develop a green performance measurement system", and Enabler 12, namely, "integration among supply chain members", help in achieving each other. Thus, the relationship between these factors is X.

3.3 Reachability matrix

The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are the following.

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- If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.
- If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.
- If the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.
- If the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Based on above rules and transitivity effect, final reachability matrix is developed as given in Table IV.

3.4 Level partitions

The reachability and antecedent set for each enabler are found from the final reachability matrix. The reachability set consists of the element itself and other elements, which it may help achieve, whereas the antecedent set consists of the element itself and the other elements, which may help in achieving it. Then, the intersection of these sets is derived for all elements. The element for which the reachability and intersection sets are same is the top-level element in the ISM hierarchy. The top-level element of the hierarchy would not help achieve any other element above their own level. Once the top-level element is identified, it is separated out from the other elements. Then, the same process finds the next level of element. This process continues till the levels of each element are found. All iterations for finding levels of different factors are shown in

Serial no.	Enablers	1	2	3	4	5	6	7	8	9	10	11	12	D.P
1	Top management commitment	1	1	1	1	1	1	1	1	1	1	1	1	12
2	Vendors' development	0	1	1	1	1	1	1	0	0	1	0	0	7
3	Material store and management	0	0	1	1	1	1	1	0	0	1	0	0	6
4	effective GSCM	0	0	0	1	0	0	0	0	0	0	0	0	1
5	Pollution prevention and hazardous waste management	0	0	0	1	1	0	0	0	0	1	0	0	3
6	Reverse logistic management	0	0	0	1	1	1	1	0	0	1	0	0	5
7	Environmental friendly packaging and transportation	0	0	0	1	1	1	1	0	0	1	0	0	5
8	application of advance technology and IT tools	0	1	1	1	1	1	1	1	1	1	0	0	9
9	development of trained and skilled manpower	0	1	1	1	1	1	1	0	1	1	0	0	8
10	Environment management certification(ISO 14000)	0	0	0	1	0	0	0	0	0	1	0	0	2
11	Development a green performance measurement system	0	1	1	1	1	1	1	1	1	1	1	1	11
12	Integration among supply chain members	0	1	1	1	1	1	1	1	1	1	1	1	11
	Dependence	1	6	7	12	10	9	9	4	5	11	3	3	

Table IV.
Final reachability matrix

Tables V-XIV. These identified levels will help in building the digraph and the final ISM model. In the present case, the factors along with their reachability set, antecedent set, intersection set and corresponding levels for factors are derived from different iterations, which is summarised in Table XV.

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1	1	
2	2, 3, 4, 5, 6, 710	1, 2, 8, 9, 11, 12	2	
3	3, 4, 5, 6, 7, 10	1, 2, 3, 8, 9, 11, 12	3	
4	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	4	I
5	4, 5, 10	1, 2, 3, 5, 6, 7, 8, 9, 11, 12	5	
6	4, 5, 6, 7, 10	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
7	4, 5, 6, 7, 10	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
8	2, 3, 4, 5, 6, 7, 8, 9, 10, 12	1, 8, 11	8	
9	2, 3, 4, 5, 6, 7, 9, 10, 12	1, 8, 9, 11	9	
10	4, 10	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	10	
11	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 11, 12	11, 12	
12	, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 11, 12	11, 12	

Table V. Iteration 1

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	1	1	
2	2, 3, 5, 6, 7, 10	1, 2, 8, 9, 11, 12	2	
3	3, 5, 6, 7, 10	1, 2, 3, 8, 9, 11, 12	3	
5	5, 10	1, 2, 3, 5, 6, 7, 8, 9, 11, 12	5	
6	5, 6, 7, 10	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
7	5, 6, 7, 10	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
8	2, 3, 5, 6, 7, 8, 9, 10	1, 8, 11, 12	8	
9	2, 3, 5, 6, 7, 9, 10	1, 8, 9, 11, 12	9	
10	10	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	10	II
11	2, 3, 5, 6, 7, 8, 9, 10, 11, 12	1, 11, 12	11, 12	
12	2, 3, 5, 6, 7, 8, 9, 10, 11, 12	1, 11, 12	11, 12	

Table VI. Iteration 2

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 2, 3, 5, 6, 7, 8, 9, 11, 12	1	1	
2	2, 3, 5, 6, 7	1, 2, 8, 9, 11, 12	2	
3	3, 5, 6, 7	1, 2, 3, 8, 9, 11, 12	3	
5	5	1, 2, 3, 5, 6, 7, 8, 9, 11, 12	5	III
6	5, 6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
7	5, 6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	
8	2, 3, 5, 6, 7, 8, 9	1, 8, 11, 12	8	
9	2, 3, 5, 6, 7, 9	1, 8, 9, 11, 12	9	
11	2, 3, 5, 6, 7, 8, 9, 11, 12	1, 11, 12	11, 12	
12	2, 3, 5, 6, 7, 8, 9, 11, 12	1, 11, 12	11, 12	

Table VII. Iteration 3

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Table VIII.
Iteration 4

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 2, 3, 6, 7, 8, 9, 11, 12	1	1	
2	2, 3, 7, 6	1, 2, 8, 9, 11, 12	2	
3	3, 6, 7	1, 2, 3, 8, 9, 11, 12	3	
6	6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	IV
7	6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	IV
8	2, 3, 6, 7, 8, 9	1, 8, 11, 12	8	
9	2, 3, 6, 7, 9	1, 8, 9, 11, 12	9	
11	2, 3, 6, 7, 8, 9, 11, 12	1, 11, 12	11, 12	
12	2, 3, 6, 7, 8, 9, 11, 12	1, 11, 12	11, 12	

Table IX.
Iteration 5

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 2, 3, 8, 9, 11, 12	1	1	
2	2, 3	1, 2, 8, 9, 11, 12	2	
3	3	1, 2, 3, 8, 9, 11, 12	3	V
8	2, 3, 8, 9	1, 8, 11, 12	8	
9	2, 3, 9	1, 8, 9, 11, 12	9	
11	2, 3, 8, 9, 11, 12	1, 11, 12	11, 12	
12	2, 3, 8, 9, 11, 12	1, 11, 12	11, 12	

Table X.
Iteration 6

Factor	Reachability matrix	Antecedent set	Intersection Set	Level
1	1, 2, 8, 9, 11, 12	1	1	
2	2	1, 2, 8, 9, 11, 12	2	VI
8	2, 8, 9	1, 8, 11, 12	8	
9	2, 9	1, 8, 9, 11, 12	9	
11	2, 8, 9, 11, 12	1, 11, 12	11, 12	
12	2, 8, 9, 11, 12	1, 11, 12	11, 12	

Table XI.
Iteration 7

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 8, 9, 11, 12	1	1	
8	8, 9	1, 8, 11, 12	8	
9	9	1, 8, 9, 11, 12	9	VII
11	8, 9, 11, 12	1, 11, 12	11, 12	
12	8, 9, 11, 12	1, 11, 12	11, 12	

4. Results and discussion

Considering the relationships of different factors in the final reachability matrix and levels, the ISM model has been made as given in Figure 1. According to this framework, top management commitment will help in achieving integration among supply chain and in developing a green performance measurement system. These factors will help in the application of advance technology and IT tools and development of trained and

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skilled manpower. Application of IT tools and trained manpower will help in achieving vendor development and effective material store and management. The above-discussed factors will help in reverse logistic management, environment-friendly packaging and transportation, pollution prevention and hazardous waste management, environment management certification and finally successful implementation of GSCM. Based on driving power and dependence power, these factors are further classified into four clusters (Figure 2). The objective behind the behavioural classification of these factors is to analyse the driving power and dependence power of the factors that influence the implementation of GSCM.

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 8, 11, 12	1	1	
8	8	1, 8, 11, 12	8	VIII
11	8, 11, 12	1, 11, 12	11, 12	
12	8, 11, 12	1, 11, 12	11, 12	

Table XII. Iteration 8

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1, 11, 12	1	1	
11	11, 12	1, 11, 12	11, 12	IX
12	11, 12	1, 11, 12	11, 12	IX

Table XIII. Iteration 9

Factor	Reachability matrix	Antecedent set	Intersection set	Level
1	1	1	1	X

Table XIV. Iteration 10

Enabler	Reachability matrix	Antecedent set	Intersection set	Level
1	1	1	1	X
2	2	1, 2, 8, 9, 11, 12	2	VI
3	3	1, 2, 3, 8, 9, 11, 12	3	V
4	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	4	I
5	5	1, 2, 3, 5, 6, 7, 8, 9, 11, 12	5	III
6	6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	IV
7	6, 7	1, 2, 3, 6, 7, 8, 9, 11, 12	6, 7	IV
8	8	1, 8, 11, 12	8	VIII
9	9	1, 8, 9, 11, 12	9	VII
10	10	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	10	II
11	11, 12	1, 11, 12	11, 12	IX
12	11, 12	1, 11, 12	11, 12	IX

Table XV. Level partitions for enablers

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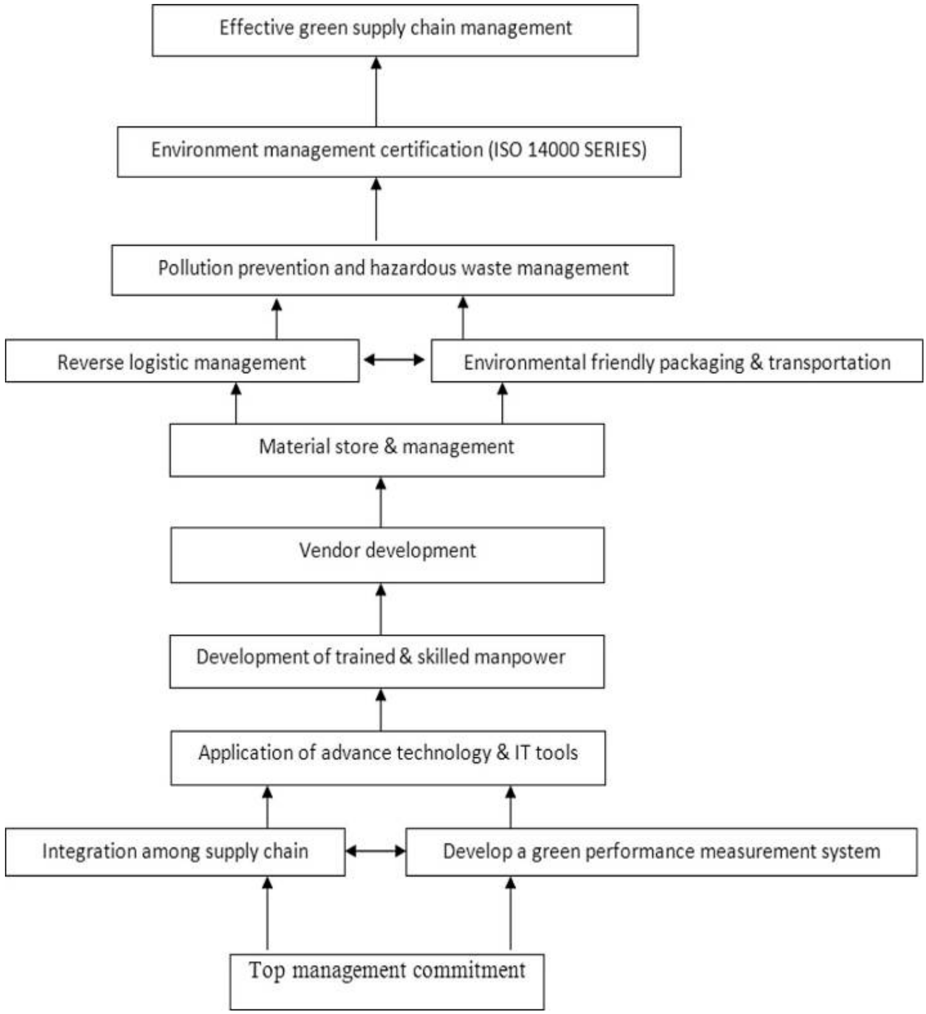

Figure 1.
ISM framework for enablers of GSC

4.1 Cluster I: weak driving power and weak dependence

This group is called autonomous or excluded factors. These factors are situated in the southwest frame and have only a few links with the system. They appear quite out of line with the system. However, a distinction may be drawn within this group between the disconnected factors situated near the axis' origin, whose evolution therefore seems to be rather excluded from the system's global dynamics and secondary levers which, although quite autonomous, are more influent than dependent. In the present study, no one is the disconnected enabler.

4.2 Cluster II: weak driving power and strong dependence

These factors are called depending factors, or rather, result variables. These variables, located in the southeast frame of the chart, are, at the same time, little influent and very

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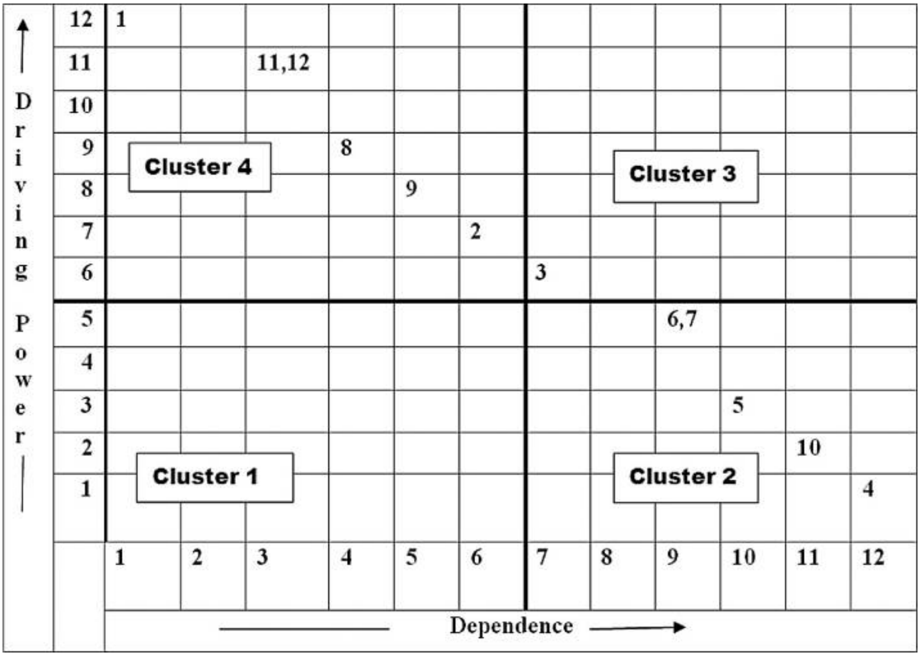

Figure 2.
Classification of enablers

dependent. So, they are especially sensitive to the evolution of influent factors and/or relay factors; these are effective GSCM, pollution prevention and hazardous waste management, reverse logistic management, environment-friendly packaging and transportation and environment management certification (ISO 14000) that have a weak driving power, but strong dependence for GSCM.

4.3 Cluster III: strong driving power and strong dependence

These factors are at the same time very influent and very dependent. They are also called relay factors. These factors are situated in the northeast frame of the chart and are unstable. Any action on these indicators will have an impact on others and feedback effect on themselves also. In the present study, there is only one enabler in this category that is material store and management. It has a strong driving power and strong dependence power. The presence of one linkage variable indicates that this is the only enabler that is unstable among all of 12 factors chosen for this study for implementing GSCM. Such unstable factors should be handled even more carefully than the others.

4.4 Cluster IV: strong driving power and weak dependence

These factors are altogether very influent and little dependent. These factors are located in the northwest frame of the perception chart. They are also called independent factors. These factors are most crucial elements, as they can act on the system depending on how much we can control them as a key factor either of inertia or of movement. They are also considered as entry factors in the system. The analysis reveals that five factors: top management commitment, vendors' development, application of advance technology and IT tools, development of trained and skilled manpower, development of a green

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performance measurement system and integration among supply chain members are ranked as strong drivers for GSCM.

5. Conclusion

For globalised markets, presently organisations are highly concerned for environmental issues in all aspects of their production systems. Therefore, due to many operational constraints, GSCM has become a crucial part of their operations strategies for sustainable competitiveness. Many of the organisations are not able to develop effective strategies under changing market scenario in terms of green operations. This paper has analysed main barriers in GSCM and identified key factors for implementation of GSCM. Based on literature review and experts opinion, total 12 factors are identified, and the ISM approach has been applied for developing a framework for effective GSCM. These factors were further categorised in four clusters based on their driving power and dependence power. It has been observed that for successful GSCM, top management commitment, vendors' development, application of advance technology and IT tools, development of trained and skilled manpower, development of a green performance measurement system and integration among supply chain members are major drivers. Effective GSCM, pollution prevention and hazardous waste management, reverse logistic management, environment-friendly packaging and transportation and environment management certification are major outcomes of GSCM initiatives by management of organisation.

5.1 Managerial implications and future scope for research

Jayaram and Avittathur (2012) have observed that greening initiatives are especially important for developing countries such as India, Pakistan and Sri Lanka due to lower purchasing power of consumers and shortage of electricity supplied from the grid. Therefore, these findings will be very useful for developing economies. These findings imply that top management should be very proactive in taking different initiatives for application of advanced technology and IT tools for development of vendors and skilled manpower for GSCs. Performance framework for GSC should try to integrate all perspectives such as social, economical and environmental for sustainability. Usually it is observed that many organisations fail in successful implementation of GSCM due to short-term approach; therefore, these findings would be very helpful in developing strategies for GSCs. These findings should not be generalised and need further validation with the help of empirical findings and case studies. This study has considered absolute values for developing SSIM. Therefore, it may be further extended by considering Fuzzy ISM approach.

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