ASSESSMENT AND DESIGN FOR SUSTAINABLE GREEN SUPPLY CHAIN MANAGEMENT

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Abstract:
Green Supply Chain Management (GSCM) is one of the recent innovations for the enhancement of capabilities of Supply Chain Management. In this paper, we aim to study the various activities of the Supply Chain processes of the various Indian Manufacturing Industries i.e. both Small & Large Scale Industries and finds how much eco-friendly they are (i.e. how much % of the green factor are involved in their supply chain activities from the procurement of the raw material to the transportation of the final product to consumer) for the purpose of metering the performance of the manufacturing sectors has been studied. The major eight activities of the supply chain; namely Green Procurement, Green Manufacturing, Green Warehousing, Green Distribution, Green Packaging, Green Transportation, Life cycle Assessment, Eco-design are being covered throughout the research. From these above process activities we measured the green practise and performance of green supply chain management with the various case studies. These are helps to various crucial performance indicators & their sub-indicator's. The research outcome based on the case study in this paper we identifies the important results that are causes impact on the environment by supply chain of manufacturing sectors. In this paper, we discussed how the various supply chain factors affecting environment. By the help of literature review we identify various Indicators & Sub-Indicators in order to find out the sustainability performance of various manufacturing sectors towards Green future.

Keywords: *GSCM, Life Cycle Assessments, Eco-Design, Sustainability.*

1. INTRODUCTION

reduce cost and add value in the supply chain. However, traditional Supply Chain has focused primarily on cost, with professional consulting targeting costs (including transport, inventory, and administration).GSCM was developed in the 1990s, due to numerous challenges; most industries did not begin to adopt Green Production until 2000 or even later. The recent emergence of Green SCM provides the opportunity to review processes, materials, and operational concepts from a different perspective.

GSCM is driven mainly by the escalating deterioration of environment, e.g. diminishing raw material resources, overflowing waste sites and increasing level of pollution. However, it is not just about being environment friendly; it is about good business sense.One of the key aspects to green supply chain is to improve both economic and environmental performance simultaneously throughout the supply chains by establishing long-term relationships between buyers and suppliers [1].

1. A. Traditional Versus Green Supply Chain Management

Traditional Supply Chain: In which the flow of materials and information is linear from one end to another in which limited collaboration and visibility. Each supply chain partner has limited information regarding, for example the carbon footprint and green house gas emission of the other partners. It is mainly focused on end-to-end supply chain costs but due to limitations of information sharing, the costs are different from optimized in most cases.

Green Supply Chain: It considers the environmental effects of all processes of supply chain from the extraction of raw materials to the final

B. Activities of Green Supply Chain Management

GSCM is treated as important innovations that assist organizations develop "win-win" strategy. Generally, green design and green operation are the key factors of GSCM practice. Supply chain management is the coordination and management of a complex network of activities involved in delivering a finished product to the end-user or customer.

All stages of a product's life cycle will influence a supply chain's environment burden, from resource extraction, to manufacturing, use and reuse, final recycling, or disposal.

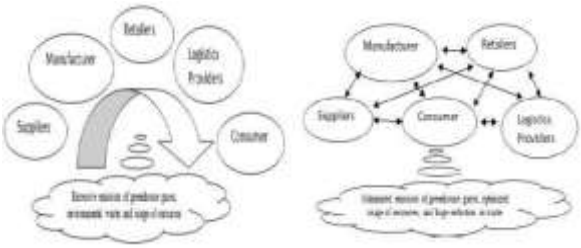

Figure 1: Traditional Versus Green Supply Chain Management [20]

Green supply chain management (GSCM) which is defined as "green procurement+ green manufacturing+ green distribution+ reverse logistics". The idea of GSCM is to eliminate or minimize waste (energy, emissions, and chemical/hazardous, solid wastes) along supply chain [11].

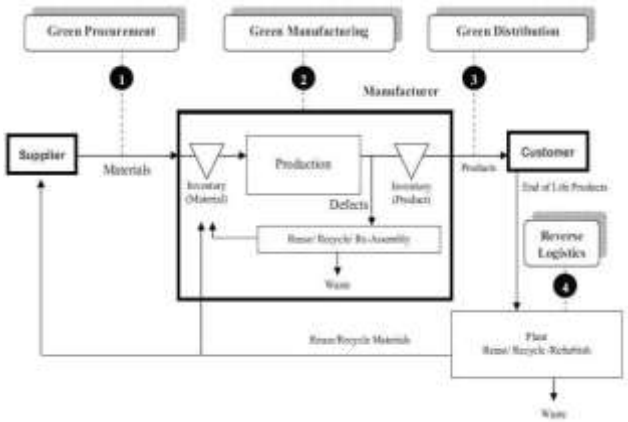

Figure 2: Activities of Green Supply Chain Management [11]

C. Classification of GSCM Green Operation: It refers all strategic and operational aspects related to green procurement, green manufacturing, green distribution, reverse logistics, logistic management, waste management, remanufacturing of products, use, handling [13].

Green Design: Green design includes design for the environment and product life cycle assessment, to consider environmental aspects in the products design means It is about designing for disassembly/ recycle-ability and allowing for alternative uses after the product has reached the end of its original purpose [4]

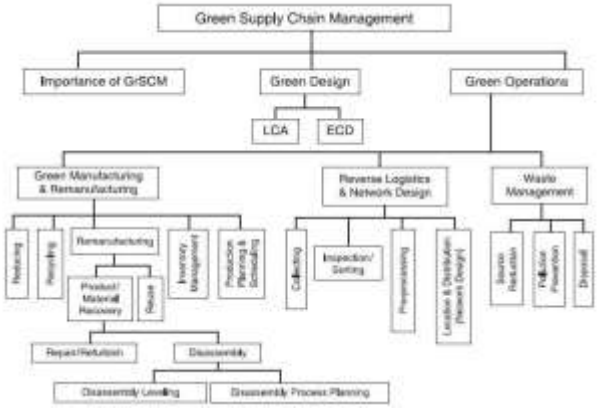

Figure3: Classification of GSCM [12]

Life-Cycle Assessment (LCA)*:* Life cycle assessment is a "cradle-to-grave" approach for assessing industrial systems. "Cradle-to-grave" begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. LCA evaluates all stages of a product's life from the perspective that they are interdependent, meaning that one operation leads to the next. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not considered in more traditional analyses (e.g., raw material extraction, material transportation, ultimate product disposal, etc.). By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection [16].

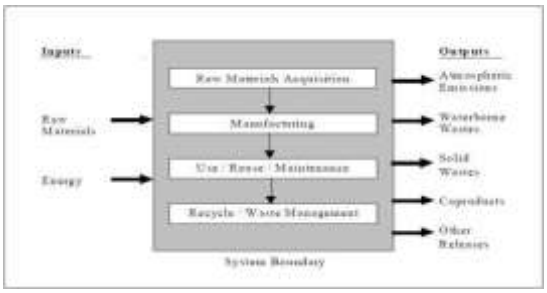

Figure 4: Life Cycle Stages [16]

Solutions: Reduce quantities, choose the most appropriate materials, transform waste into raw materials, and prefer renewable materials and products that use only one type.

2nd stage – production: Manufacturing tends to consume large amounts of energy because of the complex processes it involves.

Solutions: optimize production processes; assemble products so they are easy to separate into their different components for repair or recycling.

3rd stage - packaging: Bottles, boxes, cans and other packaging currently account for over half the volume of household waste in developed countries. **Solutions:** Concentrate products; reduce the amount and volume of packaging to make savings along the chain, from manufacturing to waste disposal.

4th stage - Transportation: Dislocated production, cost-cutting and liberalized markets all add up to one thing: products travel thousands of kilometres before being used.

Solutions: choose manufacturing sites according to the products' final destination, use combined transport and alternative fuels, optimize loads. **5th stage - Use:** Using products, operating appliances and maintaining them in working order requires more or less energy, water, etc. Usually designed to be frequently replaced, goods today are increasingly fragile and hard to repair, which encourages wastefulness and generates waste.

Solutions: design functional, energy-saving or autonomous products that are lasting, safe and easy to maintain or repair.

6th stage - Disposal and Recycling: Worn-out or damaged products are more or less easy to recycle. The multiple components, alloys and other combinations of materials from which they are made render disassembling and processing a complex and costly procedure.

Solutions: develop reusable or recyclable products. and components.

II RELATIONSHIP BETWEEN GSCM PRACTICES & SCM PERFORMANCE

Eco-Design: An international concept, developed by the World Business Council for Sustainable Development (WBCSD) at the Rio summit, eco-design is the culmination of a holistic, conscious and proactive approach. It consists in designing a product -or service- so as to minimize its impacts on the environment. Eco-design applies at every stage in a product's life: raw material extraction, production, packaging, distribution, use, recovery, recy-cling, incineration, etc.

All consumer goods, even "green" ones, have negative repercussions on the environment. They are manufactured using raw materials, energy and water. Then they must be packaged and transported to their place of use, before finishing up as waste. Eco-design is a means of minimizing these impacts throughout a product's lifecycle for the same degree of efficiency and utility.

Some of the ways for minimize the eco-design impacts:

1st stage - Raw materials: Manufacturing a product means first exploiting raw materials. Extracting and processing these constituent parts consumes natural resources, uses energy and is a source of pollution.

A. Deployment of Green Supply ChainPractices

1. Upstream Deployment of Green Practices

These practices are associated directly with interactions between a firm and their suppliers involving environmental concerns. The green practices that involve suppliers are:

- **Environmental collaboration with suppliers:**
  This green practice produces the same benefits as other non-green SC practices concerned with supplier collaboration, since it increases the level of SC integration. It improves the ability to coordinate operations and workflow in different SC tiers in order to respond to changes in customer requirements. Therefore, it increases customer satisfaction and contributes to the reduction of business waste, environmental cost and SC cost [19].

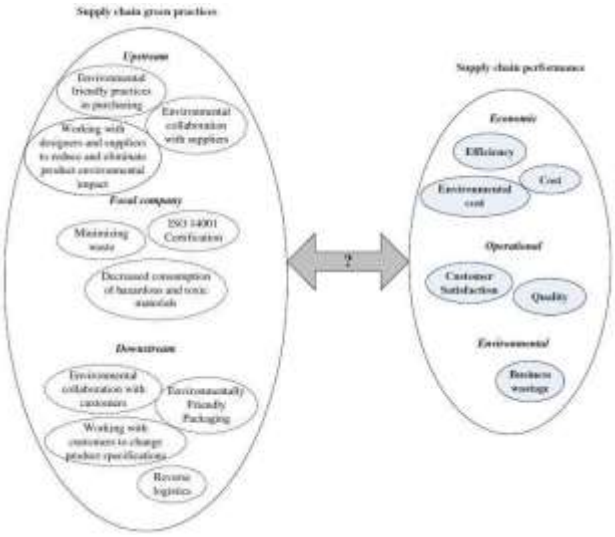

Figure 5: Relationships Model between GSCM Practices & SC Performance [19]

- **Environmentally friendly purchasing practices:** Suppliers' ability to develop environmentally friendly goods is becoming an important factor in supplier selection. In which the purchase of green materials represents a cost, it can economic value such as disposal and liability costs. Adopting green purchasing practices avoids buying in waste and reduces environmental costs. Even among those which are certified under ISO 14000 [19].

- **Working with designers and suppliers to reduce and eliminate product environmental impact:** In the product development stage, designers should consider the effect of design on energy and material requirements for manufacturing, usage and secondary usage. At the same time, design collaboration with key suppliers enhances greenefforts and reduces the product introduction time.

2. Deployment of Green Practices by Company Itself

These practices depend only on the firms' decisions to deploy an environmentally friendly behaviour are considered:

- **Minimizing waste:** This can be accomplished by handling and minimizing waste after it has been generated. This green practice is also incorporated into lean practices for the elimination of waste or non-value-adding activities throughout the chain.

- **ISO 14001 certification:** ISO 14001 is an internationally recognized standard which defines the criteria for an environmental management system, requiring commitment to compliance with applicable legislation, regulations and continuous improvement. However, it promotes the reduction of resource usage and waste reduction, and contributes to quality improvement. To adopt ISO 14001, because of their better economic performance, they may also require that their domestic and foreign suppliers also adopt this standard in the global SC.

- **Decrease consumption of hazardous and toxic materials:** This helps to minimize the cost of eliminating and treating hazardous and toxic materials, just as it limits business waste. However, while this practice could be adopted by an individual organization, it will only produce the desired environmental performance if suppliers with environmental concerns are also involved. This kind of practice can only be implemented if all partners throughout the SC share the same environmental concerns.
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3. Downstream Deployment of Green Practices

These practices are those which incorporate environmental concerns in all kinds of flows (materials and information) between the firms and in which green practices are involves customer [19].

- **Environmental collaboration with customers:** An effective customer relationship allows SC cost reduction and maintains the reliability of operations, thereby increasing
  quality and customer satisfaction. This helps to increase responsiveness to customers' environmental concerns as well as to improve the fulfilment rate and on-time delivery. However, environmental collaboration with customers requires a different SC structure and an appropriate SC approach.

- **Environmentally friendly packaging:** This is among the most visible indications of an organization's environmental commitment. It is expected that the application of environmentally friendly packaging initiatives will reduce environmental costs and business waste while improving customer satisfaction.

- **Working with customers to change product specifications:** This helps to establish product specifications that are compatible with process modifications, increasing process efficiency and input substitution while having a positive influence on product conformance with respect to specifications and durability.

- **Reverse logistics:** The environmental gain from minimizing business waste through product recovery as well as the collection and transportation of recovered products. It represents an environmental cost for organizations. Minimizing such costs is important in order to increase the total environment gain from recovery. Main objective of reverse logistics is integration and collaboration of SC.

Green practices	Operational measures		Economic measures			Environmental measures
	Quality	Customer satisfaction	Cost	Efficiency	Environmental cost	Business waste
Environmental collaboration with suppliers		↑	↓		↓	↓
Environmentally friendly purchasing practices					↑	↓
Working with designers and suppliers to reduce and eliminate product environmental impact		↑			↓	↓
Minimization of waste			↓	↑	↓	↓
Decreased consumption of hazardous and toxic materials					↓	↓
ISO 14001 certification	↑				↑	↓
Reverse logistics					↑	↓
Environmental collaboration with customers	↑	↑	↓		↓	↓
Environmentally friendly packaging		↑			↓	↓
Working with customers to change product specifications		↑		↑		

↑ Increase; ↓ decrease.

TABLE I: Linkages between Green Practices and Supply Chain Performance [22].

B. Deployment of Supply Chain Performances

Supply chain performances also deployed in three level analyses are [15]:

1. Operational Performance

• Quality

Customer satisfaction

2. Economic Performance

- Cost
- Environmental cost
- Efficiency

3. Environmental Performance

- Business waste

III CASE STUDIES ON GSCM Company Status: Nantong Yiyi Interlining Company is a privately owned manufacturer of fabrics, dying chemicals, fibber setting, and coatings for high-end clothing producers, Located in Nantong City, Jiangsu Province. With an annual production capacity of more than 60 million meters of cloth, the firm's buyers include at least

20 China-based garment manufacturers of high-end clothing brands whose products are exported to markets in Asia, Middle East, Europe, and the United States [20].

Quick Facts: Garment Industry: The garment industry is one of China's most competitive sectors with approximately 50,000 of companies have annual sales of at least RMB5 million. The industry is also one of China's most polluting sectors. In 2007, the industry's waste water discharges exceeded 2.2 billion tons, accounting for 10 percent of China's total industrial wastewater pollution [20].

Figure 5: Environmental Benefits Models for Case Study

Environmental Problem

- In June 2007, Nantong City Environmental Protection Bureau issued Nantong Yiyi a code red violation, indicating that the company had violated national environmental standards. The government sanction led to its placement on the China Water Pollution Map.
- As a result of its listing, one of its buyers, the Esquel Group – a Hong Kong-based clothing manufacturer – discovered Nantong's environmental noncompliance in July 2008 and requested that Nantong Yiyi take internal corrective action. In response to the request from the Esquel Group, Nantong Yiyi contacted the Green Choice Alliance (GCA) to remove its violations record from the China. .
- In March 2009, the GCA and an independent international environmental consulting firm conducted a third-party audit of the company. The environmental audit found that the company's effluent discharges exceeded the local environmental regulation's permissible

Chemical Oxygen Demand (COD) levels. It also found that the main source of COD pollutants originated from the production of one low-quality lining fabric, which also consumed disproportionately large amounts of water.

Solutions Implementation

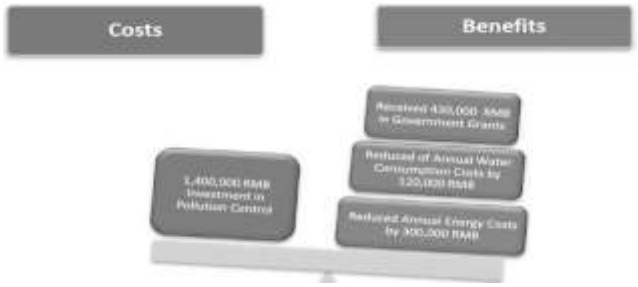
- Nantong Yiyi did not believe it was economically viable to invest in the appropriate environmental clean-up measures for the production of the low-quality lining fabric because of very low profit margins.

- However, with ongoing pressure from the Esquel Group to resolve its noncompliance issue, Nantong accepted the recommendation

  of the environmental consulting firm to replace the polluting product line with a less water-consuming and water-polluting fabric. The company also decided to improve its recycling system for processed water.

- As a result of these measures, Nantong Yiyi increased its water use efficiency by one-third and significantly reduced its COD discharges to comply with the regulatory COD levels, which were independently verified by the GCA in July 2009.

- In addition, the company's manufacturing system received ISO 14000 certification, the global industry-rating system for production processes with environmental management systems.



6: Economic Benefits Model for Case Study

Key Lessons

1. Engage key stakeholders – the government, customers and citizen groups – to identify innovative solutions and gain financial support.

2. Evaluate opportunities to replace the manufacture of highly polluting products with environmentally friendly alternatives, to address environmental problems in an effective and cost-efficient manner.

IV CONCLUSION

This papers conclusion highlights the pressure on supply chain design to supply products that are environmentally friendly in their sourcing, production, delivery, usage and disposal. Not just for marketing purposes or 'green washing'. While companies sometimes limit innovation to benefiting their reputations by association, the real challenge is to mainstream them across existing product ranges. Carbon footprint consideration, but also sourcing, procurement and end-of-life, will therefore be a crucial allying 'greening' the supply chain and providing supply chain executives with a transparent view of the entire supply chain.

The purpose of this study was to measure performance of GSCM practices including external, internal, eco design factors with supply chain performance measurement system reflecting resource, output, and flexibility. Existing body of study indicates that GSCM practices are positively or negatively associated with economic and environmental performance. In this paper GSCM practices revealed a significantly positive relationship with the three supply chain performance parameters.

Finally from study, identify some key factors which are mostly facing manufacturing industries are:

1. 40% of 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. Almost a third of respondents are not collaborating with their extended supply chain on green practices.

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