An Integrated Framework of Green Supply Chain Management Implementation

M. Ghobakhloo, S. H. Tang, N. Zulkifli, and M. K. A. Ariffin

***Abstract*—With increase in environmental concerns during the past decade, a consensus is growing that environmental pollution issues accompanying industrial development should be addressed together with supply chain management. Therefore, the greening of the supply chain initiative, as implemented by world-class ISO 14001 certified companies has become an obligation to the environment and to the society itself, obligated mainly by governmental regulations and customer perspective on environmental issues. To facilitate the growth of Green Supply Chain Management (GSCM) some implementation guidelines to help academicians, researchers, and practitioners in better understanding integrated GSCM from a wider perspective is needed. The purpose of this paper is to present and integrated framework of GSCM implementation which is based on the rich body of available literature, including earlier reviews that had relatively limited perspectives. This study will assist different parties involved with greening supply chain processes to achieve a practical synopsis of the GSCM implementation.**

***Index Terms*—Green design, green manufacturing, green supply chain, reverse logistics, supply chain management.**

I. Introduction

Years ago, the concept of environmental quality was almost non-existent in the business environment. However, the quality revolution of the 1980s and the supply chain revolution of the 1990s have made it evident that the business best practices call for integration of environmental management with ongoing operations [1]. The implementation of Green Supply Chain Management (GSCM) is such innovative idea that is fast gaining attention in the industry and has received a great interest among researchers and practitioners of operations and Supply Chain Management (SCM) [2]. The concept of GSCM within the prior literature ranges from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer, and even Reverse Logistics (RL) [3]. Srivastava [1] however defines GSCM 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".

In the early 1990s, the environmental impacts of production were the main reason for commitment to the greening of SCM [4] [5]. However, the perspective was converted from greening as a burden to greening as a potential source of competitive advantage for businesses [6]. There are some reasons explaining why greening of the supply chain is gaining a significant support in organizations. Bacallan [7] and Rao [2] suggest that as customers and other stakeholders may not be able to distinguish between a company, its suppliers, and its trading partners (e.g., due to high level of integrity between supply partners in the recent business environment), greening of the supply chain will help companies with controlling and avoiding the potential environmental concerns and problems, which can emerge due to their suppliers that in turn would threaten their own environmental performance. In addition, the highest conservation of natural resources using the principles of reuse, recycle, and recovery of materials and energy where possible is another driver persuading businesses to implement GSCM.

In this study, we seek to contribute to the literature by providing a concise framework of GSCM implementation to help academicians, researchers and practitioners in understanding integrated GSCM from a holistic perspective through applying qualitative analysis on the existing literature. To address the mention objective, this paper begins with a general discussion of SCM and GSCM. This initial discussion is extended by incorporating different dimensions of effective GSCM implementation.

II. Green Supply Chain Management

As companies began to interact with their suppliers electronically over the last decade, SCM has inherited the forefront of organizational practice to form inter-functional operations within their organizations and to forge electronic connections with key customers [7] [8]. The main objectives of the SCM function include cost reduction, improvement and innovation of end-to-end processes between firms and their customers and suppliers, improved communication and interaction among supply chain partners, and improved performance and productivity in a way that benefits all contributors in the supply chain [9]. Fig. 1 describes the typical life cycle of supply in which designing the supply chain concurrently with the product is a SCM best practice. Although similar to the concept of SCM, the boundary of GSCM is dependent on the supply chain concurrently with the product; however, adding the 'Green' component to SCM involves addressing the influence and relationships between SCM and the natural environment [1]. Accordingly, GSCM recognizes the disproportionate environmental impact of supply chain processes in an organization.

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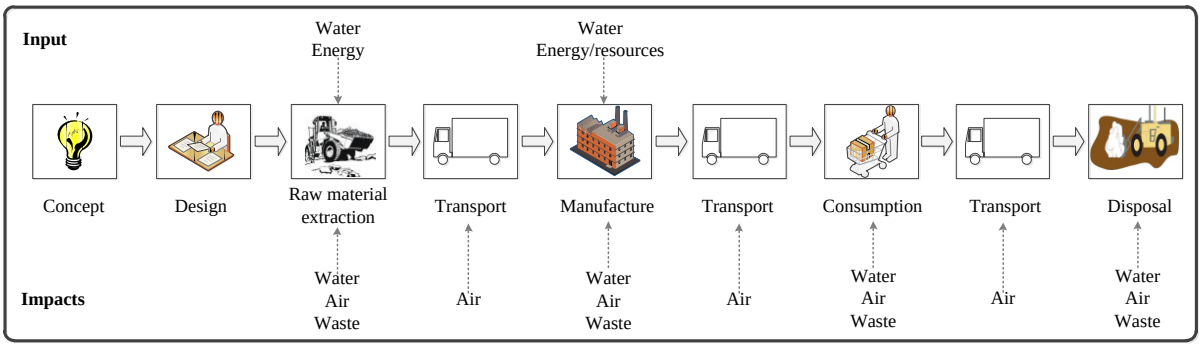

Fig. 1. Typical supply chain scope and relative environmental impacts

As suggested by Fig. 1, the impact of manufacturing operations and productions of goods on the environment may be generally categorized as waste (all forms), energy use, and resource use (material consumption) [10]. In order to achieve the GSCM, manufacturing organizations must follow the basic principles established by ISO 14000, and particularly, by state-of-the-art ISO 14001. In doing so, it is imperative that organizations develop procedures that concentrate on operations analysis, continuous improvement, measurement, and objectives [3] [10]. However, to more systematically come up with guideline for effective GSCM implementation, we present and interactive framework of GSCM (Fig. 2) which is based on following definition of GSCM:

Green Supply Chain Management (GSCM) = Green Product Design + Green Material Management + Green Manufacturing Process + Green Distribution and Marketing + Reverse Logistics (RL)

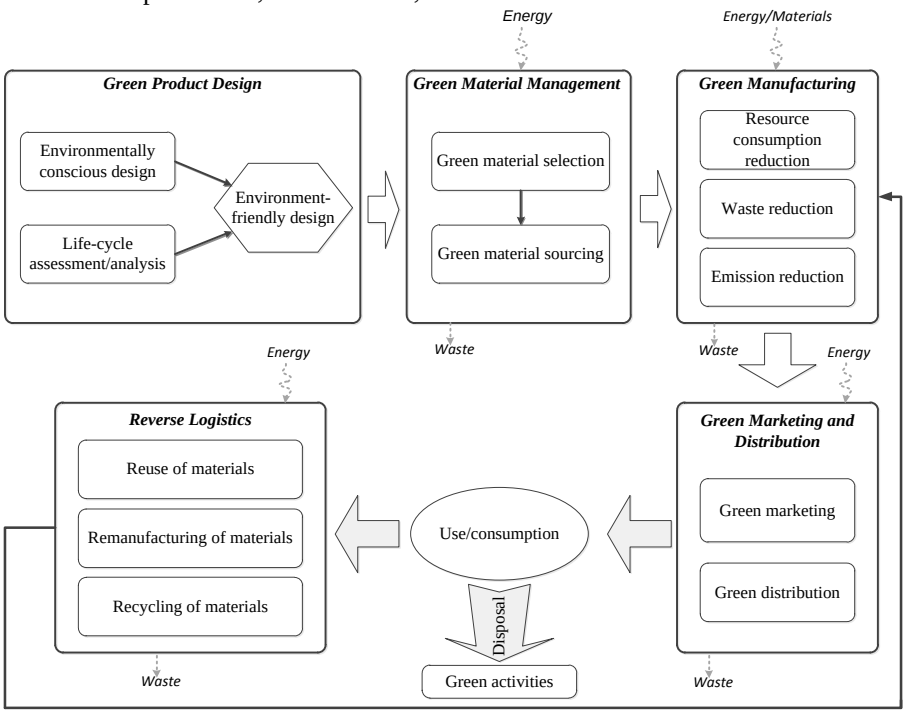

Fig. 2. Framework of green supply chain process implementation

In this framework, green product design includes Environmentally Conscious Design (ECD) and Life-Cycle Assessment/analysis (LCA) of the product, green manufacturing process consists of resource consumption reduction, waste reduction, and emission reduction, and RL closes the loop of generic supply chain and includes reuse, remanufacturing, and/or recycling of materials into new materials or other products with value in the marketplace.

A. Green product design

Prior literature on GSCM emphasizes both ECD and LCA of the product. LCA is generally concerned with the process for assessing and evaluating the environmental, occupational health and resource consequences of a product through all phases of its life [11]. Accordingly, its scope encompasses 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 [1]. LCA is considered as basis for the development of environmental laws, taxes and regulations. Moreover, businesses can use LCA to strengthen their product development so that the overall environmental impact of the product is minimized [11]. Based on the commonly repeated steps of LCA in the literature, process of LCA can be exemplified in Fig. 3 [1] [12] [13].

ECD which is also known as Design for Environment (DFE) however seeks to design products with certain environmental considerations [11]. In ECD context, information provided by LCA should to be transferred into the initial design of a new product. ECD can be broken down into many stages such as Design for Recycling (DFR) and

Designing for Disassembly (DFD) [14] [15]. Using DFD businesses try to correctly identify the design specifications of the product to minimize its complexity of the structure through minimizing the number of parts, increasing the use of common materials and choosing the fastener and joint types which are easily removable. Therefore, specific software are typically used for DFD due to the complexity of the problem [11] [16]. DFR however mainly deals with making better choices for material selection.

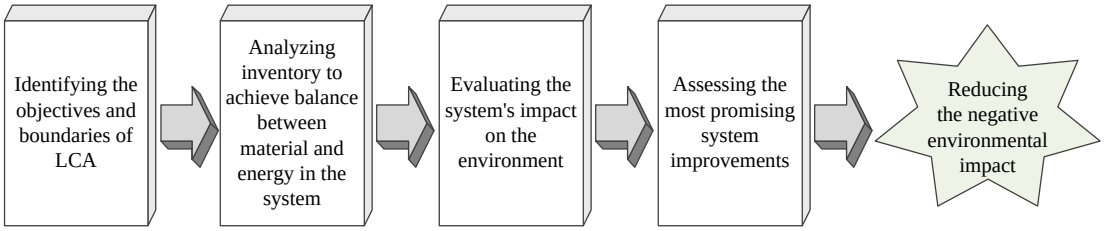

Fig. 3. Life cycle analysis or assessment

B. Green Material Management

One of the most reasonable actions in GSCM is to replace a potentially hazardous material or process by one that appears less problematic [1]. For green material management, following processes of material selection, separation and material recovery should receive more support [11], [17]:

1) Different materials used in a product should be easy to separate;
2) While maintaining compatibility with the existing manufacturing infrastructure, fewer numbers of different materials in a single product should be used;
3) More adaptable materials for multiple product applications should be used;
4) Smaller number of 'secondary operations' should be used to reduce the amount of scrap and simplify the recovery processes.

C. Green Manufacturing Process

In addition to environmentally friendly product designs, issues involving manufacturing must also be addressed to have a complete concept of green manufacturing [11]. One of the main objectives of green manufacturing process is reduced use of virgin material and other resources/energies as it indirectly reduces the amount of waste at manufacturing stage. Many companies now are monitoring their waste generation as a result of their manufacturing processes. In doing so, Pinch analysis [18], industrial energy [19] and energy and life-cycle analysis [20] are three main techniques for minimum energy and resource consumption for flow systems. Similarly, recycling, mainly driven by economic and regulatory factors, is performed to retrieve the material content of used and non-functioning products [1]. For example, BMW has announced a pilot program in North America to test the feasibility of recycling BMW automobiles (because of the strict German laws the company already recycles cars in Europe). Likewise, consumer electronics and computer industries are also involved in the environment-friendly movement. For example, IBM has developed design specifications for its new products to improve product's end-of-life material recovery.

On the other hand, emission reduction is another significant accepts of green manufacturing. There are two primary emission reduction means which are; (1) control, emissions and effluents are trapped, stored, treated and disposed of using pollution control equipment; or (2) prevention, emissions and effluents are reduced, changed or prevented altogether through better housekeeping, material substitution, recycling or process innovation [21].

D. Green Marketing and Distribution

Green marketing dates back to the early 1970s, however, many different aspects of green marketing were discussed academically in the early 1990s [22]. Although it is mostly believed that green marketing refers solely to the promotion or advertising of products with environmental characteristics, in general, green marketing is a much broader concept which should comprise product modification, changes to the production process, packaging changes, as well as modifying advertising [23]. In the green marketing context, green advertising is of prime importance. Green advertising is defined as any advertisement that presents a corporate image of environmental responsibility, supports a green lifestyle with or without highlighting a product/service and clearly and understandably addresses the relationship between a product/service and the biophysical environment [24].

Green distribution is of extra importance in the greening of SCM, due to its great impact on the natural environment. Green distribution relies on green transportation which is defined as; "transportation service that has a lesser or reduced negative impact on human health and the natural environment when compared with competing transportation services that serve the same purpose" [25]. Investigating potential suppliers' environmental status, informing and educating suppliers in environmental matters, and addressing the environmental aspect in the written contract can be examples of practices which take green consideration into account when transportation services are purchased [25] [26].

E. Reverse Logistics

Recycling, reusing, and remanufacturing are considered to be RL functions that also serve to GSCM. Reuse is defined as to use an item more than once. This includes conventional reuse where the item is used again for the same function and new-life reuse where it is used for a different function. Reuse can also be defined as the utilization of reusable packaging or shipping materials [27]. Remanufacturing however refers to repairing, refurbishing, or overhauling an item in order to extend the life of and derive value from the original core unit. The proper management of remanufacturing may improve the product from its current condition (e.g., end-of-life) to that of a condition acceptable for reuse and can create lucrative business opportunities through recapturing [27]

[28].

Nevertheless, prior literature in RL mostly focuses on recycling. In fact, some assert that RL has been most closely associated with recycling and environmental matters [27]. Recycling refers to processing used materials (waste) into new products to prevent waste of potentially useful materials. It will result in the reduced consumption of fresh raw materials, reduced energy usage, reduced air and water pollution through decreasing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production [29].

III. Conclusion

With regard to the rising global awareness of environmental protection, businesses have employed their GSCM to improve their core competitive advantage. GSCM is a progressively widely-diffused practice among companies that are seeking to improve their environmental performance. GSCM practices, which are viewed as cross-organizational and closed loop reduces the ecological impact of industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency.

We presented a state-of-the-art and succinct framework of effective GSCM implementation which is based on the literature review of GSCM while integrating the whole gamut of activities in the area. We found that the key themes that came out of the GSCM literature over the last twenty years are the concepts of greening the product design, material management, manufacturing process, distribution and marketing, and RL. Although many empirical studies (e.g., case studies and survey-based empirical methods) have been carried out, they have not completely dealt with each and every aspect of GSCM and there are areas around Green supply chain that still require further empirical study. For example, it is expected that most of top management team, as well as stakeholders to hold different opinion on GSCM as they are mostly concerned with profitability of their businesses. They may go against GSCM and consider it as a constraint to the organization's profitability (based on profitability analysis). Therefore, detailed empirical case studies need to be carried out in such areas as individual and organizational commitment to GSCM at the individual and firm level.

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