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# Sustainable green supply chain management: trends and current practices

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## Abstract

**Purpose** – The purpose of this paper is to give an up-to-date and structured insight into the literature published during the past decade on sustainable green supply chain management. It also suggests trends for future research based on the research issues identified through systematic and comprehensive analysis of previous studies in the area of green and sustainable supply chain management.

**Design/methodology/approach** – A state-of-the-art literature review is carried out by systematically collecting the existing literature over a period of 10 years (2005-2014) and categorizing it on the basis of attributes such as stages in supply chain, methodology and the industries/sectors under consideration. The classification of literature is also done according to the geographic region and year of publication.

**Findings** – There has been an increased interest among researchers and practitioners in the area of sustainable green supply chain management in the past decade. A need for achieving sustainability through adoption of greener practices has been universally felt, owing to an increasing environmental and ecological complexity. The review reveals that there exists a need to address behavioural issues like human resource management and supply chain partner relationship management. Moreover, reverse logistics, closed-loop supply chain management and waste management are areas that need special focus to achieve environmental sustainability.

**Research limitations/implications** – The current review focuses on research trends in the past 10 years only. Moreover, papers from only good quality, peer-reviewed journals are considered in the study.

**Originality/value** – Most of the previous reviews have either focused on specific issues related to sustainable supply chains only or green supply chains. The present study collectively takes into consideration papers both from green supply chain management as well as from sustainable supply chain literature that have a prime focus on environmental sustainability.

**Keywords** Supply chain, Green supply chain, Sustainable supply chain

**Paper type** Literature review

## 1. Introduction

A major challenge faced by firms of all sizes and industries is to become more responsible and accountable towards the environment and society. It has been widely recognized that they must address the issue of sustainability in their operations and management of supply chains. To widely adopt and develop sustainability, there should be an increased attention on supply chains (Ashby *et al.*, 2012). In the initial few years, sustainability initiatives focused on environmental issues only, but they have now moved to adopting a triple bottom line (i.e. environment, economic and social) approach. There are two terms that link sustainability and SCM concepts closely: green supply

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chain management (GSCM) and sustainable supply chain management (SSCM) (Ashby *et al.*, 2012). A number of literature reviews in the areas of green and sustainable supply chains have been published in the recent few years. Srivastava (2007) carried out a comprehensive literature review on GSCM. Supplier selection in green supply chains has been addressed by Igarashi *et al.* (2013), whereas Brandenburg *et al.* (2014) and Govindan *et al.* (2013) carried out a review of analytical models used in GSCM. Moreover, Sarkis *et al.* (2011) categorized the GSCM literature on the basis of organizational theories. In the area of SSCM, a number of comprehensive reviews have been completed. (Brandenburg *et al.*, 2014; Seuring and Muller, 2008a, 2008b; Seuring, 2013; Tang and Zhou, 2012; Varsei *et al.*, 2014; Carter and Easton, 2011; Abbasi and Nilsson, 2012; Ashby *et al.*, 2012; Gimenez and Tachizawa, 2012; Carter and Rogers, 2008).

The extant literature reviews have dealt with the two concepts in isolation. A majority of reviews have addressed various topical issues having limited focus and narrow perspective within the existing research literature. A number of definitions of sustainable and green supply chains are present in the literature. Ahi and Searcy (2013) focused on these definitions and identified 22 definitions for green and 12 definitions for SSCM. Most articles on sustainable supply chains have a major focus on environmental sustainability only (Ashby *et al.*, 2012), while some are largely biased towards social aspects. Because the areas of SSCM and GSCM are overlapping with very thin boundaries separating them, there is a need to consider both these areas simultaneously while identifying the trends of past researches and scope of future works. Therefore, the present attempt seeks to provide a state-of-the-art literature review on sustainable GSCM by taking into consideration a systematic and structured analysis of relevant researches from GSCM and SSCM together. The rationale of using relevant sustainability literature is to include every possible issue of green supply chains that has been addressed in the reported literature.

The remainder of the paper is as follows. Section 2 gives an overview of the field of sustainable and GSCM, explaining the key definitions and concepts. Then the next section provides a detailed methodology adopted to collect and refine the literature that is to be evaluated and reviewed later on. Section 4 provides the segmentation of the extant literature and the subsequent analysis. Conclusions are drawn in the last section along with an agenda for further research.

## 2. Overview of sustainability and green supply chain

Supply chain management refers to the planning and control of materials, information flows and the logistics activities within an organization and also between multiple firms (Cooper *et al.*, 1997). The integration of sustainability with supply chain management has emerged as an ubiquitous topic among academicians and practitioners (Carter and Easton, 2011; Connelly *et al.*, 2011; Seuring and Muller, 2008a, 2008b). Sustainability has been popularly defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). The concept of triple bottom line is based on the notion that companies should consider environmental and social aspects rather than focusing on purely economic value (Elkington, 1998). This implies that to achieve an accepted level of sustainability, a firm should address environmental or ecological issues along with meeting the social standards across all levels of their supply chains (Seuring, 2013). The integration of environmental, economic and social

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performances to achieve sustainable development is a major challenge for all businesses (Srivastava, 2007). Many firms are now undertaking major initiatives to make their supply chains greener in response to stricter governmental regulations and increased public awareness of environmental protection, (Zhu *et al.*, 2013; Mirhedayatian *et al.*, 2014). Initially, the concept of sustainability was largely oriented towards environmental issues and lesser attention was given to the social aspects. Environmental management has been widely accepted among organizations as a strategic practice to gain competitive advantage. Firms are adopting practices and processes in the supply chains that pose lesser threat to the environment. This consideration given to the ecology while managing supply chains is referred to as GSCM. A number of definitions for GSCM are present in literature. Srivastava (2007) defined it 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.

The scope of GSCM ranges from green purchasing to integrated green supply chains flowing from supplier till end customer, and even closing the supply chain by incorporating reverse logistics (Zhu and Sarkis, 2004). Only by implementing "greener" approaches in their business operations companies can cope with the pressures from customers, buyers, communities, government regulators, non-governmental organizations and media who have increasing concern for environment (Seman *et al.*, 2012).

In the present study, a conceptual framework for sustainable GSCM is developed. The framework is shown in Figure 1 and it lists down all the relevant activities and issues in a typical sustainable green supply chain. The elements of this framework will later be used in the content analysis presented in Section 4.2.

## 3. Methodology

Meredith (1993) reported that a literature review is a summary of the extant literature by identifying focus of research, trends and issues from past researches. The definition given by Fink (1998) emphasized both on the review process as well as the desired results, describing it as "a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents". A literature reviews has dual purpose of consolidating the intellectual structure of an identified field and identifying the key knowledge gaps and opportunities to address them (Tranfield *et al.*, 2003). Following this rationale, a systematic literature review process has been adopted in this paper.

### *3.1 Literature collection*

As previously mentioned, the purpose of this paper is to review the recent literature on sustainable green supply chains. To achieve this purpose, the current study focuses on academic peer-reviewed journals in sustainable and GSCM literature. The literature search confined itself only to articles published in English language. The management and science journal databases such as Science Direct, EBSCOHOST and Google Scholar were explored using a structured keyword search to identify relevant articles in the area. Accordingly, the terms "green supply chain management", "Green supply chains", "sustainable supply chain management", "sustainable/sustainability", "sustainable

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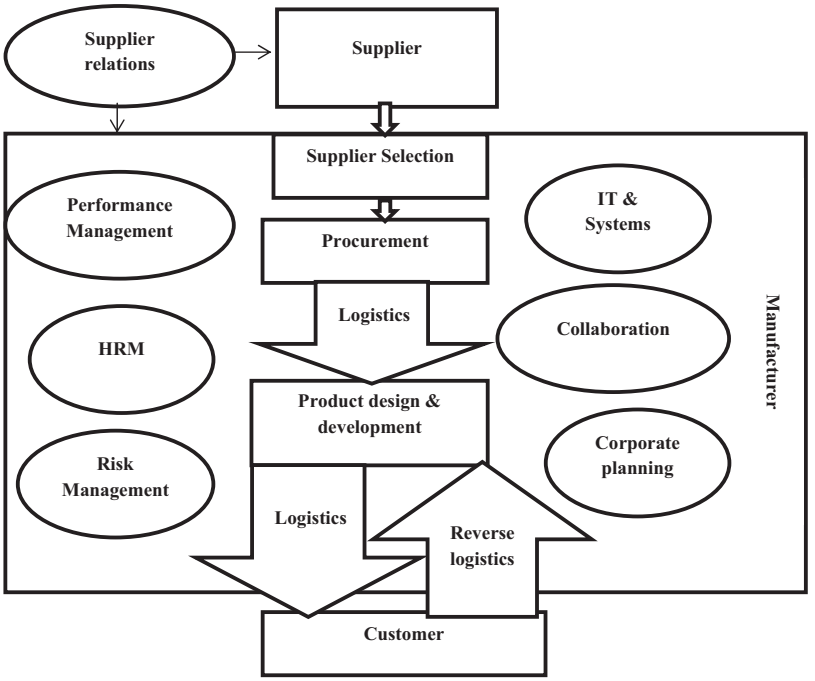


**Figure 1.**
Framework of activities for a sustainable green supply chain

development", "environment(al)", "ecological" and "green" were used for the search process. The motivation of using these keywords came from their adoption in previous literature reviews conducted by other researchers. Further, additional relevant publications were obtained through references cited in the papers identified through the database search. This was followed to ensure that all the relevant papers have been included in the study and unintended omissions are avoided.

*3.2 Screening of relevant literature*

The keyword search across the databases and cross-referencing procedure to collect all the literature on sustainable GSCM resulted in over a thousand articles. These included research papers from journals, conference proceedings, white papers and editorials. To remain within the scope of study, certain delimiting conditions were established. To increase the reliability of review process and to avoid repetition of works, publications from academic peer-reviewed quality journals were selected. Further, as the main objective of this review is to focus on the researches conducted in the past decade, so only the articles published over a period of the past 10 years (2005-2014) were shortlisted. The methodology of reading the abstracts, as proposed by Jahangirian *et al.* (2010), was adopted to eliminate irrelevant papers from the selection. This process revealed that many papers dealt with issues that did not fall precisely into the category of sustainable green supply chain and therefore, were removed from the purview of this study. The final search resulted in 138 articles from 29 journals. Despite careful segregation and collection of articles, there can be some subjectivity involved in deciding which articles actually belong to the domain of sustainable GSCM.

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*3.3 Category selection*

All the practical dimensions of sustainable GSCM were covered so that an exhaustive analysis and review of existing body of knowledge can be performed. A structured classification scheme was developed to enable an effective categorization of existing literature. A part of the categorization came from the previous studies and review papers and the rest came from individual analysis.

The literature search was limited to the period of the past 10 years from 2005 to 2014. Each of the 138 articles was categorized as per its publication year.

As the study includes publications from both the sustainability and green supply chain literature, the articles were categorized into two segments. The first segment contained publications from green supply chain area, while the other one included sustainability literature that predominantly dealt with environmental sustainability. This classification intends to provide an idea of the literature composition from the two areas. They go to the market.

The next classification was carried out on the basis of adopted methodology in the papers. The scheme adopted to classify articles in terms of type of research is based on the work of Natarajarathinam *et al.* (2009). They have classified theory-building research into four groups: conceptual, analytical, empirical and applied research. The category of conceptual work includes articles that primarily focus on development of a theoretical framework or new approach to sustainable green supply chain. These frameworks or approaches may or may not be supported with any additional work like survey, modelling or case study. As literature reviews are also intended to integrate and compile previous body of knowledge, it is also kept under conceptual research. Analytical research includes the use of mathematical models, heuristics and simulation, while case studies, interviews and opinions are covered in applied research. Lastly, empirical work includes surveys where empirically collected data from a large number of organizations are analysed. It also involves investigating relationships between variables by manipulating them in a controlled environment to assess their effect on specific dependent variables.

Another classification scheme is on the basis of geographical locations. Here, articles are categorized according to cases of different countries. Moreover, papers that have addressed continental, multi-national as well as global supply chains are also listed separately. The rationale behind this classification is to identify the degree to which organizations from different countries are aware and agile in adopting sustainable and greener practices in their supply chains.

The operations of different industries have different impacts on the environment and ecology. In an era of rising concern about environmental issues, although all corporations and sectors are encouraged to adhere to environmental norms, some have larger scope of adopting green practices, because of the inherent nature of their operations. Therefore, the next categorization attempts to classify articles on the basis of different industries and sectors. Initially, the papers are classified on the basis of whether they have addressing manufacturing or service sectors in their studies. Next, they are segregated based on various industries within each sector. The segmentation used within manufacturing sector includes mining and metallurgy; fashion and apparels; automobiles; battery; fuel and energy; foods and beverages; electrical and electronics; computer and information technology (IT); mobile phones; glass and

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packaging. On the other hand, banking; retail; tourism and education come under the service sector.

The last classification attempts to explicitly divide all the articles according to the contexts that have been addressed by researchers for achieving a sustainable green supply chain. A wide variety of contexts have been used in the previous works, depending on the themes of reviewing the literature. To comprehensively review the trends that have been followed by researchers while addressing the contexts of supply chain, the present study takes into consideration all the activities that are involved in a typical supply chain. Articles have been divided into themes such as supplier selection, supplier relations, procurement, product design and development, inventory management, transportation and network design, reverse logistics and recycling. In addition to this, other important issues like strategic planning, human resource management, collaboration, risk measurement, use of IT infrastructure and performance measurement have also been included as key themes for analysing the literature. Moreover, certain articles have adopted a holistic approach to address sustainable and green supply chain issues; hence, they have been placed separately in the classification. The elements that have been used to categorize the articles shown in the framework presented in Figure 1.

## 4. Analysis and discussions

This section presents a detailed report of all the results according to classifications defined earlier. These results are shown in figures and form the basis of subsequent analyses.

### *4.1 Descriptive analysis*

This preliminary stage of analysis deals with the formal aspects of the literature. The yearly distribution of all 138 articles reviewed in this study is shown in Figure 2. Number of publications per year was reported to give an idea of publication trends. From the Figure 2, it can be seen that there has been a continuous increase in the number of publications in the past 10 years. This can easily be attributed to the increasing awareness and interest among researchers and practitioners in the area of sustainable green supply chains.

Table I represents the number of papers from each of the given journals. The papers were distributed across a wide variety of operations, management and technology

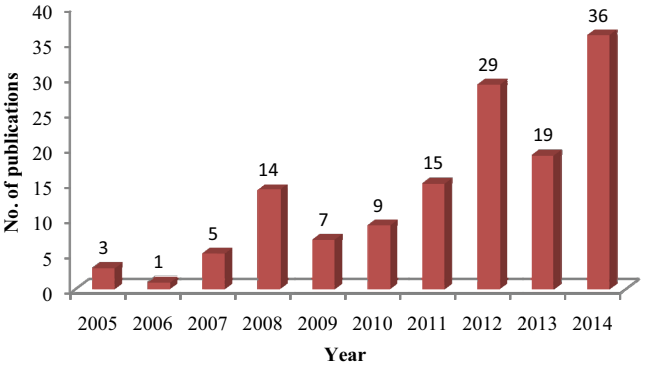


**Figure 2.**
Year-wise distribution of publications

| Journal name | No. of articles |
|---|---|
| *International Journal of Production Economics* | 31 |
| *Journal of Cleaner Production* | 25 |
| *International Journal of Production Research* | 15 |
| *European Journal of Operational Research* | 10 |
| *Journal of Purchasing & Supply Management* | 6 |
| *Procedia – Social and Behavioral Sciences* | 6 |
| *Business Strategy and the Environment* | 4 |
| *Expert Systems with Applications* | 4 |
| *Procedia Engineering* | 4 |
| *Supply Chain Management: An International Journal* | 4 |
| *Transportation Research Part E* | 4 |
| *International Journal of Physical Distribution & Logistics Management* | 3 |
| *Journal of Business Ethics* | 3 |
| *Corporate Social Responsibility and Environmental Management* | 2 |
| *Journal of Supply Chain Management* | 2 |
| *Automation Science and Engineering, IEEE Transactions on* | 1 |
| *Benchmarking: An International Journal* | 1 |
| *Business Process Management Journal* | 1 |
| *CIRP Journal of Manufacturing Science and Technology* | 1 |
| *Computer Aided Chemical Engineering* | 1 |
| *Decision Support Systems* | 1 |
| *Ecological Economics* | 1 |
| *International Journal of Business and Social Science* | 1 |
| *International Journal of Operations & Production Management* | 1 |
| *Journal of Operations Management* | 1 |
| *Journal of Sustainable Tourism* | 1 |
| *Logistics Research* | 1 |
| *Production & Operations Management* | 1 |
| *Renewable and Sustainable Energy Reviews* | 1 |
| *International Journal of Management Reviews* | 1 |

**Table I.**
List of journals reviewed

journals. This shows the contribution of prominent and quality journals towards the existing body of knowledge in the area of sustainable GSCM.

### *4.2 Content analysis*

This section provides a comprehensive analysis of the existing literature on the basis of different classifications provided in the previous section.

*4.2.1 Classification based on countries.* A geographical location-wise categorization of articles, as shown in Figure 3, was carried out to examine the degree of attention that has been paid to sustainable green supply chain from different countries. Only 37 articles mentioned cases of industries of specific countries or continents. It is revealed that the contribution of cases from developing economies is greater than that of developed economies as only three emerging economies like China, India and Taiwan have contributed to 44 per cent of the articles reviewed. Tian *et al.* (2014) proposed a system dynamics model for promoting the GSCM diffusion in China. Zhu *et al.* (2012) surveyed 396 Chinese enterprises and evaluated the mediation relationships between practices of GSCM on performance. Similarly, the roles of organizational size (Zhu *et al.*, 2008) and institutional pressures (Zhu

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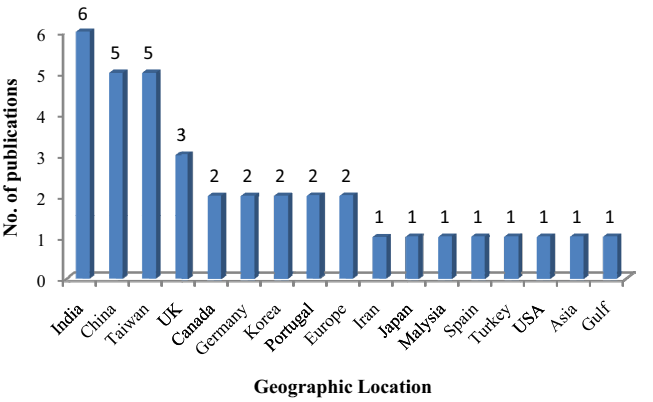


**Figure 3.**
Distribution of articles according to geographical locations

and Sarkis, 2007) on GSCM practices in China have also been addressed. In Indian context, researchers have prominently analysed the barriers in implementing sustainable green supply chains management (Govindan *et al.*, 2014a, 2014b, 2014c; Jayant and Azhar, 2014; Muduli *et al.*, 2013; Mathiyazhagan *et al.*, 2013). There was one study by Tseng *et al.* (2013) that focused on Asian context by examining sustainable consumption and production (SCP) opportunities to achieve sustainability through GSCM practices.

*4.2.2 Classification based on "sustainability with green perspective" or "green" dimension.* To make the review more robust and comprehensive, this paper takes into consideration together articles from GSCM as well as from sustainability having a strong focus on the green or environmental dimension. A study by Ahi and Searcy (2014) collectively incorporated literature on green as well as SSCM to analyse 2,555 published metrics. Fifty-three per cent of the articles are from the area of GSCM, while the rest include sustainable supply chain perspective specifically paying attention to the environmental consideration. Ji *et al.* (2014) used triple bottom line principles of SSCM and double environmental medium regulations to show environmental impact on four phases of product lifecycle. Seroka-Stolka (2014) presented factors affecting the green logistic concept development in companies as a core element of sustainable development. Similarly, works of Tseng *et al.* (2013) and Chaabane *et al.* (2012) also have attempted to attain sustainability through adoption of green dimension (Figure 4).

*4.2.3 Classification based on methodology.* Figure 5 presents the distribution of publications on the basis of scientific research methods. A strong focus, in the past decade, has been on theory development and knowledge consolidation as 40 per cent of publications fall in conceptual research category. A number of reviews, each addressing

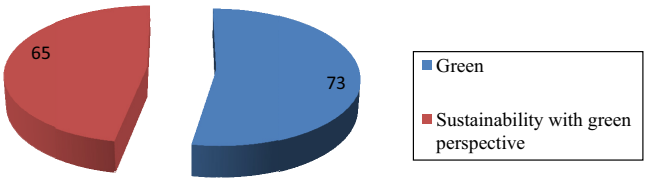


**Figure 4.**
Distribution based on "green" or "sustainability with green" dimension

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a new dimension, have been published in area of sustainable and GSCM (Subramanian and Gunasekaran, 2014; Genovese *et al.*, 2013; Igarashi *et al.*, 2013; Ahi and Searcy, 2013; Tang and Zhou, 2012; Sarkis *et al.*, 2011; Benjaafar *et al.*, 2013; Brandenburg *et al.*, 2014; Seuring, 2013; Varsei *et al.*, 2014). Seman *et al.* (2012) reviewed the literature to study the relationship between GSCM and green innovation and revealed that former leads to latter. In addition to this, analytical researches have been conducted in 37 per cent of the papers involving an extensive use of operations research techniques and analytical models. Dekker *et al.* (2012) highlighted the contribution of operations research to green logistics. Linear programming, non-linear programming and mixed integer linear programming have been employed to a large extent. Sazvar *et al.* (2014) used bi-objective stochastic mathematical model to propose replenishment policy for deteriorating items. Tsai and Hung (2009) proposed a fuzzy goal programming approach, while Yeh and Chuang (2011) proposed a mathematical planning model for addressing optimal green supplier selection problem. Fuzzy set theory along with various multi-criteria decision-making techniques such as the analytic hierarchy process (Govindan *et al.*, 2013; Wang *et al.*, 2012), analytic network process (Cabral *et al.*, 2012), interpretive structural modelling (Mathiyazhagan *et al.*, 2013), decision-making trial and evaluation laboratory (Lin, 2013; Lin *et al.*, 2011; Wu *et al.*, 2011), technique for order preference by similarity to ideal solution (Kannan *et al.*, 2014; Wang and Chan, 2013) and data envelopment analysis (Tajbakhsh and Hassini, 2014) have been extensively used. Moreover, simulation has found application in works of Mangla *et al.*, (2014) and Jayant *et al.* (2014). Empirical studies are conducted in 17 per cent of the papers, while applied research appeared in only 6 per cent of papers.

*4.2.4 Classification based on industry addressed.* The articles were also categorized based on the industries addressed in the studies. A large number of papers have focused on the manufacturing sector (88 per cent), while service sector has gained limited attention from researchers. This can be attributed to the fact that environmental damage has been largely caused by manufacturing enterprises, whereas services, because of inherent intangibility associated with them, have little or no environmental impact. Ten articles were explicitly based on cases from manufacturing sector. Automobile sector was addressed most frequently in comparison to other industries (Tian *et al.*, 2014; Govindan *et al.*, 2014a, 2014b, 2014c; Jayant and Azhar, 2014; Mathiyazhagan *et al.*, 2013; Caniëls *et al.*, 2013; Olugu and Wong, 2012; Lee, 2011; Lin *et al.*, 2011). The next most

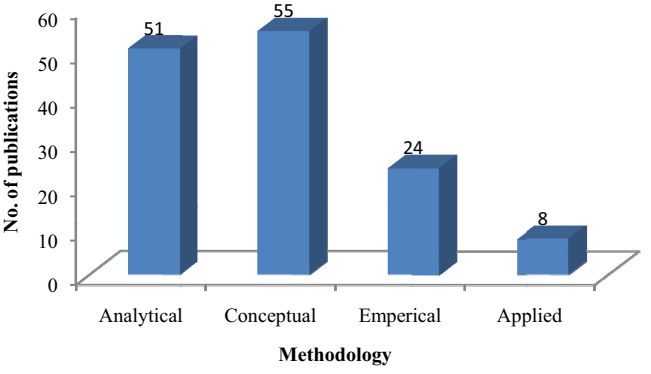


**Figure 5.**
Distribution of papers on the basis of type of research

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prominent industry according to available literature was electronics and electrical sector. E-waste recycling and reverse logistics have gained increased popularity to bring about environmental sustainability in this sector. Kannan *et al.* (2014) developed a framework to select green supplier selection for a Brazilian electronics company. Tseng and Chiu (2013) used a case study of Taiwanese printed circuit board manufacturer to demonstrate implementation of GSCM. Based on the survey of USA and Taiwan manufacturing plants in the electric and electronics industry, Lin and Sheu (2012) examined the influence of institutional theory on GSCM practices. In an another study, Trappey *et al.* (2012) used the case of an electronic image projector to demonstrate that a product's carbon footprint can be reduced by adopting collaborative green product design and production planning. Wee *et al.* (2011) proposed a model that performed a life cycle cost and benefit analysis for green electronic products by including vendor-managed inventory strategy. Erol *et al.* (2011) proposed a multi-criteria framework to evaluate and compare performances of Turkish grocery retailers in terms of sustainable supply chain (Figures 6 and 7).

*4.2.5 Classification based on contexts of problem.* The classification of articles according to the activities involved in a supply chain practice is shown in Figure 8. A holistic approach for managing sustainable green supply chains has been used in 38 per cent of the papers. Supply chain performance evaluation and measurement has gained substantial attention from researchers. Hervani *et al.* (2005) provided an overview of the various issues related to performance measurement of GSCM. Kainuma and Tawara (2006) proposed multiple attribute utility theory as one of the lean and green supply

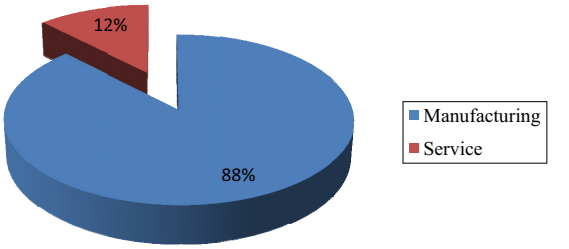


**Figure 6.**
Sector-wise distribution of publications

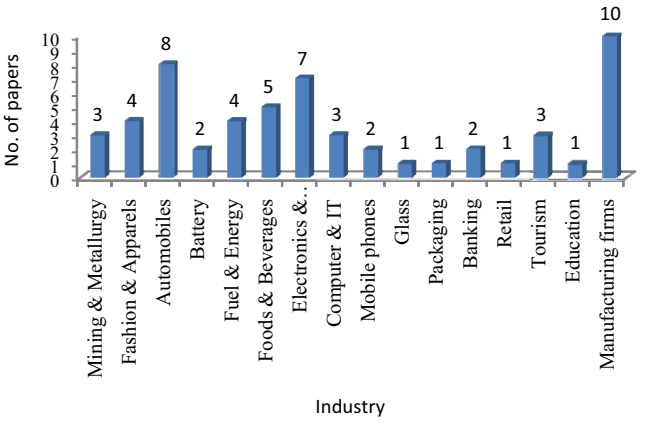


**Figure 7.**
Number of papers from each industry

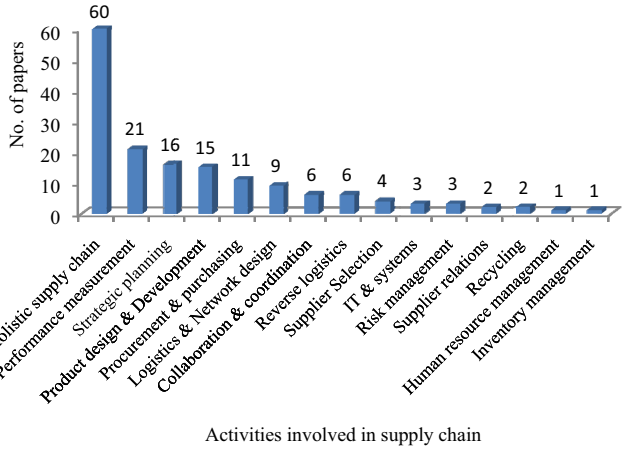


**Figure 8.** Distribution of papers according to activities in a supply chain

chain methods for assessing a supply chain performance, whereas Zhu and Sarkis (2007) studied the effects of institutional pressures on the performance of green supply chains. In the automobile sector, the performance of green supply chains based on certain criteria was studied by Lin *et al.* (2011), while closed-loop supply chain performance was analysed by Olugu and Wang (2012). Kim and Rhee (2012) found a number of relationships between the critical success factors and balanced scorecard performance of green supply chain management enterprises in Korea. De Giovanni and Vinzi (2012) investigated the relationships between environmental management and performance to determine the impact of environmental practices on firm's economic performance. In a study conducted in the UK, Yusuf *et al.* (2013) empirically identified the impact of sustainable practices on performances in the oil and gas sector. Additionally, many studies have been conducted to evaluate and measure sustainability performance (Tajbakhsh and Hassini, 2014; Varsei *et al.*, 2014; Erol *et al.*, 2011).

Strategic and corporate planning for implementing sustainable green supply chains has been addressed in a number of articles. Wu *et al.* (2014) empirically examined the links between supply chain and corporate environmental strategies and reported that alignment of both the strategies leads to improved firm performance. Youn *et al.* (2013) revealed that strategic supply chain partnership is vital for an effective environmental supply chain management.

Design and development of products significantly impact the performance of a sustainable green supply chain initiative. Green supply chain management and green innovation have strategic interconnection in the context of new product development (Seman *et al.*, 2012). Green product design maximizes product reusability and minimizes waste. Kristianto and Helo (2014) studied the implications of product architecture modularity on green supply chain's operational economy. For an effective sustainable supply chain, Büyüközkan and Berkol (2011) proposed a decision framework using quality function deployment, analytic network process and zero-one goal programming to identify design requirements.

Green supplier selection has started being considered as an area of interest among researchers. Kannan *et al.* (2014) developed a framework for green supplier selection in the context of a Brazilian electronics firm. Caniëls *et al.* (2013) further highlighted the

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significance of suppliers by addressing their participation in implementing GSCM. Ferretti *et al.* (2007) used an aluminium case study to illustrate that a supply chain can be made greener by adopting an alternative supply method. Walker and Brammer (2012) studied the relationship between sustainable procurement and e-procurement and reported that e-procurement and communication with suppliers helps in environmental aspects of sustainable procurement. Bala *et al.* (2008) illustrated a case of Universitat Autonoma de Barcelona to describe its strategy and procedures followed for spreading green purchasing practices throughout its administration and supply chain. Some review articles have also been published in the context of green supplier management (Tate *et al.*, 2012; Igarashi *et al.*, 2013).

Reverse logistics and closed-loop supply chains have emerged as critical to attainment of sustainable green practices. Mishra *et al.* (2012) proposed a multi-agent architecture to handle recycling and reverse logistics issues, thereby efficiently managing firms' green supply chain systems. Similarly, a framework for end-of-life computer recycling operations was developed by Rahman and Subramanian (2012). Faccio *et al.* (2014) addressed an innovative sustainable closed-loop supply chain problem using reprocessing of end-of-life product and disposal of unusable parts from manufacturers as the elements to attain sustainability.

The model proposed by Wee *et al.* (2011) considered vendor-managed inventory strategy for green electronic products. In addition to the above-mentioned issues, very limited attention has been paid to inventory management in sustainable green supply chains. Moreover, articles dealing with human resource issues are also limited in number. With the emergence of information technology and systems, the implementation and monitoring of green practices has become simpler. Researchers have started focusing on the use of IT to achieve sustainability in operations. Kandananond (2014) introduced different aspects of enterprise resource planning implementation for a successful green supply chain system. Supplier relations and collaboration have proved to be crucial for an efficient green supply chain (Rota *et al.*, 2013; Tseng and Chiu, 2013; Barari *et al.*, 2012; Foerstl *et al.*, 2010; Youn *et al.*, 2013; Walker and Brammer, 2012).

## 5. Conclusions and future research directions

This paper attempts to present a state-of-the-art comprehensive literature review of publications in sustainable GSCM. The objective of present research work is to highlight the trends and opportunities in research addressing the sustainable GSCM. A total of 138 papers, both from sustainability and green supply chain literature, published over a period of 10 years (2005-2014) are selected, shortlisted, categorized and analysed to identify future directions and research opportunities in the area of sustainable GSCM. A structured and fit-for-purpose systematic research process is followed in both the collection and content analysis of the literature, so that the rigor of the process is maintained. The research issues from the literature are identified and completely discussed to clarify the future research opportunities for researchers/scholars interested to extend research in this area.

The descriptive analysis of papers reports that there has been a consistent increase in the number of publications in sustainable GSCM in the past decade. This trend can be attributed to the increased awareness and concern among companies and various stakeholders for the environmental protection and sustainability. On classifying the

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literature on the basis of geographical locations, it was identified that articles have considered contexts of emerging economies like India, China and Taiwan more than that of developed nations. Moreover, most of the studies have confined to either a single firm or a country. Very limited studies are reported that have adopted a global perspective of addressing the issue of environmental sustainability. Next classification of literature was on the basis of types of research adopted by researchers. Analytical and conceptual research methods have found prominent applications in the reviewed articles. Mathematical modelling and multi-criteria decision-making tools have been extensively applied. However, use of multi-criteria optimization as a methodology has been paid limited attention in the reported literature. Although a number of empirical studies have been conducted, more sophisticated statistical techniques and analyses may be used in future.

Majority of the existing studies have focused on the manufacturing sector only, and very limited attention is given to the service sector. Research on greener services is at a nascent stage and needs immediate attention.

The classification of articles was carried out on the basis of proposed framework showing different activities and contexts involved in sustainable green supply chains. Majority of papers have considered a holistic supply chain perspective while addressing the issue, whereas others have emphasized on one or two contexts together. Performance measurement, strategic planning, procurement and product design and development have been studied in greater details in the reported literature. Use of IT and information systems have started gaining attention from researchers and practitioners. Reverse logistics, recycling and waste management are now being considered vital for successful implementation of green practices. However, based on an exhaustive analysis of literature, few issues offer abundant scope for further studies in the area.

### *5.1 Logistics*

Transportation is the most vital element of a supply chain. As it is a main source of various gaseous emissions and particulate matter, it poses a serious threat to the environment. There have been very limited studies that have focused on the issues related to transportation such as choice of mode and type of vehicles and fuels used. Mathematical models can be used to integrate environmental impact optimization along with costs, time and profit optimization objectives. Moreover, facilities like warehouses and ports also have an impact on environmental sustainability. Their location and layout have implications on the emissions as internal transportation and distribution requires energy consumption. Although in recent years, green facility and green buildings have become popular and zero emission warehouses have been built, research on this aspect of logistics is still in its infancy. Fleet management, layout decisions and other issues can effectively be addressed using operations research techniques.

### *5.2 Reverse logistics*

Although issues like reverse logistics and closed-loop supply chains have been extensively addressed in the past, their significance, as means of implementing sustainable green supply chain practices, has not been considered much; and thus, offers scope for further research. One of the most important research areas in the segment of reverse logistics is network design. Not only has it affected environmental sustainability, but also impacts companies' profitability. Location decisions related to

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reverse supply chain processes can be studied and linked with storage and transportation issues. This way, maximum value can be extracted from used products and they can be made environmentally safe. In addition to this, waste management also contributes towards achievement of greener practices. Waste disposal and recycling issues can further be investigated in greater details. In the service sector, management of healthcare waste is another issue that has found limited attention from researchers and should be addressed to attain efficiencies.

*5.3 Performance assessment*

Researchers have proposed a number of frameworks and techniques, both qualitative and quantitative, to assess the performance of sustainable supply chains in the past few years. Although green supply chain performance measurement, too, has been studied in few articles, the focus has been to assess its overall performance. However, to obtain a deeper understanding, there is a need to assess performance in terms of individual activities of a green supply chain such as green logistics, green production, green procurement, etc. Moreover, some more quantitative methods can be adopted to bring robustness into sustainable green performance measurement. Lastly, certain studies have evaluated green supply chain performances based on a specific sector only. Studies can be carried out to measure performance effectiveness of other industries also.

*5.4 Production*

The environmental impact that a product has, depends on the way it is manufactured. This can be measured by assessing its carbon footprint (Dekker *et al.*, 2012). Issues such as greener design, procurement and production can be studied in greater details individually by researchers. Although a few studies have tried to bring together lean manufacturing and sustainable green practices, more work can be carried out in this direction. Moreover, there exists a need of generalized frameworks that are applicable across all sectors.

*5.5 Supplier selection and relations*

There has been an extensive research on green partner selection because of growing worldwide environmental awareness (Seuring and Muller, 2008a, 2008b). Studies should consider both contemporary environmental issues and traditional economic factors for developing a greener supply chain. There has been a limited focus on supplier relationship management and, hence, should also be studied as a key factor to attain environmental sustainability.

*5.6 Human resource management*

Human resources are key elements involved in a supply chain. The success or failure of a supply chain to achieve green objectives is largely determined by the motivational levels of actors involved in it. Researches should focus on behavioural aspects like coordination, collaboration and motivation of members in a supply chain.

*5.7 IT and systems*

Use of information technology and information systems for implementation of green supply chain practices offers ample scope for research. Big data analytics and data mining can be utilized to assess current practices in terms of their environmental impact, which could further lead to removal of inefficiencies and bottlenecks associated with

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supply chains. Moreover, use of decision support systems may lead to better decisions that result in adoption of sustainable green practices.

In the days to come, environmental issues would pose more challenges to business organizations, leading to more evolving concepts and theoretical contributions. Newer technologies and players would play a significant role for sustainable GSCM.

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