

Project Dissertation Report on

AN INTENSIVE ANALYSIS ON GREEN

SUPPLY CHAIN MANAGEMENT

Submitted By :

Kushagra Singhal

2K17/MBA/039

Under the Guidance of :

Dr. Vikas Gupta

Assistant Professor, DSM-DTU



DELHI SCHOOL OF MANAGEMENT

Delhi Technological University

Bawana Road Delhi 110042

January - May 2019

CERTIFICATE FROM INSTITUTE

This is to certify that the Project Report titled **An Intensive Analysis of Green Supply Chain Management**, is an original and bonafide work carried out by **Mr. Kushagra Singhal** of MBA 2017-19 batch and was submitted to Delhi School of Management, Delhi Technological University, Bawana Road, Delhi-110042 in partial fulfilment of the requirement for the award of the degree of Masters of Business Administration.

Signature of Guide

Dr. Vikas Gupta

Signature of Department Head

Mr. Rajan Yadav

DECLARATION

I, **Kushagra Singhal**, student of MBA Batch 2017-19 of Delhi School of Management, Delhi Technological University, Bawana Road, Delhi-110042 declare that Project Report on **An Intensive Analysis of Green Supply Chain Management** submitted in partial fulfilment of Degree of Masters of Business Administration is the original work conducted by me.

The information and data given in the report is authentic to the best of my knowledge.

This report has not been submitted to any other university for the award of any other degree, diploma and fellowship.

Kushagra Singhal

Place: New Delhi

Date of Submission:

ACKNOWLEDGEMENT

I gratefully acknowledge my profound gratefulness towards my esteemed guide, Dr. Vikas Gupta, Assistant Professor, Delhi School of Management, DTU, for his invaluable guidance, excellent supervision and constant encouragement during the entire duration of the project work. I am thankful to him to provide me with useful references and information, which were of significant importance for the completion of this study. His valuable insights and attention to detail made this exercise a great learning experience. I perceive this achievement a milestone in my career development. I strive to use the skills and knowledge gained here in the best possible way and will continue to work on further improvement, in order to attain my desired career objectives. The project would never have been possible without his guidance and supervision.

I also express my sincere thanks to Dr. Rajan Yadav, Head of Department and all the faculty members of Delhi School of Management, DTU, Delhi. I extend my sincere gratitude and thanks to my friends and family for their help and assistance during my training, without whom it would not have been possible for the project to take its final shape.

Sincerely,

Kushagra Singhal

ABSTRACT

Environment friendliness and sustainability have been the talk of the town and have become a major part of any business so there is a growing need for integrating robust environment conscious practices in to supply chain management research and this newly found consciousness towards the environment gave birth to Green Supply Chain Management. Green supply chain management broadly includes inbound logistics, production, outbound logistics, marketing and reverse logistics. As the research in this area has increased, there have been multiple literature reviews in this field focusing on performance measurement, supplier/vendor evaluation, analytical modelling efforts, etc. This paper researches already existing papers and aims to find out what is the definition of a green supply chain, focuses on what does a modern green supply chain management constitutes, how this concept of green supply chain management been developed over time what the past was, what the present is and what could be the future. Now to narrow down the scope of research we focus on what all has been done in the field of green supply chain management in developing countries, what is the scope of green supply chain in India and what has already happened in India in this field. Also, the focus is on the trends and challenges in this field broadly and in India and how is it implemented across the world by companies and also can the already existing practices and methods can be directly lifted from developed countries and implemented in countries like India. The findings and interpretations will be summarized and main issues highlighted. By doing this we aim to have a robust knowledge and establish what is the state and scope of green supply chain management in India and what are problems associated with it while also opening possible research area in this field for the countries like India.

TABLE OF CONTENTS

S. No.	PARTICULARS	PAGE NO.
1.	Certificate	ii
2.	Declaration	iii
3.	Acknowledgement	iv
4.	Abstract	v
5.	Introduction	1
6.	Literature Review	6
7.	Research Methodology	13
8.	Research Background	19
9.	Research Findings and Trends	47
10.	Industry Focus	50
11.	Conclusion	57
12.	Research Direction	60
13.	References	61

List of Figures

Figure 1	Stages involved in the lifecycle of a product (National Institute of Standards and Technology's Manufacturing Engineering)	30
Figure 2	Porter's Value Chain	31
Figure 3	Barriers in implementing green supply chain management	34
Figure 4	Phases of Green Supply Chain Management	42
Figure 5	Green Supply Chain Management	44

INTRODUCTION

The inception of Green Supply Chain Management (GSCM), conceptually taken its roots during the Industrial Revolution. However lately it came to the forefront with increased sensitivities of the nations & society towards mitigation of the industrial or other waste's malefic effects on environment. In early environmental management frameworks, operating managers were involved only at arm's length. Separate organizational units had responsibility for ensuring environmental excellence in product development, process design, operations, logistics, marketing, regulatory compliance and waste management. Today, this has changed. As in the quality revolution of the 1980s and the supply-chain revolution of the 1990s, it has become clear that the best practices call for integration of environmental management with ongoing operations. Green supply-chain management (GSCM) is gaining increasing interest among researchers and practitioners of operations and supply chain management. The growing importance of GSCM is driven mainly by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profits. In fact, it is a business value driver and not a cost centre (Wilkerson 2005). In addition, the regulatory requirements and consumer pressures are driving GSCM. Hence, the scope of GSCM ranges from reactive monitoring of the general environment management programmes to more proactive practices implemented through various Rs (Reduce, Re-use, Rework, Refurbish, Reclaim, Recycle, Remanufacture, Reverse logistics, etc.).

Also, Realizing that sustainability can drive the improvement of the company's bottom line through cost savings, improved market share, and stronger brand images, a growing number of firms have begun to take "greening" (environmental-friendly) initiatives as their strategic weapons. Following this industry trend, the interest of academia on sustainability has also begun to increase substantially in the late 1990s. This growing interest sparked a series of new lines of research dealing with various supply chain activities that have important environmental implications. These activities include sourcing that involves acquiring, storing, handling, and recovering

virgin or recycled materials. In sourcing, for example, the failure to reduce the obsolescence and waste of maintenance, repair, and operating (MRO) supplies or scrap materials can contribute to environmental problems. In manufacturing, for example, the irresponsible disposal of defective products or unwanted manufacturing by-products can adversely impact the environment. Likewise, logistics reliance on transportation modes such as trucks and airplanes using fossil burning fuels and the subsequent emission of CO₂ can pollute the living environment such as air, water, and ground.

Earlier works and reviews have a limited focus and narrow perspective. They do not cover adequately all the aspects and facets of GSCM. For example, Bey (2001) presents a critical appraisal of developments in the field of industrial ecology only, while Zhang et al. (1997) focus only on green design. Much of the work is empirical and does not focus adequately on modelling and network design related issues and practices. Our objective is to present a comprehensive integrated view of the published literature on all the aspects and facets of GSCM, taking a 'reverse logistics angle' so as to facilitate further study, practice and research.

Sustainability refers to integration of environment, society etc to operations of the firm minimizing the impact of the waste generated on the well-being of the inhabitants of mother earth aims to alignment of profit realization activities along with environmental considerations. The triple bottom line concept emphasizes giving equal weight Companies and the economy, people's future success and long-term future of the planet. A similar concept i.e. 3P's refereeing to profit, people & planet echoes the similar overtones nudging the Operations or supply chain management to toe in line.

It bifurcates the two distinct drivers of SCM into terms and corporate image stability, regulatory compliance, liability, and regulatory drivers of sustainability as community relations, public expectations of employee health and safety, customer relations, cost reduction, and quality improvement to public expectation dimensions. Moreover Regulations, Marketing, Suppliers, Competitors and Internal factors have been identified to be motivational factors into GSCM practices.

GSCM = Green purchasing + Green manufacturing/materials management + Green Distribution / marketing + Reverse logistics.

The green sourcing wave has begun to roll with an increasing number of companies beginning to catch on and ride the wave in an effort to proactively manage a new era of customer needs, environmental regulations and competitive realities that will ultimately impact the business. Companies that want to get ahead of the curve and stay there need to begin thinking green now and develop an approach to sourcing and supply chain management that factors this new reality into their plans. One of the ways to know where your organization stands by carbon footprint study or an assessment of your organization's "green" status. "How to improve end – of – life of product management & how your organization is going to get there plan"?

Green Supply-Chain Management Defined

Green supply-chain management has its roots in both environment management and supply chain management literature. Adding the 'green' component to supply-chain management involves addressing the influence and relationships between supply-chain management and the natural environment. Similar to the concept of supply chain management, the boundary of GSCM is dependent on the goal of the investigator. The definition and scope of GSCM in the literature has ranged from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer, and even RL (Zhu and Sarkis 2004). For the purpose of this paper, GSCM is defined as 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'. We specifically focus on RL and mathematical modelling aspects in order to facilitate further study and research.

Green design has been used extensively in the literature to denote designing products with certain environmental considerations. It is the systematic consideration of design issues associated with environmental safety and health over the full product

life cycle during new production and process development (Fiksel 1996). Its scope encompasses many disciplines, including environmental risk management, product safety, occupational health and safety, pollution prevention, resource conservation and waste management.

Green operations relate to all aspects related to product manufacture/remanufacture, usage, handling, logistics and waste management once the design has been finalized. Green manufacturing aims to reduce the ecological burden by using appropriate material and technologies, while remanufacturing refers to an industrial process in which worn-out products are restored to like-new condition (Lund 1984).

Rogers and Tibben-Lembke (1999, 2) define Reverse Logistics as ‘the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal’, while Maruglio (1991, 57) defines waste minimization as ‘the reduction ... of hazardous waste which is generated (during production and operations) or subsequently treated, stored or disposed ...’.

Although, we have established some definitions of GSCM above, a consensus definition for green and sustainable supply chains does not exist. In fact, a review paper focusing purely on definitions for green and sustainable supply chains found a total of 22 definitions for green and 12 definitions for sustainable supply chain management (Ahi and Searcy, 2013). This issue alone makes a literature review on this topic a non-trivial exercise due to the many definitions that do exist. Part of this difficulty is the definition of a supply chain and where the boundaries are to be drawn (Sarkis, 2012). Whether terms such as logistics, reverse logistics, purchasing, and procurement are to be considered synonyms for supply chain management is another point of confusion. Similarly, whether definitional boundaries are affected by the inclusion of upstream and downstream partners in the supply chain is another concern in determining the search terms. To help bound the scope of our research, we focus our review on forward supply chains, leaving reverse logistics and closed-loop supply chains outside the scope of this study.

Importance of GSCM

As in any emerging research area, the early literature focuses on the necessity and importance of GSCM, defines the meaning and scope of various terms and suggests approaches to explore the area further. Fundamentals of greening as a competitive initiative are explained by Porter and van der Linde (1995a,b). Their basic reasoning is that investments in greening can be resource saving, waste eliminating and productivity improving. Three approaches in GSCM, namely reactive, proactive and value-seeking, are suggested (Kopicki et al. 1993; van Hoek 1999). In the reactive approach, companies commit minimal resources to environmental management, start labelling products that are recyclable and use 'end of pipeline' initiatives to lower the environmental impact of production. In the proactive approach, they start to pre-empt new environmental laws by realizing a modest resource commitment to initiate the recycling of products and designing green products.

In the value-seeking approach, companies integrate environmental activities such as green purchasing and ISO implementation as strategic initiatives into their business strategy. The perspective then changes from greening as a burden to greening as a potential source of competitive advantage (van Hoek 1999). Owen (1993) and Sarkis (1995) discuss environmentally conscious manufacturing. Friedman (1992), Guide and Wassenhove (2002) and Gupta (1996) discuss the changing role of the environmental manager. Interactions among various stakeholders on integrated GSCM and advantages that may accrue to them have been described by Gungor and Gupta (1999).

LITERATURE REVIEW

Literature review may be considered as the primary method of synthesizing previous research on GSCM. Structured literature review considers the GSCM research that can be applied both in qualitative and a quantitative way. The structured review represents an effective tool for analyzing a sample of research document in a systematic and rule-governed way. Over the past 3 years, the authors had several opportunities to collect and study the literature concerning to GSCM. There were two main reasons:

- a) Interactions with the organizations with focus on GSCM and
- b) One of the authors is pursuing doctoral in the field GSCM implementation.

The green supply chain management has gained more interest among the researchers of the supply chain management. However, it is important to have information about what research has already been done in the green supply chain which will help us to come with the better suggestions to find out how it will actually affect the bottom line. The review of the previous literatures has been discussed as follows:

- a) The review paper “An Overview on Green Supply Chain Management in India” by NimavatDheeraj and Namdev Vishal shows that with the adoption of green practices there will be many benefits to an organization and allow them to have a competitive advantage. It also shows that Environmental Performance Index of India is very poor due to lack of awareness of Green Supply Chain Management so there is scope for working in this direction as well.
- b) In the article ”Greening the Supply Chain Through Supply Chain Initiatives Towards Environmental Sustainability” Tareq et al. attempted to show the path and the various steps to be taken by the various business firms to make sustained environmental development. The paper investigated the adoption of green supply chain initiatives and the data was extracted from ISO 14001 certified firms through survey in Malaysia.

The study also tells the four main drivers for the Malaysian companies to implement green practices which were regulations, customer requirements, expected business gains and social responsibility.

c) The study by Dixit Garg, S. Luthra and A.Haleem in the article “Ranking of Performance Measures of GSCM towards Sustainability :Using Analytical Hierarchy Process” demonstrates the various performance measures useful for any organization. The five perspectives (Environment, Social, Economic, Operational& Cost) and nineteen performance measures were identified and ranked towards sustainability framework using Analytical Hierarchy Process. This paper made a benchmarking framework to take the difficult decisions related to GSCM for any firm to experience increase in benefits.

d) The authors Noor Aslinda Abu Seman, NorhayatiZakuan, Ahmad Jusoh and MohdShokiMdArif in the paper “GREEN SUPPLY CHAIN MANAGEMENT: A REVIEW AND RESEARCH DIRECTION” have briefly reviewed the various literatures and has given a research direction framework for this emerging concept. The author has put emphasis on development of GSCM in developed and developing countries. The study also tells that there is scope for working towards the adoption and implementation of green supply chain management in Malaysia’s manufacturing industries.

e) The paper “Overview of Green Supply Chain Management: Operation and Environmental Impact at different stages of supply chain” by Rajesh Kumar and Rituraj Chandrakar focuses on the need for eco-friendly systems so as to reduce the deterioration of environment. The author writes by establishing long term relationships between buyer and supplier both environmental and economic performance can be improved. The author also attempts to study the optimization and implementation of the supply chain system. The paper also gives the importance about why GSCM is an important measure for the conserving the energy.

f) The article “Designing the green supply chain strategy for Indian Manufacturing firm” by Surajit Bag offers the Indian manufacturers an opportunity to appreciate the green perspectives of supply chain which can help to implement green supply chain strategy to have maximum benefits. The paper focuses on how to integrate the supply chain strategy with the traditional supply chain. The author has done thorough

literature review, examined small, medium and large organizations who are implementing the GSCM in their practices and provided a six step strategic approach for the implementation of green supply chain management. It also tells that the companies can have a sustained competitive advantage if they involve suppliers and third parties.

g) “A Study of Success Factors in Green Supply Chain Management in Manufacturing Industries in Malaysia” by Norlinda Mohd Rozar, Wan Hasrulnizzam Wan Mahmood, Abdullah Ibrahim, Muhammad Ashlyzan Razik showed that due to increasing environmental issues green supply chain is gaining momentum in Malaysia. The survey was carried to 241 out of 522 certified companies in Malaysia. The author found out that it is raw materials which is allowing companies to have a competitive advantage and only four firms have merged with the GSCM to meet the needs of the customers and the implementation of green supply chain initiatives.

h) The paper on “Current status of Green Supply Chain Practices and Initiatives in the Indian SMEs: An Exploratory Study ” by Sarabjit Singh, Arwind Bhardwaj identifies the various factors in the environment that affects the manufacturing sectors at the same time greens the traditional supply chain through survey questionnaire. The author focuses on the various activities involved in the supply chain system of Indian manufacturing firms and how much green they are in their activities taking into consideration the procurement, transportation and the distribution of raw materials.

i) In the paper on “Application of Critical Success Factors in Supply Chain Management” by Mohamed SyazwanAbTalib, Abu Bakar Abdul Hamid the various success factors in supply chain management were reviewed. A total of 42 critical success factors’ studies related to supply chain management was obtained from the major databases. The major four critical success factors were identified from the literature survey were collaborative partnership, information technology, human resource and top management support. This paper will serve as a platform for for the further and future research on critical success factors.

j) The author Ming-Kuei Chien in his article “Influences of green supply chain management practices on organizational sustainable performance” demonstrated how implementing the six step green supply chain strategies/practices will improve the

organizations' environmental, economic, social and sustainable performance through literature survey, interviews, questionnaire survey and after that analysis of the data collected. The study also demonstrates the various environmental protection standards. This research discusses the Taiwan's electronics and electrical industries by considering the green standards for green supply chain practices for sustainability in organizations.

k) The paper "Barriers to implement green supply chain management in automobile industry using interpretive structural modelling technique-An Indian perspective" by Sunil Luthra, Vinod Kumar, Sanjay Kumar, Abid Haleem aims to develop a structural model of the barriers for implementation of green supply chain management in Indian Automobile Industry. 11 barriers were identified which were later classified on the basis of dependence and driving power. The removal of the barriers is also suggested in this paper.

These are some of the well published papers in the field of green supply chain management.

Now, to provide an organized look at the published literature and review it in a systematic fashion, the taxonomy of the GSCM literature was developed by H. Min and I. Kim. This taxonomy will help the researcher identify hot research fields of GSCM, neglected areas of research, and research trends. In terms of the subject areas of research, this study classified the published GSCM articles into six areas of applications. These six categories are developed by (H. Min and I. Kim) by taking into account a sufficient number of published articles (at least a total of 40 hits) in the each cluster of categories and the typical breakdown of key supply chain activities (sourcing, making, and delivering):

- **Policy**, which is mainly concerned with business ethics and corporate social responsibility tied to triple bottom lines (namely the three pillars of people, planet, and profit), environmental policy guidelines addressing public community concerns, environmental audits, statutory requirements, and government regulations.
- **Synthesis**, which portrays a broad picture (e.g., literature reviews, research agenda explorations, and tutorials) of green supply chain management that cuts across the

different boundaries (business activities integrating sourcing, making, and delivery processes) of supply chain management.

- **Purchasing**, which focuses on environmental issues related with supplier–buyer relationship, environmentally sound sourcing decisions, and supplier certification and selection based on environmental quality standards such as ISO 14000 guidelines.
- **Manufacturing**, which pays attention to remanufacturing, environmental-friendly product design and development that aims to reduce pollution and harmful waste.
- **Green Logistics**, which deals with environmental issues related to sustainable transportation, hazardous material handling and storage, inventory control, warehousing, packaging, and facility location-allocation decisions that aim to reduce carbon footprints.
- **Reverse Logistics**, which improves logistics efficiency in handling returned or recycled products and managing waste disposal and removal after the end of a product life cycle.

Sarabjit Singh, Arvind Bhardwaj, (2013) studied the various activities involved in the supply chain processes of the various Indian manufacturing industries and finds how much eco-friendly they are in their logistics as well as supply chain activities.

Byeong-Yun Chang et al.(2013) identified the determinants or drivers and its impact on implementation of GSCM in the Korean companies. The green supply chain practices discussed are inbound function, production function and outbound function.

The determinants or drivers for the implementation of green supply chain management practices include external and internal pressures. The relation between these determinants and the green supply chain practices are studied. Lakhwinder Pal

Singh et al (2011) found out the relationship between the role of logistics and transportation in GSCM and found that the use of e-shopping drastically decreased the carbon dioxide emissions when compared to ordinary shopping and hence the importance of e-shopping is insisted. Balaji Met al.(2014) identified the common barriers in implementing green practices in Indian foundries and prioritized using Interpretive Structural Modelling (ISM) approach. Goshen Stephen et al.(2015)

conducted a survey on current green activities in automobile parts manufacturers in India and suggested to maintain a better collaboration among important stakeholders to obtain efficient and effective green supply chain practice. Noor Aslinda Abu Semanet al.(2012) reviewed the literature and to develop the research direction of the study focused on the development of green supply chain management in a developed and developing countries. Quinghua Zhu et al.(2005) aimed to evaluate and describe GSCM drivers, practices and performance among various Chinese manufacturing organizations. An exploratory factor analysis was conducted to derive groupings of GSCM pressures, practice and performance. Yan Li, (2011) aimed to examine the adoption levels of green supply chain practices in Chinese manufacturing facilities also explored performance measurement for GSCM and concluded that practicing green purchasing can ensure product environmental quality. M. Ghobakhloo et al.(2013) presented the integrated framework of GSCM implementation as a holistic perspective through applying qualitative analysis on the existing literature. Rajesh Kumar, Rituraj Chandrakar,(2012) The paper emphasizes upon the application of Supply Chain Management and adding the Green component so as to insist the need of environment friendly systems. The factors include external GSCM relationship factors, eco-design, investment recovery, organizational learning, management support and commitment. The study has provided ample reasons for GSCM to be adopted as one of the important measures towards conservation of environment. Nimawat Dheeraj and Namdev Vishal, (2012) made a comparison between lean manufacturing and green manufacturing from which green manufacturing techniques dominates lean manufacturing in some aspects and it is more advantageous. L.K.Toke, R.C.Gupta, Milind Dandekar, (2010) highlighted the green supply chain process and number of integrative issues effecting these process are presented. Ashish Kumar Bhateja et al.(2011) aimed to study the various activities of the supply chain processes of the various Indian manufacturing industries and discussed the environment factors affecting it. Rajesh Kumar and Sheina Shekhar,(2015) studied the level of implementation of green supply chain management in the steel industries in the state of Chhattisgarh and suggest the mode of action for a green environment and also for increasing the profitability. The steel industries have a very large number of inputs including machine components and raw materials. The study concentrated on green sourcing and procurement, green productions and

manufacturing, green warehousing and distribution, and green transportation focused initiatives. It has been observed that that the implementation of GSCM in the steel industries in the state of Chhattisgarh is still in primitive stage except for a few manufacturers. Samir K. Srivatstava, (2007) identified major works on green supply chain management and classified them to identify gaps, issues and opportunities.

RESEARCH METHODOLOGY

Despite the relative youth of GSCM research, its body of literature is abundant. Given this rich GSCM literature, it is important for us to examine, evaluate, and integrate prior studies related to the topic of GSCM. Without the effort to synthesize prior GSCM research, we may end up duplicating what has already been studied, fail to develop a new theory built upon the previous efforts of others, and experience difficulty in identifying emerging research agenda that were often overlooked in the past. This effort began with the retrieval of past research works on GSCM through the on-line literature search, a summary of research outcomes, critiques of prior research works, identification of key research themes and popular research streams, and integration of past research efforts. To elaborate, we first defined GSCM in the broadest possible sense so that we could conduct thorough literature searches and determine how GSCM literature was evolved from the theoretical underpinnings of other related social science, economics, business, and engineering fields. To avoid confusion created by a lack of consensus on GSCM terminology and the introduction of rivalling concepts such as sustainable supply chain management (SSCM) propagated by some circles of the academia, we would like to define GSCM as an incorporation of environment-friendly initiatives into every aspect of supply chain activities encompassing sourcing, product design and development, manufacturing, transportation, packaging, storage, retrieval, disposal, and post-sales services including end-of-product life management.

Herein, the examples of environment-friendly initiatives include the company-wide environmental guidelines/policy, compliance with environmental regulations (e.g., U.S. Environmental Protection Agency rules, European Union environmental regulations) and standards (e.g., ISO 14000 environmental management standards), supplier certification and selection based on its commitment to sustainability, use of renewable energy (e.g., sunlight, wind, rain, and geothermal heat), use of biofuels, use of degradable or compostable packages, and environmental performance monitoring.

In terms of the research methodologies, the papers are categorized into the following areas:

- **Conceptual** Those expository studies that discuss the strategic importance of greening initiatives to supply chain management and summarize emerging trends and/or newer environmental quality concepts based on qualitative analyses.
- **Case study** Those intensive studies primarily focused on idiosyncratic nature of a single or several real-life examples that reflect the relevance/irrelevance of certain theories or prescriptions. Case studies as a research methodology explain, explore, or describe a phenomenon of interest. This requires a methodologically rigorous and accurate representation of actual data and multiple sources of evidence. Thus, the purposes, presentation of data, and methods for gathering data may differ among cases. However, real life contexts under special focus of the case study are not perfect representation of the population and thus can be questioned for generality and consistency.
- **Exploratory** Those employing descriptive data analyses based on the questionnaire survey data that intend to identify the most prevalent environmental practices and synthesize the common opinions of practitioners regarding environmental initiatives. This type of methodology that often relies on the summary statistics is less concerned about theory building or theory refinement for an application of an exploratory study to the logistics area.
- **Empirical** Those based on a social science research tradition that aims to develop, advance, and refine theories through hypotheses testing by employing rigorous statistical data analyses such as a structural equation model or other forms of confirmatory data analysis such as path analysis that helps find cause– effect relationships among a set of variables. This type of methodology is increasingly used to build theories in the GSCM literature for a methodological foundation of an empirical study.
- **Analytic** Those employing quantitative tools such as integer programming, dynamic programming, goal programming, nonlinear programming, and other techniques such as simulation, systems dynamic modelling, or soft systems methodologies (SSM).

The objective of this paper is to identify major works on green supply-chain management research integrating environmental thinking into supply-chain management, and thereafter, to classify them so as to identify gaps, issues and opportunities for further study and research. A literature review seems to be a valid approach, as it is a necessary step in structuring a research field and forms an integral part of any research conducted (Easterby-Smith et al. 2002). This helps to identify the conceptual content of the field (Meredith 1993) and guides towards theory development.

The research by various researchers is driven by theoretical pre-considerations and follows a clear process, as this allows conclusions to be drawn on the reviewed literature. It may be classified as an archival research method in the framework for conducting and evaluating research suggested by Searcy and Mentzer (2003). The process of analysis comprises of the following steps:

- **Defining unit of analysis:** The unit of analysis has been defined as a single research paper/book. We further delimit the material (research paper/book) to be collected as per our scope.
- **Classification context:** We select and define the classification context to be applied in the literature review to structure and classify the material. There are two contexts: the problem context and methodology/approach context.
- **Material evaluation:** The material is analysed and sorted according to the classification context. This allows identification of relevant issues and interpretation of the results. Problem context and related methodology/ approaches allow classification of the reviewed literature, which can be derived deductively or inductively.
- **Collecting publications and delimiting the field:** Our literature review focuses upon books, edited volumes and journal articles only. To establish a time span, a starting point was set at 1990. This seems justified, as the beginning of the debate on GSCM can be traced to this period. Library databases were used where a keyword search using some important keywords such as ‘green supply chain’, ‘remanufacturing’, ‘green purchasing’, ‘green design’, ‘industrial ecology’,

‘industrial ecosystems’, ‘RL’, ‘remanufacturing’ and ‘waste management’ were conducted.

To delimit the number of publications, empirical papers mainly addressing firm-level or specific operational issues were excluded from the review. Similarly, highly technical work on topics such as life-cycle assessment, inventory, pollution prevention and disassembly was also excluded from the review. Research with a highly ecological rather than supply chain perspective (green purchasing, industrial ecology and industrial ecosystems) was also excluded. This seems to be justified when considering the objective outlined, which concentrates on integrating environmental thinking into supply-chain management.

The researchers use the published literature, which I used in my study, from 1990 onwards to go back to other papers by cross-referencing. As the published literature is interlinked to a considerable degree, one paper (stem) leads to others (branches). So, when we pick up one thread, we are able to find others. As references accumulated, we found that some of them were more central and useful than others. We consider such references as seminal papers. These were also found to be generally referenced a number of times in subsequent literature.

Thus, within our defined objective, my study covers the work which is already done by researchers and which integrates and takes forward the literature on GSCM since its conceptualization. About 1500 books, articles from journals and edited volumes have been covered. The list of 227 cited references is given at the end.

Classification Based on Problem Context

We classify the existing GSCM literature into three broad categories based on the problem context in supply chain design: literature highlighting the importance of GSCM; literature on green design; and literature on green operations. Green design may be looked into from the viewpoint of environment conscious design taking lifecycle assessment of the product/process into account. Similarly, green operations involve all operational aspects related to RL and network design (collection; inspection/sorting; pre-processing; network design), green manufacturing and

remanufacturing (reduce; recycle; production planning and scheduling; inventory management; remanufacturing: re-use, product and material recovery) and waste management (source reduction; pollution prevention; disposal). We purposely do not consider literature and practices related to green logistics, as we feel that the issues are more operational than strategic in nature and may not be significant in the supply chain design per se. We also do not focus in detail on empirical studies on GSCM and literature on green purchasing, industrial ecology and industrial ecosystems, as it is delimited by our research design. We focus more on RL as the establishment of efficient and effective RL networks is a prerequisite for efficient and profitable recycling and remanufacturing. We also focus more on mathematical modelling aspects. Both of these have received less attention in the GSCM literature so far.

The classification is for the purpose of easier understanding of different problem contexts of GSCM – their interactions and relationships – in order to present a well-defined and clear picture for further study and research. It is not rigid, and there may be many overlaps (for example, reduce gets attention not only in green manufacturing and remanufacturing, but also elsewhere as in reverse logistics and waste management; green design, too, emphasizes reduced use of virgin material and other resources. Similarly, green design should take into account the whole product life-cycle cost, including those during manufacturing and remanufacturing, reverse logistics and disposal. The figure does not take account of all these complex relationships and interactions but presents a simplistic view. Further, we do not show some other relevant aspects and areas such as green purchasing, industrial ecology and industrial ecosystems, as they are delimited by our research design.

Classification Based on Methodology/Approach

The literature on GSCM may also be classified on the basis of methodology and approach used into: thought papers and perspectives; frameworks and approaches; empirical studies; mathematical modelling approaches; and reviews. This helps us to understand GSCM from a different perspective from the problem context described earlier. Thought papers and perspectives as well as frameworks- and approaches-related articles have been sufficiently covered. Similarly, review papers have been covered in the Introduction, and are not covered further.

Therefore, empirical studies and mathematical modelling approaches are covered here.

RESEARCH BACKGROUND

Green Design

The literature emphasizes both environmentally conscious design (ECD) and life-cycle assessment/analysis (LCA) of the product. The aim is to develop an understanding of how design decisions affect a product's environmental compatibility (Glantschnig 1994; Navin-Chandra 1991). Madu et al. (2002) present a very useful hierarchic framework for environmentally conscious design.

A common approach is to replace a potentially hazardous material or process by one that appears less problematic. This seemingly reasonable action can sometimes be undesirable if it results in the rapid depletion of a potentially scarce resource or increased extraction of other environmentally problematic materials. Several examples of such equivocal proposals are presented by Graedel (2002). Azzone and Noci (1996) suggest an integrated approach for measuring the environmental performance of new products, while Arena et al. (2003) assess the environmental performance of alternative solid waste management options that could be used.

Life-cycle assessment/analysis is described as a process for assessing and evaluating the environmental, occupational health and resource-related consequences of a product through all phases of its life, i.e. extracting and processing raw materials, production, transportation and distribution, use, remanufacturing, recycling and final disposal (Gungor and Gupta 1999). The scope of LCA involves tracking all material and energy flows of a product from the retrieval of its raw materials out of the environment to the disposal of the product back into the environment (Arena et al. 2003; Miettinen and Hämäläinen 1997; Tibben-Lembke 2002). Attempts have also been made to develop operational models to help companies understand, monitor and assess life-cycle management (Sanchez et al. 2004).

Green Operations

Some of the key challenges of GSCM such as integrating remanufacturing with internal operations (Ferrer and Whybark 2001), understanding the effects of

competition among remanufacturers (Majumder and Groenevelt 2001), integrating product design, product take-back and supply chain incentives (Guide and van Wassenhove 2001, 2002), integrating remanufacturing and RL with supply chain design (Chouinard et al. 2005; Fleischmann et al. 2001; Goggin and Browne 2000; Savaskan et al. 2004) are posed in this area.

Green manufacturing and remanufacturing. This is a very important area within green operations. The techniques for minimum energy and resource consumption for flow systems in order to reduce the use of virgin materials are based on three fields of study: pinch analysis (Linnhoff 1993), industrial energy (Boustead 1979) and energy and lifecycle analysis (Lee et al. 1995). Recycling, mainly driven by economic and regulatory factors, is performed to retrieve the material content of used and non-functioning products. Logistics represent up to 95% of total costs (Stock 1998) in recycling. Economically driven recycling finds its application in automobiles (Bellmann and Khare 1999) and the consumer electronics industry (de Fazio et al. 1997; Johnson 1998). Regulatory electronics recycling is also practised (Krikke et al. 1999a,b; Nagel and Meyer 1999; Pohlen and Farris 1992).

Hoshino et al. (1995) define remanufacturing as recycling-integrated manufacturing. Industries that apply remanufacturing typically include automobiles, electronics and tyres. Product recovery refers to the broad set of activities designed to reclaim value from a product at the end of its useful life. Pugh (1993) uses mathematical models in evaluating resource recovery options. Various authors categorize and classify the recovery process differently. Johnson and Wang (1995) define it as a combination of remanufacture, re-use and recycle, whereas Thierry et al. (1995) divide recovery into repair, refurbish, remanufacture, cannibalize and recycle. Melissen and de Ron (1999) define recovery practices and provide relevant definitions and terminology. A model for evaluating recovery strategies for the product without violating the physical and economical feasibility constraints is proposed by Krikke et al. (1998), which has been further modified and updated (Fleischmann et al. 2001, 2002; Goldsby and Closs 2000; Inderfurth et al. 2001; Krikke et al. 2003).

The purpose of repair is to return used products to 'working order'. The quality of repaired products is generally lower than the quality of new products. The purpose of refurbishing is to bring used products up to a specified quality. Analysis of

remanufacturing facilities for household appliances and automotive parts by Sundin and Bras (2005) reveals that cleaning and repairing are the most critical steps in the remanufacturing process. Amini et al. (2005) find that RL operations and the supply chains they support are significantly more complex than traditional manufacturing supply chains. They present a case study of a major international medical diagnostics manufacturer to illustrate how a RL operation for a repair service supply chain was designed for both effectiveness and profitability by achieving a rapid cycle time goal for repair service, while minimizing total capital and operational costs. Most remanufacturing literature also deals with repair/refurbish (Ashayeri et al. 1996; Ayres et al. 1997; Craig Smith et al. 1996; de Ron and Penev 1995; Dowlatshahi 2000; Ferrer 1997a,b, 2001; Guide and Srivastava 1997c; Guide et al. 2000b; Gupta 1993; Linton and Johnson 2000; Thierry et al. 1995).

Disassembly is a systematic method of separating a product into its constituent parts, components, subassemblies or other groupings (Taleb and Gupta 1997). It may involve dismantling and/or demolition and/or reprocessing. Tani and Güner (1997) compare assembly and disassembly and describe the identifiers of the disassembly process. An important aspect of disassembly is to find efficient disassembly process scheduling (Dowie 1994; Gungor and Gupta 1998; Gupta and Taleb 1994).

Many of the authors have distinguished remanufacturing and manufacturing on the basis of activities involved in remanufacturing process, which is absent in case of manufacturing, activities are disassembly, cleaning, inspection and sorting. In remanufacturing the quality, quantity and timing of the used products cannot be controlled, whereas it can be controlled in the case of manufacturing (Fleischman and Krikke 2000). It can be inferred that production planning for remanufacturing is a complex task (Sundin 2006). In general remanufacturing is 3 to 5 times more labour intensive. Nevertheless, it has advantages over the manufacturing as the customer has to pay less, the remanufacturing companies earn more since fewer new components are required and the whole process is pro to the environment. That is why remanufacturing is sometimes being referred to as a “winwin- win” situation compared with manufacturing (Seitz and Peattie 2004). In spite of having advantages, some challenges exist at each phase, i.e. collection, remanufacturing process and distribution of remanufacturing system. The main challenge in remanufacturing is to match the demand and supply of remanufactured goods, which

is due to uncertainty in both demand for remanufactured products and supply of remanufacture-able product to the firm.

Performance Measurement of Green Supply Chain Management

Many firms are adopting GSCM policy due to pressure from public, government, competition, and numerous benefits such as cost reduction supplier integration environmental innovation (Rao 2002). Large firms are not only adopting GSCM but also putting pressure over their suppliers (small firms) to go green (Zhu et al. 2005). To improve environmental image and gain economic profit, GSCM has become emerging environment practice for manufacturer (Zhu et al. 2007). Seeing the importance, it has become obvious to measure the degree of GSCM practice and its contribution to the firm's performance (Zhu et al. 2007). The relationship between environmental and economic performance is positive and significant (Zhu and Sarkis 2004), however direct impact of GSCM on economic performance probably takes longer time to realize (Bowen et al. 2001). Firms may have to bear short term economic losses when going for improving their environmental performance but in long term, there is possibility of environmental practices due to competitive pressure and other factors which can lead to fetch positive economic performance (Zhu and Sarkis 2007).

Performance of GSCM should be measured on the basis of some criteria. Zhu et al. (2007) in their paper has mentioned that the criteria should recapitulate the overall impact of GSCM. In general, criteria can be divided into following heads.

- 1) Generation of pollution and waste management, which may include emissions of hazardous gas, water consumption, reducing the volume of residues and lowering pollution levels.
- 2) Preservation of resources, it may include using fewer natural resources and less energy, decreasing the consumption of hazardous and toxic materials.
- 3) Economical benefits, it may include reduction in costs material purchasing, fees for water treatment and discharge, penalties for environmental accidents. On the basis of these criteria or such other criteria performance of can be measured for the long term benefit.

The ISO 14031 further extension of ISO 14000, is designed for use in environmental performance evaluation with indicators in three key areas: (1) Environmental condition indicators; (2) Operational performance indicators; and (3) Management performance indicators (Zhu et al., 2013).

Performance measurement tools for environmental operations are increasing, but they are not so adequate to entirely evaluate the impact of GSCM. Hervani et al. (2005) in their paper has mentioned the following common tools used for measuring the performance. They are Analytical Hierarchy Process (AHP), Activity-Based Costing (ABC), Balanced Scorecard (BSC), Life Cycle Analysis (LCA), Product Stewardship, Design for Environment (DEF), and Data Envelopment Analysis. Some of the tools can be directly applied to aspects of GSCM and performance, and others require adjustments and extensions (Hervani et al. 2005). Overall, there is none of the tools are perfect for performance measurement of GSCM. Any of the tools that are to be used for planning, estimation, and management, their practice is greatly rely on agreement across organizations and the ease and accessibility of data and knowledge to apply these tools.

Green Purchasing

Green Purchasing means procurement of raw/finished products and services that have less effect on human health and the environmental condition which when compared with same competing products and services they fulfil the same purpose. This comparison may include raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, and disposal of the product or service. Green purchasing is also defined as environmentally preferred purchasing (EPP), environmentally responsible purchasing, green procurement, affirmative procurement, eco-procurement, and environmentally responsible purchasing. A green product is one which satisfies and fulfil consumers' desire without damaging the environment and contributes towards a more sustainable world. Green purchasing allow a firm/industry to offset financial and environmental risk. Customer demand and pressure for suppliers to go green can facilitate environmental purchasing activities such as evaluating environmentally friendly products and packaging, reducing packaging material, and performing product environmental design

Alternatively, firms/industries now want to involve their suppliers at the basic design stage or to develop a network to pre-qualify suppliers that have responsible environmental management system. Continuous assessments and benchmarking can uplift an organization with their existing process. Green purchasing do bring important benefits as well as advantages for its practitioners.

Green Manufacturing

Green manufacturing is a new tool that can be viewed as a products environmental friend. Green Manufacturing means increasing production efficiency, lowering raw material costs, basic designing, manufacturing, delivering, and disposing products that produce minimum negative effect on environment ie reducing environmental safety expenses in society which are economically viable. Green manufacturing can be termed as an economically-driven, plant-wide and integrated approach to reduce and eliminate all waste associated with the product i.e. design phase, manufacture, use and/or disposal of products and materials. The drivers and barriers of green manufacturing practices in India as seen in Small scale industries differ from those large enterprises due to the fact that small scale industries lack the raw data, resources, technical expertise and experience required to implement green manufacturing initiatives. Studies on green manufacturing topic are very few till date. The implementation of Green Manufacturing in INDIAN industries is possible only with the collaborated efforts of government and industry in a strategic way by mitigating the Green Manufacturing barriers. In today's scenario the problem of e-waste is the major issue, green technology is the only solution to this as it is the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the environment. The main goal of Green Manufacturing is sustainability. However, there has been few studies which focus the issue of Green Supply Chain Management performance evaluation. The process of Green Manufacturing involves investing in production process improvements rather than control technology, substitute renewable sources for finite ones, employee recycling and the companies must decide whether to make or buy the product. Burk and Goughran (2007) also presented another framework for sustainability to realize green manufacturing. The framework on their study was

based on SME manufacturers who achieved ISO 14001 certification. Green manufacturing (GM) is defined in most generic manner as “manufacturing practices that do not harm the environment during any of its journey phases” (Srivastava,2007). It involves green design of products, use of environmental friendly raw materials, eco-friendly packing, distribution, and reuse after end of life of product. It slows the depletion of natural resources and lowers the trash (Foster,2001). GM concepts originated in Germany, but its scope, nature of activities and focus kept changing with respect to time. GM is not restricted to manufacturing alone. One can notice, it has been continuously evolving and has been demanding comprehensive treatments.

The increasing need for achieving higher economic prosperity among firms with least environmental impact has led to the birth of a new manufacturing paradigm of Green Manufacturing (GM). However, the implementation of Green Manufacturing in any industry is not an easy task mainly in developing and underdeveloped country because of many issues limited financial and human resources, awareness about environmental aspect of manufacturing, governmental policies, immediate impact on GDP, etc. The implementation of Green Manufacturing is possible only with combined efforts of government and industry in a planned way. So there is a need to understand the role and potential of various drivers helping in the implementation of Green Manufacturing in any industry. The standards to reach green manufacturing include zero potential safety problems, zero health threats on the operators and product users, and zero environmental pollution, waste recycling, and waste disposal during the production process as much as possible (Gao et al. 2009).

Lean Manufacturing

Lean manufacturing, often pronounced as Toyota production system (TPS) in many academic literature, ea started in Toyota Motor Manufacturing Company after the Second World War when many Japanese firms including Toyota were facing with the new challenge of managing production system with limited resources (Liker, 1998; Pavnaskar et al., 2003). Firms that have successfully reduced their internal waste through lean production methods also implement practices for better environmental management. Lean manufacturing is a conceptual work identified in

many industrial organizational. Accordingly, the goal of lean manufacturing is to minimize the waste in human effort, inventory maintained, product availability timely to market and manufacturing space to become highly responsive to customer demand while producing quality products in the most efficient and economical manner. Lean manufacturing is a concept which mainly aims at sounder, more productive as well as more effective manufacturing by eliminating all elements of waste in the manufacturing process. Lean manufacturing can be best defined as eliminating waste in a production process (Womak & Jones, 1996). Anything whether process or product which may be tangible and intangible that does not add value to the final product is called waste (Henderson & Larco, 2003). Basically lean manufacturing aims to perform production with zero defects, to reduce costs, so that firm meet customer requests with amount desired, to hold no excess inventories, and to continually make improvements by eliminating waste product. Elimination of the waste elements is one of the most important elements to obtain the maximum outputs with minimum inputs in all processes in production during the lean manufacturing process. Lean Manufacturing aims at delivering sustainable competitive advantage to organizations as a change and improvement strategy it has not been successfully implemented in manufacturing industries at large.

Green Marketing

The concept of green marketing has now become important in the last few decades due to dramatic increase in environmental awareness worldwide. Green marketing practices as such till date has not received much attention what they deserve, there are several studies on green marketing that indicates both the importance of examining actions/doings and the social complexity involved in accomplishing green marketing. Though green marketing is a more fluctuating issue in the western countries, the emerging economies in Asian countries is not left too far behind. A good green consumer can be defined as one who avoids any such product which may harm or damage to any living organism, cause deterioration on the environment during process of manufacturing or during process of usage, and consume a large amount of non-renewable energy. Green products can be used for a number of reasons, including being manufactured through a green way or products when used

make for a greener way of life (Mohanasundaram, 2012) .The dramatic growth of new green industries indicated the positive attention by the consumers. There are many evidences that various types of companies are now switching to adopt green philosophies such as traditional manufacturing companies become more profitable after transforming to green manufacturing system.

Reverse Logistics and Network Design

Reverse logistics activities differ from those of traditional logistics (Carter and Ellram 1998). Reverse logistics networks have some generic characteristics related to the coordination requirement of two markets, supply uncertainty, returns disposition decisions, postponement and speculation (Blumberg 1999; Fleischmann et al. 2000; Hess and Meyhew 1997; Jahre 1995; Krikke et al. 1999a, 1999b; Lambert and Stock 1993; Yalabik et al. 2005). As a result, they affect network design to a considerable extent. Collection is the first stage in the recovery process in which product types are selected and products are located, collected and transported to facilities for remanufacturing. Used products originate from multiple sources and are brought to the product recovery facility in a converging process (Krikke et al. 1998). Inspection/sorting illustrates the need for skill in the sorting of used products (Ferrer and Whybark 2000). This may be carried out either at the point/time of collection itself or afterwards (at collection points or at remanufacturing facilities). Cairncross (1992) suggests that collection schemes can be classified according to whether materials are separated by the consumer (i.e. separation at source) or centralized (i.e. mixed waste processed).

The need for environmentally responsible logistics systems is highlighted by Wu and Dunn (1995). The importance of RL programmes and the process of their development and implementation have also been described in the literature (Poist 2000; Stock et al. 2002). Redesigning logistics networks to accommodate product returns and remanufacturing and re-use of such parts and components can often be profitable and is assuming greater importance in business as well as in research (Tibben- Lembke 2002). The physical location of facilities and transportation links need to be chosen to convey used products from their former users to a producer and to future markets again (Fleischmann et al. 2001).

Companies need to realize the hidden value in RL and start to focus in this area (Mollenkopf and Closs 2005). They need to understand the financial impact of RL strategies. Srivastava and Srivastava (2005) develop a hierarchical decision-making framework to find the feasibility of profit-driven RL networks. They find RL activities profitable for their select category of products. Nowadays, information and communication technologies (ICT) are likely to play a key role in the co-ordination and integration of GSCM activities (Dekker et al. 2004). Problems related to the integration of RL activities within an organization have been dealt by Chouinard et al. (2005), while Daugherty et al. (2005) find that resource commitment to information technology leads to superior RL performance.

For traditional 'forward logistics' environments, quantitative approaches such as mixed integer linear programming (MILP) models (Mirchandani and Francis 1989) are readily available; however, a standard set of models is yet to be established for reverse networks. A survey by Fleischmann et al. (2000) compares nine case studies on recovery networks in different industries. These include carpet recycling (Louwers et al. 1999), electronics remanufacturing (Jayaraman et al. 1999; Krikke et al. 1998), reusable packages (Kroon and Vrijens 1995), sand recycling from demolition waste (Barros et al. 1998) and recycling of by-products from steel production (Spengler et al. 1997). They discuss the applicability of traditional forward approaches and examine the resulting network structure in different contexts.

Waste Management

Caruso et al. (1993) model a solid waste management system (including collection, transportation, incineration, composting, recycling and disposal) using a multi objective location-allocation model supported by planning heuristics. A decision support system, for urban waste management in a regional area, for evaluating general policies for collection and for identifying areas suitable for locating waste treatment and disposal plants is presented by Haastrup et al. (1998). Giannikos (1998) uses a multi-objective model for locating disposal or treatment facilities and transporting waste along the links of a transportation network. Bloemhof-Ruwaard et al. (1996a,b), Richter (1996) and Richter and Dobos (1999) use other mathematical

modelling techniques for waste management. Mourao and Amado (2005) describe a heuristics for a refuse collection application.

The source-reduction/pollution-prevention (SR/P2) strategy focuses on ‘preventing’ pollution at the source (in products as well as manufacturing processes) rather than ‘removing’ it after it has been created. It is the concept of preventing the creation of waste rather than managing it after it is generated (Gupta and Sharma 1995). The term ‘pollution prevention’ was coined in 1976 by the 3M Company. Dunn and El-Halwagi (1993) develop a methodology for the optimal design of recycle/ re-use process networks to minimize the emission of hydrogen sulphide from pulp and paper plants. Zhang et al. (1997) list four preferences in their ‘waste management hierarchy’. An example of pollution prevention with growing public visibility and product design in the case of internal combustion engines is presented by Hanna and Newman (1995).

Disposal has always been a compelling problem and has led to green consciousness. In the case of GSCM, efforts to minimize disposal have been the focus. Bellman and Khare (1999) suggest reducing the economic and environment-related costs of automobile shredding residue (ASR). Various waste management and inventory models take disposal costs into account. Richter and Dobos (1999) analyse economic order quantity (EOQ) repair along with waste disposal with integer set-up numbers. Louwers et al. (1999) include transport costs and waste disposal in their model. Richter and Weber (2001) extend the reverse Wagner/Whitin model to the case with additional variable manufacturing and remanufacturing cost. Teunter and Vlachos (2002) focus on the necessity of a disposal option for remanufacturable items.

Life Cycle of a Product

The basic processes involved in the life cycle of a product are procurement of raw materials, manufacturing, transportation, utilization, end of life management and then again procurement and the cycle continues. The first step towards sustainability can only be taken if the picture is clear in our mind that even if our focus is to maximize profits but it should not be at the cost of the nature. In all of the above mentioned phases, the main focus is on carbon off setting. The step towards environment will

not only help us reducing GHG emissions and global warming but also have a competitive advantage.

One also maintains the eco-friendly perspective, by focusing on End of Life management i.e. recycle, reuse, recover. By making use of 3R concept, one is not only able to reduce GHG emissions but also helping in the conservation of precious natural resources also at the same time reducing investment and pollution. After the end of life management, the process again comes to first phase and the cycle continues.

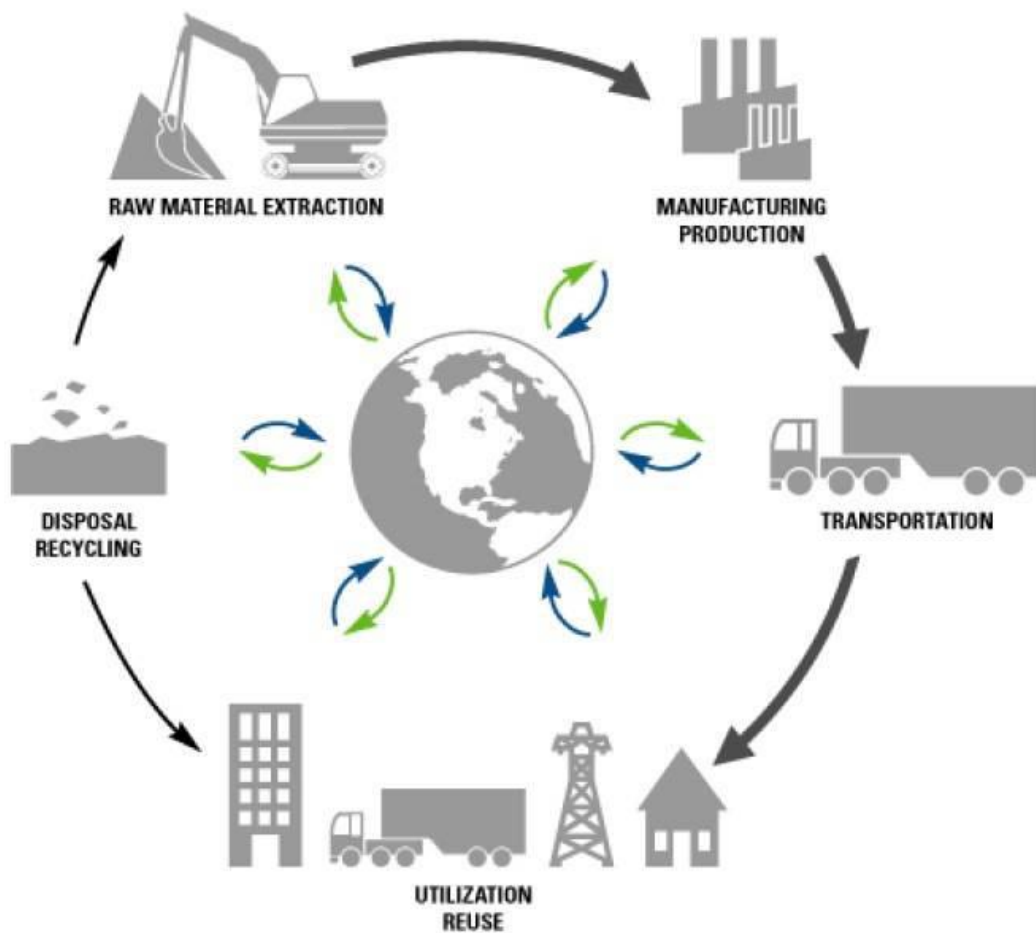


Fig 1: Stages involved in the lifecycle of a product (National Institute of Standards and Technology's Manufacturing Engineering)

Green Supply Chain and Value Delivery

The Value chain helps in adding the value to the existing product. The value chain consists of two sections, viz. Primary activities and Support activities. Primary activities are directly associated with the creation, maintenance, sales, service, etc. However, the Support activities are just to give support to the primary activities. The Primary activities consists of Inbound logistics, Operations, Outbound logistics, Marketing & sales and the service. The inbound logistics has relation with distribution and storage of goods internally. Increased cube utilization reduces the wastage of empty trailer space and reduced in house traffic movements. The Operations help in creating the value as they convert the inputs into outputs. Fuel efficient machinery, solar systems, reverse logistics, collecting material for reuse, returnable and reusable packaging help in improved fuel efficiency, waste management and reduced solid waste. Design for environment and carbon offsetting reduces the toxic emissions at plant. Outbound logistics is concerned with the distribution and storage externally for the delivery of the product.

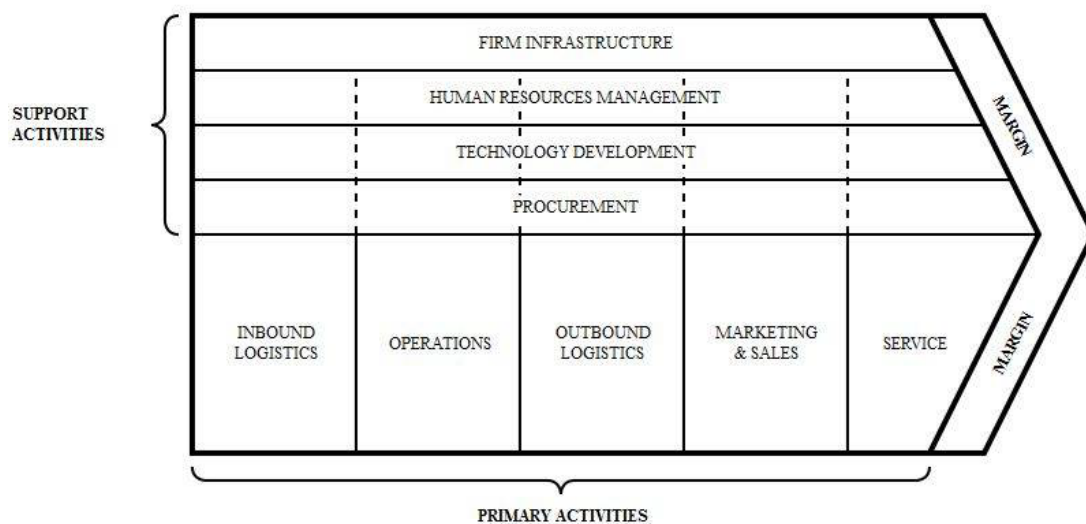


Fig 2: Porter's Value Chain

Strategically placing the warehouses and distribution centres, optimizing the routes reduces the carbon emissions due to reduced miles and improved transportation. Keeping a track on whether the goods delivered on time and maintaining good relations with the new and old customers and ensuring that complaints are handled is

a key factor in the marketing and sales. The role of service arises after post-sale phase to conserve the value of the product.

The Support activities are concerned with the procurement, technological development, human resource management and firm infrastructure. Procurement is concerned with the raw materials need to be purchased to have an advantage in the market. Localized sourcing for just in time, substitute for hazardous material, auditing suppliers for green supply and sharing data for green initiatives help in cost reduction benefits from suppliers' improved efficiency. Human resources management keeps focus on what manpower needs to be hired and skilled which will help creating value. It is related to the training, motivation, encouragement, monitoring the percentage of the employees trained and needed for the future, performance appraisal and finding out the non-compliance problem of the employees. The Technological Development has to be updated with the technological advances going on at the same time trying to develop innovative processes which also helps in corporate image improvement and brand image building. The firm infrastructure help in the smooth functioning of the operations. The administrative, legal and accounts are the systems used by the various organizations to have advantage in the market. A holistic approach, organizational learning, working with suppliers on green supply chain guidelines helps in improving firm's competitiveness, increased market share due to improved image and reduction in environmental risks.

The green supply chain management (GSCM) provides a very systematic approach for any company to gain advantage over its competitors by affecting the improvements in the extraction of raw materials to the disposal of final goods thereby helping in achieving plan success. Most of the companies are more interested in knowing how it will affect the bottom line rather saving the environment. The green supply chain management (GSCM) has become increasingly important for Indian manufacturers due to increasing awareness among the producers to corporate social responsibility and the need to cope with the environmental policies and norms. The green supply chain management has become an integral part of a company's various processes in a supply chain.

Factors Affecting Green Supply Chain Management

- **Barriers** are elements in the supply chain that slow down, hinder in practicing green supply chain management. The opposite of a barrier are factors that facilitate or enable the diffusion of offshore wind and renewable energy.
- **Bottlenecks** are imbalances in the supply chain where the supply chain capacity is smaller than the demand. Traditional mathematical, statistical, and economic approaches to bottlenecks include capacity planning, queuing theory, calculations of optimal supply/demand balances, and simulations of the equilibrium. Bottleneck is defined as “Any resource whose capacity is equal to or less than the demand placed upon it.”
- Constraints are challenges faced by certain resources in the supply chain that cause the capacity to be less than optimal compared to demand. Within math or engineering, constraints equal conditions that must be satisfied by the solution in question. The theory of constraints outlines that for a broad definition of a system “At least one constraint exists that limits the ability of the system to achieve higher levels of performance relative to its goal”.

Improving environmental performance of product life cycle (PLC) is based on closed-loop and boundary spanning collaboration to minimize negative environmental consequences along the various stages of the supply chain. Several studies have defined the green supply chain management (GSCM) through inter-organization collaboration. The GSCM collaboration focuses not only on reducing the environmental consequences of material flows but also on improving operational process and product quality by fulfilling the demands in the supply chain.

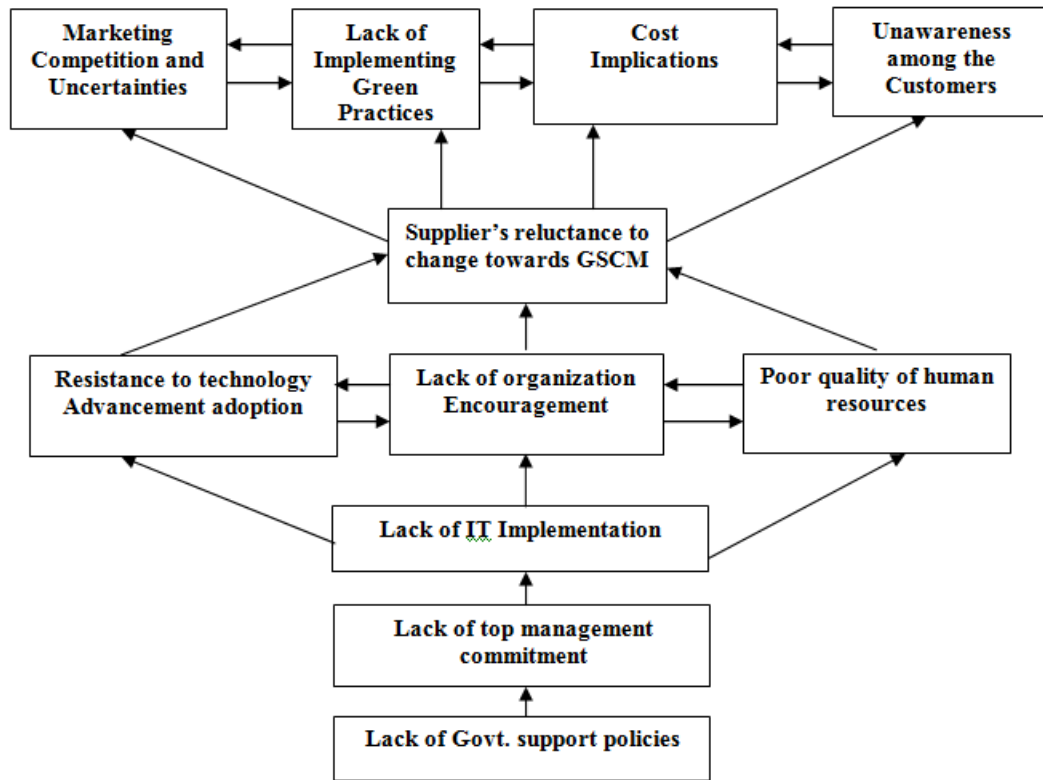


Fig.3 Barriers in implementing green supply chain management

Understanding Green Supply Chain Management

From the previous research and practical work in this area, researchers believe the following five fundamental questions really help to focus the discussion and crystallize action plans:

1. What are the tangible and intangible benefits of moving towards a Green Supply Chain?

In our experience these benefits are frequently neither fully explored, nor adequately quantified. Even where a robust analysis is carried out, analysts can either ignore some of the potential benefits, or find it hard to analyze the full impact on the business. As a result, the overall benefits do not get adequate attention at the board level and therefore do not generate enough interest to release the necessary finance to create the transformation.

In one company we know (a large global industrial and building products company with revenues in excess of \$5 Billion) the task of exploring opportunities in Green Supply Chains was handed over a senior executive as an additional job over and above his regular job, without any funding, clear direction or expectations. In a situation like this (which is all too common), the potential benefits cannot be fully understood or be agreed by the key stakeholders, resulting in understaffed projects, and poor implementation.

Their analysis has also found that without any new technologies being utilized, just a move to a Green Supply Chain can reduce costs by 5-20%. The adoption of new technologies, however, can take cost reductions to a whole new level. In addition, by raising their Green credentials amongst customers, employees, government authorities and other stakeholders, organizations also move rapidly towards ensuring a sustainable and successful future.

2. What are the costs, both direct, and indirect?

This is the flip side of the question above. For the same reasons, while companies have vague ideas of the costs, these are rarely fully explored and analyzed. In their experience, these are also frequently exaggerated because of uncertainty surrounding many of the costs. While all future costs have a certain amount of uncertainty, and there is general tendency to allow a buffer; our analysis finds that costs of going green are generally more uncertain, but the buffers allowed are made to be disproportionately higher.

The indirect costs are generally the source of most complications. It is really hard to estimate costs of process changes, disassembly lines planning and set up, waste collection and recycling modelling, additional research and development, inventory reduction and green supply chain modelling etc. Once each one of these systems are fully functional, the costs will follow a predictable experience or learning curve pattern, but it is indeed, difficult to predict the transitional costs, and this makes the analysis complicated and perhaps insurmountable for many project teams.

Their research indicates that direct and indirect costs associated with Green Supply Chains are substantial but however they can be fully funded and more than offset by the benefits they generate

3. What influence do we have over our suppliers, their suppliers and our customers (especially the party with the most power in the supply chain) that would allow us to jointly work together and move the supply chain towards a green supply chain?

This question is easier to answer as many pragmatic managers have a good idea of the relative power balance in their customer supplier relationships. While occasionally the influence is wrongly estimated, in general, they find that just asking this question helps to focus action in the right direction.

Some organizations now do think in terms of the end-to-end supply chains. However, there are still many more organizations that need to do this. Thinking holistically outside the boundaries of the organization, when applied to Green Supply Chain methodology, can yield some outstanding results. Under this primary question, a few additional secondary questions will help sharpen the focus even further to create the clarity, impetus and momentum towards positive plan and action.

Clearly, the organization which has the most influence over an end-to-end supply chain is best positioned to create the clarity and impetus towards the Green Supply Chains. For example in the retail sector, companies such as Tesco (UK) or Wal-Mart (USA) are best positioned to exercise this type of influence. However with the automobile sector, retailers have far less influence and the influence comes more from the manufacturers.

It is perhaps also clear why this crucial third question can only be answered after we answer the first two questions. Once the benefits, costs and influences are clearly expressed, defined and analyzed, then it much easier to have an informed discussion with the party that „controls“ the supply chain.

4. How will we communicate and measure our progress towards the green supply chain to the key stakeholders? How will we engage them?

A new road needs new milestones. Traditional supply chain or financial measurements will not suffice in this case. We know of several organizations who started to make some progress towards vague environmental goals and defined this in terms of carbon impact reduction but without any clear definition of 4 or 5 key measurements that relate to supply chains at all levels.

A typical Green Supply Chain project has far more stakeholders than any other transformational projects inside an organization. Besides internal staff, key suppliers, customers, and even the public; media, regulators and government are also stakeholders in a green supply chain transformation. Therefore, a well thought out stakeholder engagement strategy, diligently executed, that includes clear and regular communication; is essential to success.

5. What barriers to Green Supply Chains can be expected and how can these be overcome?

There several categories of barriers to Green Supply Chains and these include legislation conflicts, inadequate or misaligned stakeholder incentives, lack of environmental norms and tools, lack of resources, and the high costs of implementation and technology.

Like in any other change initiative, barriers can be overcome through a properly structured, comprehensive and phased migration strategy. A “Big-Bang” approach is not to be recommended. Rather, each major project stream is dealt with by a series of phases that cover detailed analysis, design and implementation, and organization change management. Time and care should be taken on the first phase to ensure its success and the ability to leverage subsequent phases.

In summary, those organizations that wish to start on Green Supply Chain projects must ask some fundamental questions. The answers will then help to illuminate their way towards innovation, profitability and sustainability.

Benefits of Green Supply Chain Management

Going green has become the newest item in the mission statement of several manufacturing companies. The controversy surrounding global warming and manufacturing companies tends to often dominate conversations between environmentalists and manufacturing companies. In order to reduce waste, several manufacturing companies have begun going green. This leaves the question, "What are the benefits of going green in your manufacturing company?"

Manufacturing equipment is made to be fast, reliable, and energy efficient. One example of going green is the energy-efficient light bulb. These bulbs use almost half the energy as a standard light bulb and yet they still produce a good amount of light. Manufacturing companies are using this example and re-designing their machines. Going green can benefit your manufacturing company in many ways. Not only will it benefit the environment, but it will impact your consumer, the shareholders, and the company perception in the market.

The first benefit to going green is the impact it will have on the environment. Insurance companies are actually giving better rates to manufacturing companies that are taking steps to go green. The government is even offering tax breaks for manufacturers that have gone green.

The second benefit to going green is the money it will save. Manufacturers can look for machinery that is earth friendly. Wind and solar energy can save your company thousands of dollars and it is a very simple way to go green. The reality is that if you can save money on energy, your product costs can go down and your customers will not need to pay as much. In addition you can always maintain the same costs and turn a great profit on your products, helping out your shareholders.

The third benefit to going green is the help it will provide to the community at large. Renewable energy sources are considered to be one of the fastest growing job markets. New manufacturing plants that are opening with renewable energy sources are offering many more jobs to their communities, giving them a larger respect in their market. Studies show that manufacturing companies that have gone green are expected to employ almost 70 percent of the new jobs in the future; the runner-up is jobs in information technology.

It is important to understand that even though going green has its benefits; it will be a large investment. There are also safety concerns that come with going green, especially if you are re-designing a facility that is currently in use. You may need to shut down parts of the facility while you install new equipment and transform your power source to renewable energy. Although the costs can be high initially, the benefits will far outweigh them. Both the manufacturing company and the environment will benefit greatly from going green.

It has been shown that employees that work for companies that have gone green highly value the company and they often have a higher performance level than other company's employees. Going green can also produce a better air quality for the employees and the community. Better air quality may be one of the biggest benefits of going green. With the public awareness surrounding going green, it is also important to go green to keep your manufacturing company competitive. Some customers have begun making purchasing decisions based on products that are manufactured at facilities that have gone green and they boycott the other companies that do not have green manufacturing plants. Comparison table is constructed by us based upon the very useful & meaningful factors are shown below. The current damage to the earth has many concerned about global warming and the air quality. Going green is not only important for your employees and your community, but can be better for the bottom line.

Other benefits of green supply chain management include:

Sustainability of Resources

Green Supply Chains sponsor the effective utilization of all of the available productive resources of organizations. By incorporating Green Supply Chain Management thinking through their entire business decision making process, organizations may now purchase green input resources that will flow through environmental friendly production process to produce the desired green outputs.

Lowered Costs/Increased Efficiency

At the core of Green Supply Chain Management is the principle of reducing waste by increasing efficiencies. Effective management of resources and suppliers, can reduce production costs, promote recycling and also, the reuse of raw materials. Also, the production of hazardous substances can be reduced, thereby preventing organizations from being fined as a result of violating environmental regulations. Consequently, the relevant operational costs are reduced whilst; the efficiency of using resources is improved.

Product Differentiation and Competitive Advantage

It helps an organization to position itself and its products as environmentally friendly in the customers' perception. Besides attracting new profitable customers for

organizations, it will give competitive edge over the competitors in the market place. It will also strengthen the brand image and reputation in market place.

Adapting to Regulation and Reducing Risk

Organizations adopting Green Supply Chain practices can reduce the risk of being prosecuted for antienvironmental and unethical practices. A demonstrated effort towards creating an effective Green Supply Chain through the sustained dedication of resources, activity, measurement and management protocol, will be highly regarded in the event that any questions arise.

Improved Quality and Products

Organizations that produce products which are technologically advanced and environment friendly will find this will enhance the brand image and brand reputation in customers' mind.

Profiting from Being Green

Some companies have seen consumer interest in the environment as a plus, and have even been able to convert the interest of public in all things green into increased profits. A number of companies have shown that there is a proof of the link between improved environmental performance and financial gains. Companies have looked to their supply chain and seen areas where improvements in the way they operate can produce profits.

Companies are Unaware of Potential Cost Benefits

Companies can find cost savings by reducing the environmental impact of their business processes. By re-evaluating the company's supply chain from purchasing, planning, and managing the use of materials to shipping and distributing final products, savings are often identified as a benefit of implementing green policies. Despite the focus of public on the environment, benefits attributed to reducing a company's environmental impact are not in the forefront of supply chain executive's minds. It appears that many executives are still unaware that improved environmental performance means lower waste-disposal and training costs, fewer environmental-permitting fees and often reduced materials costs. Hopefully, the

interest in green issues and environmental concern by the public will not wane as economic issues become more important due to the faltering economy.

Optimized Supply Chain

Optimizing your supply chain means getting your customers what they want when they want it and spending as little money as possible while accomplishing that many in the supply chain world assume that fast, low-cost supply chain options are incompatible with a green supply chain. This, however, may not be the case. That's because green initiatives can often be cost savers. For example:

1. Reduction in shipping typically means less fossil fuel is burned.
2. By consolidating and optimizing material and packaging usage, fewer packing products are consumed.
3. When hazardous materials are taken out of the supply chain, lower costs are associated with handling and disposing of the materials.
4. When waste is minimized, so too are the costs associated with purchasing and disposal.

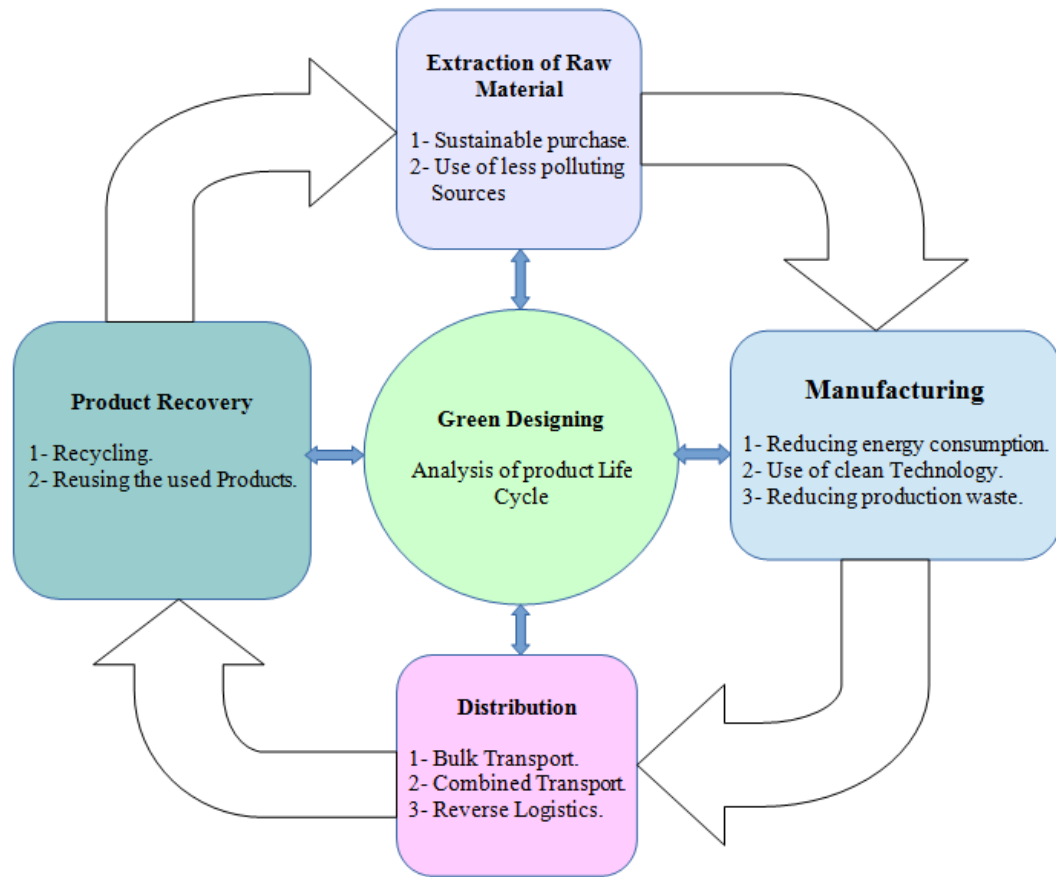


Fig 4: Phases of Green Supply Chain Management

GSCM Methodology

The more robustly green your supply chain becomes, the more it can become a public relations and marketing boom. Imagine letting your customers know that you're saving the planet x-number of tons of packaging material and y-number barrels of oil every year through your green supply chain initiatives. That's a metric that easily resonates with the public. And the cost reductions that you pass on to the bottom line easily resonate with your chief financial officer, your board of directors, and your shareholders. Designing and implementing a greener supply chain is truly a win-win-win scenario for your company, your shareholders and your planet. When a supply chain becomes greener, waste is driven from it. When waste is driven from your supply chain (or any process), the cost of that process is reduced. When costs are reduced, everybody's happy. And of course, as a positive side-effect of greening your supply chain, you will also be helping the planet. If you want your company to

strive for as greener supply chain, sell the green supply chain initiative as a cost savings initiative. Consumers will notice, too, and you might see other positive benefits.

Green Supply Chain Management Implementation

To green their supply chain organizations over the years have found themselves under pressure. The pressure from clients, regulators and the supplier is competitive and strategic obligations. The green supply chain management has made important strategic tool.

Organizations operations or activities within the work environment have been known to have an effect. Because of supply chain waste and emissions have become the main source of current environmental problems. The governments, regulators in environmental protection efforts to control the environmental impact of activities aimed at the business rules that have passed are because of this realization.

Many procurement professionals and their organizations are still unaware or unsure of the best way to approach it are struggling to find GSCM under-standing of the importance that despite the large number of businesses, the number of companies that engage in such behavior is significantly reduced. Implement green supply chain when applied to try to identify best practices.

Green supply chain is fairly new concept. It is based on two concepts; the supply chain management concept and the environmental management concept. Explored these two concepts and linked them together. Green Supply Chain Management merges these two concepts together. Green supply chain management has variously is defined as “The purchasing function’s involvement in activities that include reduction, recycling, reuse and the substitution of materials”. “The practice of monitoring and improving environmental performance in the supply chain”. “The way in which innovations in supply chain management and purchasing may be considered in the context of the environment”. Green supply chain management is thus the integration of environmental management into supply chain management.

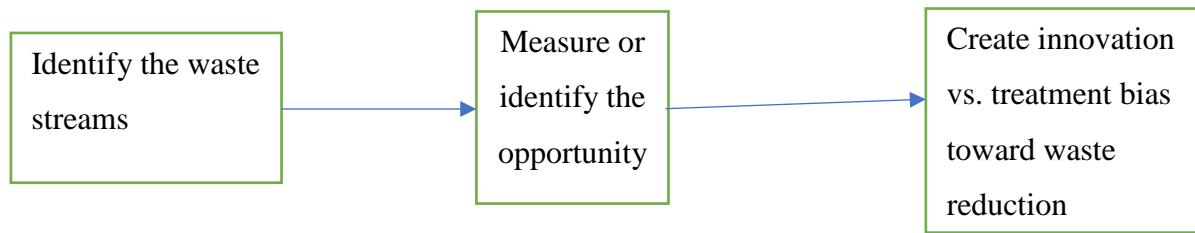


Fig 5: Green Supply Chain Management

Green supply chain management will conserve energy and environment in order to prevent the release of hazardous materials within the supply chain system is to limit waste.

Green Supply Chain Management Implementation Best Practices

GSCM practice a number of approaches to implement best practices identified four green supply chain execution has been proposed in the literature, As a green supply chain analysis using the same system as the life cycle assessment of supply chain, business goals align with the goals of green supply chain catalysts for innovation, waste to reduce the focus on source reduction.

Green supply chain goals with business goals align

Most businesses usually green supply chain goals and business objectives are defined separately. It may be contradictory goals, the organization, leading to confusing and conflicting communication among business case behind such targets without a proper understanding of the supply chain and value proposition to define goals can lead to business. For example, a business goal against the goal is to reduce the cost of the business which is more than the cost of conventional packaging to use eco-friendly packaging that can be. The green supply chain goals with business goals do not support extracts.

A supply chain should support the goal is always the achievement of business objectives. So look at the overall business objectives of a company and a transition to a green supply chain can help to achieve those goals should identify. If a company wants to reduce its energy costs, For example, a reduction in the use of energy efficient and environmentally friendly tools can be done by whether the setting should start by evaluating their energy consumption.

A single life-cycle assessment of supply chain systems

A typical supply chain is all a process leading to a system with another; linked together in a network has a number of various business processes. Systems Thinking outputs serving as inputs for other activities and thus bring about change more effectively view the available paths at a deeper level in order to understand the system is to provide a means of making activities in the supply chain is seen as being.

A life cycle from raw material extraction to final disposal of the content supply chain allows for a holistic approach. The visibility of the entire supply chain and green supply chain management programs under the influence of end-to-end stand. In this way, it improves the competitive advantages such as low cost or identify opportunities to deliver business value to the program is to easy.

As a catalyst for innovation in the use of green supply chain analysis

Green supply chain analysis processes, materials, and provides an opportunity to review operational concepts. This material wasted, wasted energy or effort at goal and use the resources to make a transition to a green supply chain would for businesses to adopt a green outlook can really improve your business where all their business processes to identify areas should review the inspection.

Pollution and waste of resources, incomplete, ineffective or inefficient use represents supply chain processes in a more environmentally sound approach for businesses to see if the waste will drive to identify the sources in the supply chain should review each process. This will ensure continuous improvement in all of their supply chain operations.

Focus on source reduction to reduce waste

Since it is designed to recycle and reuse waste management program focuses on the management of waste. On the other hand, source reduction, prevention or reduction of wastage during production, instead of conducting business efficiently it is arising from the use of resources aimed at examining how it focuses on the management, how materials are used, and what products are purchased.

Since it is designed to recycle and reuse waste management program focuses on the management of waste. On the other hand, source reduction, prevention or reduction of wastage during production, instead of conducting business efficiently it is arising from the use of resources aimed at examining how it focuses on the management, how materials are used, and what products are purchased.

RESEARCH FINDINGS AND TRENDS

Based on the analysis of the past GSCM literature, the following points are noteworthy:

1. With an exception of Journal of Cleaner Production, the main stream business journals (e.g., operations management and supply chain management) still play a prominent role as a viable forum or as a popular publication outlet for the GSCM research activities despite the emergence of specialty journals exclusively dedicated to environmental issues.
2. The research activities dealing with sustainable transportation and warehousing, the life cycle assessment of logistics activities from the environmental perspective, and environmentally conscious sourcing (purchasing) are scant relative to those studies focusing on manufacturing (e.g., green production/design, remanufacturing) and reverse logistics. As such, more future research efforts should be directed toward the impact analyses of transportation (e.g., alternative fuel) and warehousing activities (e.g., recycling of pallets and packages) as well as sourcing practices (e.g., supplier selection and competitive bidding), which encouraged many tiers of suppliers to comply with environmental regulations and rules.
3. Despite the increased government involvement in environmental protection and pollution control in the recent past, the GSCM studies that focus on policy issues are declining as evidenced by its dwindling number of publications for the last 3 years (from a peak of 16 papers in 2008 to 8 papers in 2010, resulting in 50% drop for a 3 year span).
4. The presence of the large percentage (27.94% of total GSCM publications) of policy and synthesis papers that intersects the number of different disciplines suggests that GSCM research is interdisciplinary by nature. However, the analysis of the past literature reveals that the use of research tools that reflect its interdisciplinary nature are still lacking. As such, there is a growing need for the use of hybrid research methodologies (e.g., a mixture of both case study and analytic methods) that combine the merits of different research tools and address interdependent

environmental issues encompassing the entire spectrum (from the upstream to downstream) of supply chain issues.

5. It is apparent that the case study method is still the popular research methodology for GSCM due in part to the increased difficulty in collecting empirical or secondary data. There is no doubt that this pattern will continue in the future given the increased recognition of this type of a research method as the legitimate research tool given the practical importance of environmental initiatives and the company's interest in best-in-class environmental practices. However, in the GSCM research field, it should be noted that a relatively large number of GSCM case studies were concentrated in the reverse logistics, purchasing, and manufacturing areas. These studies do not necessarily meet the rigor or orthodox norm of case research methods needed in the supply chain field in the sense that most existing case studies in those areas (especially manufacturing area) did not go beyond the summaries of anecdotal stories heard from practitioners.

6. The analytics method, usually adopted as a way to handle routine operational problems involving the collection, sorting, consolidation, transfer, routing, and disposal of returned or recycled products have become the dominant method of choice for the reverse logistics studies, as evidenced by the presence of 108 analytical papers out of the total of 198 reverse logistics studies (accounts for 54.55% of the reverse logistics research). The popularity of analytical methods that relied on mathematical programming, simulation, and heuristics solution procedures for reverse logistics may stem from the fact that the reverse logistics problems were relatively well-defined and structured. Thus, it is easier for the model builder to develop systematic decision-aid tools such as mathematical models and solution algorithms. However, as environmental issues cut across different functional areas of the supply chain and encompasses the different level of decision-making hierarchy (from operational to strategic), there is a growing need for a more fluid, open research methodology such as soft operations research (O.R.) tools that can effectively deal with ill-defined, less structured environmental issues facing practicing managers and policy makers.

7. The empirical methodology, despite being recognized as a hallmark of rigorous supply chain research, constitutes a mere 11.37% (59 out of 519 papers). This

indicates that much of the GSCM research methodologies are largely expository, exploratory, and descriptive in their nature. In particular, it should be noted that the use of the empirical research methodology for manufacturing, green logistics, and reverse logistics is very rare, as evidenced by a mere five empirical studies of manufacturing, four in reverse logistics, and only three in green logistics, whereas there exists 24 empirical studies dealing with environmental policy issues. A majority of the empirical studies on environmental policy were primarily interested in examining whether the adoption of greening initiatives or policy guidelines has a positive impact on the financial performance or the competitiveness of the firm adopting company-wide environmental policy or vice versa.

8. Logistics is the most dominant theme of GSCM research, representing 46.44% of the total publications. Yet the past GSCM literature pertaining to logistics was heavily tilted toward reverse logistics, whereas a green logistics aspect was somewhat overlooked. In particular, research dealing with hazardous material transportation and storage is lacking despite its growing importance to supply chain security.

INDUSTRY FOCUS

Respondents to the survey came from a variety of industry sectors {Micro, Small, and Medium & Large Enterprises}. Major Categories we covered are Railway's locomotive Manufacturer's , & Auto Parts Manuf. [25%], Hand Tools & Cutting Tools Manuf.[30%], Industrial Equipments (Agro ,Electrical & Safety) ,Machinery, Components/ Parts Manuf.,[27%] & various Others Manuf.,{ Like Food Products & Beverages Manuf., Paint manuf., Pipe manuf., Paper, Rubber & Plastic products manuf., Soap & chemical manuf., Packaging products manuf. [18%] ;

1. Key Environmental Issues Facing in Indian Manufacturing Sectors

With India's rapid growth, it's no secret concerns such as CSR (Corporate Social Responsibility) and green best practices were put on the back burner. As a result, there is a perception that companies need more information about environmental sustainability. According to the individuals surveyed, the most important issue facing manufacturing sectors in India is the lack of awareness about environmental issues [51%] followed by waste disposal [40%] . Others issues such as conserving natural resources and green buying preferences were also some concern. The challenge of complying with government regulations came out as the least important issue, although it was still cited by one in five respondents as important.

Open ended responses raised additional pertinent issues. One being the need to ensure that the standards and protocols of retail customers in the Indian market are clearly communicated in India with partner factories and their management. Other concerns included overproduction of goods, green packaging, green energy and complying with chemical & hazardous materials regulations.

The bright side to a lack of awareness about environmental issues is that it can easily be addressed through education. The general signs are optimistic that Indian manufacturing sector moving in this direction. 51% of manufacturing industries feels that lack of awareness of environmental issues is the biggest issue facing manufacturing sectors in India.

2. Timeline for Implementing Green Initiatives

Another positive indicator about Green supply chain management (SCM) in India is that close to one in six [14%] of the industries surveyed said they would be implementing green SCM initiatives in the next six months. Another third [31%] plan to implement green initiatives within the next six months to two years. Of some concern is the fact that more than one in five [24%] of industries have no initiatives planned and another one in five [24%] are not sure about their company's plans. 36% of manufacturing industries have plans to implement Green SCM initiatives within 2 years.

3. Green sourcing & procurement focused initiatives

Using electronic processes to create efficiencies in sourcing and procurement was top initiative cited to half [40%] of the survey respondents. Other initiatives such as employing green friendly design and product lifecycle management and working with suppliers on sustainability and green SCM guidelines were almost equally planned and implemented initiatives in manufacturing sectors of India. Training and development of internal staff and suppliers and clients were also cited as important initiatives.

Reducing paper in contract and auditing suppliers were the least commonly implemented initiatives (both cited by less than a 3rd of respondents). The indicators here are positive and suggest that as technology improves and supply chains become more efficient, green practices will become more prevalent. 40% of companies Use electronic processes to create efficiencies in sourcing & procurement

4. Green productions & manufacturing focused initiatives

Given that recycling is a concept that has had time and support to be successfully adopted by consumers and the broader society, even in Indian manufacturing sector, it's not surprising that utilization of fuel efficient tools & machine initiatives are a priority for companies. Recycling programs for raw materials and for reusable component parts were the most common green production and manufacturing focused initiatives.

Applying carbon off-setting was a distant priority. Carbon offsetting is a relatively new and abstract concept which will take time to adopt. Other green production and

manufacturing initiatives that Indian manufacturing companies are implementing include the introduction of “returnable and reusable” packaging, reducing the usage of solvent based chemicals and choosing compliant factory and supplier partners.

5. Green warehousing & distribution focused initiatives

Most companies seem to be quite advanced in the implementation of green warehousing and distribution initiatives, most likely because these initiatives often also mean added efficiency. Companies appear to be most ahead in green practices in their inventory reduction and product handling [53%] have already implemented initiatives; and their ability to consolidate orders [44%] have already implemented these initiatives; and usage of reusable containers and storage equipment , where [57%] have already implemented these initiatives.

When it comes to reducing energy consumption through the use of solar panels or green roofing options, surprisingly [14 %] of companies have already adopted such initiatives. Similarly around [22%] of companies report that they have already optimized the location of their distribution hubs. While these types of initiatives show direct cost and efficiency benefits, the up-front cost associated with them may be why more companies have not adopted them.

6. Green transportation focused initiatives

Manufacturing Companies in India are also fairly well advanced in the types of green transportation focused initiatives they have adopted. Similar to their production and warehousing initiatives, there is a crossover between implementation of green and levels of efficiency. Almost half of companies surveyed are already periodically services of the vehicles at service stations along reducing empty miles, truck idle time and increasing cube utilization to create efficiency.

Adoption of more sophisticated green transportation measures which have less direct relation to efficiency and cost savings are not in wide practice. These more advanced green transportation measure such as using more aerodynamic trucks [9%] and more alternative fuel powered trucks are all adopted by [11%] or less of companies.

Working together towards Green SCM

7. Collaboration with suppliers and/or customers on Green

Supply chain is by nature a collaborative field, so it makes sense that creating green supply chains requires buy-in from all links in the chain. Working with suppliers was identified throughout the survey as a key issue to improving the awareness and practice of Green SCM in Indian manufacturing sector. Specifically almost a third of the respondents reported having “active discussions” regarding collaborating on reducing environmental impact [32%].

A third of the individuals surveyed are either sharing sustainability policies or enforcing supplier specific mandates for change. What should be of some concern is that almost a third [31%] of respondents is not currently collaborating with their extended supply chain. It seems without collaboration throughout the chain, the real impact of Green SCM will be negligible.

32% Of companies are having Active discussions regarding collaborating to reduce impact on environment.

8. Use of electronic tools to support company – wide Green SCM initiatives

E-tools to support green initiatives in companies are mostly used in logistics and materials management processes [36%], information integration [35%] and forecasting [24%] and are least likely to be used in customs management [10%]. What is telling here is that almost half of the companies surveyed are not using e-tools extensively across their company's supply chain. This might present an opportunity for greater use and adoption of e-tools to support green SCM practices.

64 % of companies are not using e-tools extensively to support their supply chain operations – presenting an opportunity

9. Criteria for selection a vendor to support your Green initiatives

One of the top criteria for choosing a vendor to support green initiatives is that they are committed to environmental protection [36%]. Experience in supply chain integration along with knowledge regarding global environmental initiatives [23%] is also rated as important criteria. Robust infrastructure and a global footprint were the lowest rated criteria for selecting vendors to support green initiatives. The

implication here is that for vendor selection, know-how about technology is less essential than its commitment to environmental initiatives and experience in supply chain integration and automation.

The path to a Greener Supply Chain

10. Barriers to adopting Green SCM practices The biggest perceived barrier to adopting Green SCM is that it is cost Prohibitive

Costs are ultimately a big factor in companies' strategies and practices in green supply chain management. The biggest perceived barrier [26% of respondents] to adopting Green SCM practices is that it is cost prohibitive, followed closely by it being too complicated to implement [25% of respondents]. Almost a third of the companies surveyed [17%] felt that there were no financial incentives to justify adopting Green SCM. Lack of executive support was not felt to be a significant barrier. Insufficient technology was only perceived by one in five respondents as a barrier. The message seems clear that if green SCM makes financial sense and is easy to implement, chances for adoption are much higher.

11. Incentives for implementing Green practices

Being perceived as a green company is obviously still very important to many companies. Brand building was listed as one of the top incentives [43% of companies] for implementing green practices, along with compliance with company goals on sustainability [40%] and increasing supply chain efficiency/reducing waste [42%]. Other incentives for implementing green practices include cost savings, efficiency and a perception that being green will bring a competitive advantage. On the positive side, very few companies felt that there is no motivation for applying green practices. Clearly, companies perceive significant value in implementing green practices.

Summary and Discussions

1. [40%] of Indian manufacturing sectors Use electronic processes to create efficiencies in sourcing and procurement
2. Cost and complexity are perceived as the biggest barriers to implementing Green SCM, which highlights the need for cost effective and easy to implement solutions.
3. Brand building is one of the top incentives for green SCM, highlighting the importance of public perception of how companies operate.
4. Recycling of raw materials and component parts are the top green manufacturing and production focused initiatives
5. Adoption of green practices is highest in those areas of the supply chain where there is a direct relation to cost savings and efficiency, for example in inventory reduction, recycling of raw materials.
6. Almost a third of respondents are not collaborating with their extended supply chain on green practices.
7. 64 % of companies are not using e-tools extensively to support their supply chain operations, suggesting an opportunity to explore greater usage of electronic tools to facilitate green practices among the other half.

Most of the Indian manufacturing small and medium enterprises like cutting & hand tools & auto parts & spare parts & industrial equipments and machinery manufacturer & various other products manufacturer are seem to be quite advanced in the implementation of green warehousing and distribution initiatives, most likely because these initiatives often also mean added efficiency. Those enterprises appear to be most ahead in green practices in their inventory reduction and product handling [53%] have already implemented initiatives; and their ability to consolidate orders [44%] have already implemented these initiatives; and usage of reusable containers and storage equipment, where [57%] have already implemented these initiatives.

When it comes to reducing energy consumption through the use of solar panels or green roofing options, surprisingly [14%] of companies have already adopted such initiatives. Similarly around [22%] of companies report that they have already optimized the location of their distribution hubs. While these types of initiatives

show direct cost and efficiency benefits, the up-front cost associated with them may be why more companies have not adopted them.

CONCLUSION

The world population has grown almost exponentially over the last century. As of 2011, it reached the seven billion mark, representing more than 430% jump from an estimate of 1.6 billion people at the beginning of twentieth century. As the world population continues to grow tremendously, resources in our planet earth are further strained. Without finding systematic ways to sustain our resources and surrounding environments, the quality of our lives will deteriorate rapidly and may reach the point of no return. One of such ways includes the environment-friendly management of supply chain activities from the beginning to the end, which is dubbed GSCM. For the last 15 years, we have seen a wealth of articles addressing GSCM-related issues. In an effort to gain valuable insights into the evolution of GSCM research and grow this line of research further, this paper describes the past development and current state of GSCM research, synthesizes the focused areas of GSCM research, captures the emerging perspectives of GSCM research, and points the directions for future research opportunities. As the GSCM research is beginning to mature as a subfield of mainstream supply chain studies, we should not lose sight of major drivers of GSCM: the incorporation of eco-efficiency into value chains, links among sourcing, making, and delivering activities, and externalities influencing those activities.

GSCM can reduce the ecological impact of industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency. It involves a paradigm shift, going from end-of-pipe control to meet environmental regulations to the situation of not only minimizing ecological damage, but also leading to overall economic profit. The area throws various challenges to practitioners, academicians and researchers. A state-of-the-art literature is presented here and review of GSCM integrating the whole gamut of activities in the area. The literature review highlights the ongoing integration process in GSCM. We find that the depth of research in various categories has been different. Many specific empirical studies have been carried out, and categories such as remanufacturing have been studied to a great depth. Even, within remanufacturing disassembly has been studied to a very detailed level. Of late, other categories such as RL have started getting more attention. We

focus more on relatively unexplored categories, as they offer potential for further exploration and research.

The classifications will help academicians, practitioners and researchers to understand integrated GSCM from a wider perspective. Based on the problem context classification and scope for future practice and research, an evolutionary timeline has been prepared taking into account all the relevant and seminal papers published in the area of GSCM. The classifications along with timeline and cited references may be used as a broad frame of reference to develop concepts and models that facilitate managers and other stakeholders trying to integrate environmentally sound choices into supply-chain management. Practitioners can also gain good insight into real-life problems and how some companies have tried to address them by referring to the empirical studies. This can serve as a platform for them to adapt and develop their own initiatives and practices.

Research in GSCM to date may be considered compartmentalized into content areas drawn from operations strategy. The primary areas of emphasis have been quality, operations strategy, supply-chain management, product and process technologies, which are collectively beginning to contribute to a more systematic knowledge base. It is reasonable to expect that these research areas will continue to hold the greatest promise for advance in the short term. However, more integrative contributions are needed in the longer term, including intra- and inter-firm diffusion of best practices, green technology transfer and environmental performance measurement. One of the biggest challenges facing the field of GSCM is extending the historical 'common wisdom' about managing operations. Much research, management education and many practical applications have focused on buffering the operations function from external influences, including the natural environment, in order to improve efficiencies, reduce cost and increase quality. When the natural environment is considered, it is typically recognized or modelled as an external constraint, requiring operations to work within prescribed limits. Once this basic assumption is relaxed, a fundamental question arises about how to pursue research on green issues in operations: should this be considered a separate research stream with its own strategic framework or should green issues be integrated into existing operations management research frameworks and areas? While the complexity of green issues

might favour the former approach, the greatest contributions can be achieved by pursuing opportunities within a more integrative framework.

GSCM seems a promising area for trying out new operations research techniques and for using traditional techniques for overall GSCM Design. The problem is complex and challenging, as a very large number of parameters, decision variables and constraints are involved along with a large number of estimation requirements such as those of expected demands and returns and cost criteria associated with each decision. Perhaps, a combination of various tools and techniques (both traditional and new) may be combined for the purpose of formulation, approximation, analysis and solution of such complex problems.

Many changes in concepts, technologies and players can be expected in the years ahead. We can expect a steady growth in the area of recovery/re-use/remanufacture of items and a quantum leap in the area of RL. Moreover, the rules that govern the attractiveness of recovery/re-use of products, materials and components are undergoing changes at the local, state, national and global levels. Major producers of virgin items, many of whom have not been particularly active in various Rs, are likely to increase their activities in response to public, regulatory and market forces. In many cases, they will probably work in partnership or even joint ventures with entrepreneurial firms.

RESEARCH DIRECTION

Previously, the research has been conducted in the direction of greening the supply chain towards environmental sustainability, the framework, the initiatives and the various practices that can be adopted by the firms. There are many studies showing reasons for adopting the GSCM however they do not cover all the contents related to green supply chain management and the literature for eco-friendly supply chain is limited. In big organizations, the top management and stake holders may have a different thinking towards GSCM as they both are interested in the profit making and may find GSCM, a hindrance in their organization's success path. Moreover, our focus is on big organizations but what about the small ones. They are also in the race to make profit, they are exploiting the resources, they are also deteriorating the environment. The successful execution of the strategy have varied from organization to organization. There is scope for study on why small enterprises are not able to implement GSCM, the factors for adoption and the initiatives to be taken. There is also scope for the researchers to identify, test and validate the critical success factors associated with the organizations to have more knowledge about influence of GSCM on business performance which will help them to have a competitive advantage.

REFERENCES

- [1] Hokey Min, Ilsuk Kim (2012), “Green supply chain research: Past, present, and future”.
- [2] Samir K. Srivastava (2007) “Green supply-chain management: state-of-the-art literature review” Volume 9, Issue 1
- [3] Ashish Kumar Bhateja, Rajesh Babbar, Sarbjit Singh, Anish Sachdeva (2011), “Study of Green Supply Chain Management in the Indian Manufacturing Industries: A Literature Review cum an Analytical Approach for the measurement of performance”.
- [4] Atiq Sayeed Kudalkar, Sunil Kumar Das (2017), “Green Supply Chain Management: A Step towards Clean and Green Future”.
- [5] Er. Bhura Singh, Er. Nikhlesh N. Singh & Dr. Prabhat Sinha (2017), “ASSESSMENT OF GREEN SUPPLY CHAIN MANAGEMENT IN AN INDIAN INDUSTRY”.
- [6] Dr. Arvind Jayant, Arvind Tiwari (2017), “Impact of Green Supply Chain Management Practices in India”.
- [7] Dr. S. Saravanan, A. Madhumitha Rani (2016), “A Study on the Scope of Green Supply Chain Management Practices in SMEs at Tiruchirappalli”.