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A state-of-art literature review reflecting 15 years of focus on sustainable supply chain management

Zulfiquar N. Ansari*, Ravi Kant

Department of Mechanical Engineering, S.V. National Institute of Technology, Surat, 395007, India

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ABSTRACT

A large number of journals and special volumes are publishing research concerned with sustainable supply chain (SSC). The importance of this the topic has significantly grown over time thus receiving increased attention from academics and practitioners in this area. This research critically analyzes the content of 286 papers published in different journals in the area over the span of fifteen years (2002–2016). The reviewed literature was structured using the following categories: year, journal, research methodology, research design, operation research (OR)/mathematical tools and techniques, data analysis technique, industry sector, multi-criteria decision making (MCDM), authors, universities, country, enablers, and barriers. This enabled crucial gaps in knowledge of SSC to be identified allowing future research opportunities in the field to be determined. The major finding indicates that the research field is being dominated by the qualitative study. Also, of the quantitatively based studies that appeared in the literature, linear programming problem is the most often used solution approach to optimize the complex sustainable supply chain management problems. Drawn results show that there is enough scope to expand the research field and several opportunities still exist which needs to be investigated such as quantitative modeling, use of advance techniques and development of efficient algorithms.

1. Introduction

Business organizations are under serious threat to sustain their existing supply chain due to globalization, challenging market, demand uncertainty, and recent economic competitiveness. Simply focusing on internal efficiencies and processes of supply chain will not be sufficient enough for any organization to gain an advantageous position in the market. The concept of sustainability has gained prominence in past few years to comply with these growing challenges. Integrating sustainability concepts in core business functions of supply chain enables organization to achieve "competitive position" in the market, in this contemporary era of a globally challenging environment (Khodakarami et al., 2015). Sustainable supply chain management (SSCM) is being considered as an advent of a new era that incorporates environmental performance, social performance, and economic contribution- or what has been referred as an intersection of three spheres of sustainable development.

SSCM can be defined in a number of ways, of which few definitions are discussed in order to have a better understanding of sustainability with regard to supply chain. Seuring and Muller (2008a) defines SSCM as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements". Carter and Rogers (2008) defined SSCM as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains.". More recently, Ahi and Searcy (2013) defined SSCM as "the creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organizational business systems designed to efficiently and effectively manage the material, information, and capital flows associated with the procurement, production, and distribution of products or services in order to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the

* Corresponding author.
E-mail addresses: zlfqr_ansari@yahoo.com (Z.N. Ansari), ravi792002@gmail.com, ravi.kant@med.svnit.ac.in (R. Kant).

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short- and long-term".

Diversified consumer demand and complexity of product components (Karthik et al., 2015) have lead to intense internal competition amongst organizations in addition to the global competition. SSCM provides an opportunity to the organizations to distinguish itself from its competitor, thus providing a competitive edge in the market (Khodakarami et al., 2015). Many organizations have already started developing a definite level of commitment towards sustainability practices to make their supply chains sustainable (Govindan et al., 2015a). Environmentally friendly products and cleaner production methods are being looked upon to advocate sustainable development (Xie, 2016). Also, sustainability theory directs organization to incorporate various types of practices like return of product to producer at the end-of-life, eco-friendly handling of returns (Zhu et al., 2005); diffusing environmental friendly strategies at each level of supply chain (Rostamzadeh et al., 2014); providing better working conditions, fair compensation, equal human rights and cultural diversity (Rajak and Vinodh, 2015). Hence, transforming from supply chain management (SCM) to SSCM creates a significant pressure on organizations to modify their existing supply chains to meet sustainability needs (Schrettle et al., 2014). Organization advocates SSCM to ensure "long-term benefits and competitiveness" by accounting environmentally and socially responsible activities in the supply chain (Zhu and Sarkis, 2006; Ahi and Searcy 2013). Implementation of SSCM practices trigger increased material and energy efficiency, and innovation (Gunasekaran and Spalanzani. 2012); enhance organizations' economic performance (Wang and Sarkis, 2013); and creates a brand corporate reputation in the market (Zailani et al., 2012). Several studies have been carried out in the past that quantify the savings in cost and energy due to the adoption of sustainability in the industrial supply chain of which a few are discussed. Vance et al. (2015) examine that apart from the considerable ecological footprint, a significant cost reduction of up to 17% can be achieved by the use of renewable energy resources in comparison to that of electricity used from the grid and/or natural gas. Bevilacqua et al. (2014) analyzes the impact on the environment in a cotton yarn supply chain and identifies that use of energy optimization techniques during production, results into the decrease in CO_2 emission by 31.5% and also reduce energy consumption by 5%. Lee and Wu (2014) integrate sustainability concepts in logistics and SCM and propose to use high productivity freight vehicle (HPFV) during transport as it reduces the cost of transportation by 33.5%. In this world of competitiveness, SSCM is not merely a concept but becomes a strategic weapon that improves corporate effectiveness in terms of social and environmental performance and increases profitability (Seuring and Muller, 2008a; Tseng et al., 2015).

In view of these multi-fold advantages due to the adoption of sustainability practices in supply chain it is a fact that an organization would not isolate itself from its applicability, instead started developing increased interest in SSCM. Researcher's link sustainability concepts with SCM through different perspectives using a varying number of terms (Ahi and Searcy, 2013). For example green supply chain management (GSCM) (Srivastav, 2007; Ahi and Searcy, 2014); environmental sustainability (Ji et al., 2014); reverse logistics/closed loop supply chain and social sustainability (Ashby et al., 2012) etc. Several articles have been published that reviews the literature on SSCM of which few of them have been carried out recently (Table 1). The majority of these studies either focus on a specific issue (aspect) e.g. integration, analytical models, etc. or consider only a few dimensions. It is obvious that these articles enhance the understanding of SSCM but their micro-perspective approach results into a study that has a limited focus. Because, the literature on SSCM is extensive and diverse and also the fact that it is being endorsed by most of the organizations, a structural analysis is very much needed to explore the research field as a whole along different aspects. In a near present, no review had carried out a classified analysis of the relevant literature on SSCM to unleash the potential research opportunities. The present study thus synthesizes the literature on SSCM from 2002 to 2016 and conducts categorical classification and analysis to address this knowledge gap.

The rest of the paper is arranged as follows: Section 2 provides an analysis of previous literature reviews on SSCM. The methodology adopted for the study is explained in section 3. Section 4 carries out the categorical classification of the reviewed papers and present the results in tabulated and pictorial form. Discussion on classified analysis's results is carried out in Section 5 which has three subsections: significant findings, gaps identified, future research directions and limitations. Finally the paper ends up with a conclusion in section 6.

2. Previous literature review works on SSCM

The basic motive behind adopting this methodology of analyzing the former reviews is to provide an outline regarding the existing literature and justify the need as to why this study is needed. From the database obtained by a search through SCOPUS only, on the related topic, it was found that 10 articles attempt to provide a review. These ten articles are profoundly studied by the authors to evaluate the work done on SSCM.

Findings of the earlier reviews are illustrated in Table 1. The assessment of previous literature is done using certain characteristics. They are:

1. Focus area of the study: this implies which aspect of SSCM has been more stressed upon.
2. Time span and publications considered: this considers the period for which the study is undertaken and the number of publications taken into account.
3. Methodology: in what aspects the literature has been reviewed and classified is looked upon in this part.
4. Outcomes: it lists out fruitful results of the study.

Research on SSCM has matured specially in the last decade and gaining increased attention in the academic community. This is evident by the number of literature review published in this area by academicians (Table 1). However, there is still a paucity of a state-of-art literature study on SSCM as most of the studies are either focusing on a specific aspect or structured along a few dimensions only. For example review on quantitative models (Brandenburg et al., 2014; Eskandarpour et al., 2015); or reviewing theoretical dynamics in SSCM (Touboulic and Walker, 2015b) and SSCM practices (Khalid et al., 2015). Ahi and Searcy (2013) review is focused on GSCM and SSCM definition analysis, while Winter and Knemeyer (2013) deals with the integration of sustainability with SCM. Seuring and Muller (2008a) categorize the literature along four dimensions: distribution of paper across time period and journal, research methodologies applied and dimensions of sustainability addressed. They do not consider the papers that focused on reverse logistics and remanufacturing in their study. Gold et al. (2010) reviews 70 publications which are of case study type and quantitatively analyzes them i.e. the study is limited to articles that focus only on a specific research methodology. Ashby et al. (2012) structures its review along only three dimensions (research methodology, sustainable dimension addressed and key commonalities represented in literature). Carter and Easton (2011) in order to maintain a good quality of content considers a low number of publications in his study. In spite of a large number of articles being published on SSCM, none of the articles carry out a

Table 1
Summary of previous literature reviews on SSCM.

Title	Author and year of publication	Published in Journal	Focus area	Time span considered for review	Publications considered for study	Methodology used	Outcomes
Sustainable supply chain network design: An optimization-oriented review	Eskandarpour et al. (2015)	Omega	The article focuses on reviewing mathematical models that include economic factors as well as environmental and/or social dimensions.	1990 –2014	87	Peer-reviewed journals in the electronic data base (Scopus and Web of Science) were considered for the study. Authors attempt to examine four major issues: (i) which environmental and social objectives are included in sustainable supply chain network design (SCND) (ii) how are they integrated into the models (iii) which methods and tool are used and finally (iv) which industrial applications and contexts are covered in these models.	The article proposes that (i) Use of modeling tools such as General Algebraic Modeling System (GAMS), Lingo or a mathematical programming language (AMPL) and linear or non-linear programming solvers enable solving complex and usually large size SCND models. (ii) Majority of the work focus on specific applications while only few papers address generic Sustainable SCND. (iii) Economic and environmental factors are largely focused while the social factors are rarely considered in study.
Putting sustainable supply chain management into base of the pyramid research	Khalid et al. (2015)	Supply Chain Management: An International Journal	The purpose of this paper is to analyze which SSCM arguments are addressed in the Base of Pyramid (BoP) related research.	2000 –2014	77	Articles for the review were selected from peer-reviewed, English-speaking journals available on "Web of Science" database. The paper explores the BoP business issues using the tools provided by SSCM theory through contingency analysis.	The authors suggest that both BoP and SSCM research streams address issues like business partner development, stakeholder involvement, innovation, technological integration, enhanced communication, long-term relationship development with other supply chain actors and learning.
Theories in sustainable supply chain management: A structured literature review	Touboulic and Walker (2015b)	International Journal of Physical Distribution and Logistics Management	The objective of this study is to map dominant theories in SSCM and their influence on conceptualization of SSCM.	1995 –2013	308	Peer-reviewed journals from the data bases Business Source Premier and ABI/ Inform Global are used in the study. The study is focused on knowledge creation, theoretical perspectives and popular theories in the field of SSCM.	The paper proposes an integrated theoretical map of SSCM which suggests that effective utilization of resources and binding social and environmental challenges within business capabilities leads to competitive advantage.
Quantitative models for sustainable supply chain management: Developments and directions	Brandenburg et al. (2014)	European Journal of Operational Research	The study aims to review the quantitative models that focus on environmental or social factors in forward supply chains.	–	134	All papers reviewed by Seuring (2013, 36 papers), Hassini et al. (2012, 87 papers) and Tang and Zhou (2012) and in addition few peer-reviewed journals was taken as a database for the review. Literature is evaluated along four streams: supply chain management (SCM), sustainability, modeling, and research directions.	The article suggests that modeling based SSCM research enhances the inter-organizational perspective of SCM. Also social issues must be integrated in the modeling and to develop a realistic uncertain model, stochastic approach should be applied.
A comparative literature analysis of definitions for green and sustainable supply chain management	Ahi and Searcy (2013)	Journal of Cleaner Production	The article identifies the published definitions of GSCM and SSCM and provides an analysis of the identified definitions.	Until January 2012	124	Articles published in Scopus database were considered for the literature study. Study identifies a total of 22 definitions for GSCM and 12 definitions for SSCM for analysis purpose.	The authors provide a great variety of definitions published on GSCM and SSCM thus providing a needed reference point for research. They further state that GSCM is an integral part of sustainable supply chain that simply focuses on the environmental aspects of supply chain.
Exploring the integration of sustainability and supply chain management: Current state and opportunities for future inquiry	Winter and Knemeyer (2013)	International Journal of Physical Distribution and Logistics Management	The basic objective of this paper is to examine status of research on SCM and sustainability integration.	1995 –2010	456	To identify the articles for literature review search was followed in a variety of databases (EBSCO, Emerald, Taylor and Francis, Science Direct and Wiley Inter-Science). The authors categorize the literature	The authors suggest that existing literature primarily focuses on individual sustainability and supply chain dimensions rather than taking a more integrated approach. Hence rather than taking a holistic view in the

Table 1 (*continued*)

Title	Author and year of publication	Published in Journal	Focus area	Time span considered for review	Publications considered for study	Methodology used	Outcomes
						across three disciplines (logistics/supply chain management, operations/ production management and social/environmental management).	study most of the existing approaches focus on narrowly defined aspects of the concept.
Making connections: A review of supply chain management and sustainability literature	Ashby et al. (2012)	Supply Chain Management: An International Journal	The goal of this article is to investigate SCM in context of sustainability to understand structures, processes and connection by reviewing current SCM literature.	1983 –2011	134	The literature search was limited to peer-reviewed journals produced in English to journals rated from 2 to 4 in the ABS journal rankings to maintain the quality of the articles considered in the review. The review is structured along three dimensions namely research methodology, sustainable dimension addressed and key commonalities represented.	Integration of sustainability into supply chains is significant. Qualitative research methods have found more recognition in comparison to theory development (how new the integration of sustainability in supply chain is). Environmental dimension is better placed in supply chain as compared to the social dimension.
Sustainable supply chain management: Evolution and future directions	Carter and Easton (2011)	International Journal of Physical Distribution and Logistics Management	Authors conduct a systematic review of the SSCM literature in the principal logistics and SCM journals, across a 20-year time frame.	1991 –2010	80	Seven commonly recognized as the top-tier logistics and SCM journals were selected to identify the articles to be studied in the literature. Authors classify the article along subject, industry, theoretical lens, validity, social desirability bias, methodology and analysis.	The field of SSCM has evolved from a perspective and investigation of standalone research in social and environmental areas; through a corporate social responsibility perspective; to the beginnings of the convergence of perspectives of sustainability as the triple bottom line and the emergence of SSCM as a theoretical framework.
Sustainable supply chain management and inter-organizational resources: A literature review	Gold et al. (2010)	Corporate Social Responsibility and Environmental Management	The purpose of this paper is to explore the role of SSCM as a catalyst of generating valuable inter-organizational resources.	1994 –2007	70	Authors presents a quantitative content analysis of all case study publications in the field of SSCM published in English-speaking, peer-reviewed journals. Authors' carries out a quantitative analysis against the backdrop of broader SCM, SSCM, resource based view (RBV) and relational view (RV) theory.	Collaboration is essential when supply chains aim at ensuring simultaneously economic, environmental and social performance on a product's total life-cycle basis. Inter-firm resources and capabilities emerging from supply-chain-wide collaboration are prone to become sources of sustained inter-firm competitive advantage.
From a literature review to a conceptual framework for sustainable supply chain management	Seuring and Muller (2008a)	Journal of Cleaner Production	The objective of this paper is to conduct a literature review on SSCM and provide an effective overview of what has been conducted in this area.	1994 –2007	191	Major databases such as Elsevier, Emerald, Springer, Wiley or library services were used to extract articles for review. The authors categorize the literature along two dimensions: (a) supplier management and (b) SCM for sustainable products.	Authors suggest that reverse logistic aspects should be explicitly considered because returns management is a key business process within the green supply chain framework and is an important aspect of recycling. Furthermore, it is valuable to specifically examine the economic aspects of articles in this research stream, not just assume this connection.

comprehensive review. Thus, this study tries to fill this gap by carrying out a methodological review of the articles published on SSCM to identify numerous opportunities for advancement.

2.1. Research motives

To examine the current status of the field based on the nature of knowledge and the certainty with which it can be presented, it is significant to consider the specific research methodologies that are presently used. Also, Seuring (2013) suggests that to support the decision-making process effectively when integrating sustainability and SCM, much quantitative research is needed to justify the findings. Hence, in a literature review, it is vital to identify whether the current status of the research field is either driven by qualitative study or quantitative study and develop means to advance the field by applying varying methodology. It has also been found that

organizations willing to infuse sustainability practices in their supply chain, needs to satisfy various contradicting objectives such as profit maximization while reduction in environmental impacts and maximizing social responsibility. Involvement of large quantity of decision variables, parameters, constraints and cost criteria makes the problem multifaceted and challenging (Srivastava, 2007). Thus, there is a need to identify the existing tools and techniques (traditional or new OR techniques) that are presently used to formulate, analyze and generate solutions for such complex problems. Such an analysis is significant as Min and Kim (2012) suggests that combining OR applications with empirical studies result in the benefit of SSCM research. Research methodology such as survey helps researcher gather a large amount of data via. questionnaire related to a specific topic. These large quantities of data are summarized with the help of data analysis techniques and enable the researcher to come to a certain decision. Hence, determining whether the present research is dominated by traditional techniques or driven by advance data analysis techniques is important.

Damage to environment and ecology mostly depend on the operations that are performed in different industries (Singh, 2016). Even though all organizations and sectors have started promoting environmental issues due to increased concern about environmental problems, a few sectors, due to their intrinsic nature of operations, have a wider scope for adopting sustainability practices. Tonelli et al. (2013) suggest that in promotion of industrial sustainability, SSC is vital and identified as a primary factor. Hence, evaluating the role played by industries and sectors in the applicability of research field will provide further insights as to which sectors are still lacking in terms of application. Due to multidisciplinary nature of sustainability and complexity of socio-economic and biophysical systems, MCDM methods have gained increased popularity in decision-making process (Wang et al., 2009). Chai et al. (2013) suggest that MCDM permits the researcher, practitioner, and management to create balance amongst different criteria involved when most of them are differing. It is, therefore, essential to identify the potential MCDM techniques used in SSCM research. In addition, despite the organizational willingness to incorporate sustainability practices in their supply chain many times they remain unknown about the factors that aid to achieve these practices (known as the enabler) and the factors that inhibit the adoption of these practices (known as the barrier). Therefore, it is needed to identify the critical enablers and barriers of SSCM.

2.2. Research objectives

Based on the research motivations presented in the above section, the present paper aims to conduct a novel literature review on SSCM and provide the current status of the research field by classifying and analyzing the relevant papers extracted from the structured search along different perspectives. The authors attempt to achieve this goal by searching answers to the following research questions:

What is the existing research status in SSCM?

What research methodologies and research designs are being applied?

Which different data analysis techniques and OR/Mathematical tools prevalent?

What types of industries are focused and which countries are dominating in SSCM research area?

Which decision making methods are employed in SSCM research?

What are the key enablers and barriers for SSCM?

And finally, what are the future research opportunities that need to be addressed.

3. Research methodology description

A systematic literature review based study is conducted to address the above research questions. Fink (1998) defines literature review as “a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents”. Tranfield et al. (2003) suggest that to manage the diverse knowledge about a specific research topic, literature review is a decisive tool that supports researcher in the following ways:

- mapping, consolidating and evaluating the existing academic structure of identified field; and
- developing the scope of further opportunities through identifying key research gaps in the existing body of research.

Collection of data related to the field and evaluating it along various perspectives is the most acceptable approach in literature review (for e.g. Seuring and Muller, 2008a; Gold et al., 2010; Ashby et al., 2012; Brandenburg et al., 2014). This literature review conducts a (qualitative) content analysis (Krippendorff, 1980; Brewerton and Millward, 2001; Seuring and Gold, 2012) and adopts the four step procedural process model proposed by Mayring (2002) explained below:

Step 1. Material collection: Collecting the material to be analyzed, delimiting and defining the unit of analysis.

Step 2. Descriptive analysis: Accessing the formal aspect of the collected material and providing background for theoretical analysis.

Step 3. Category selection: Selection of major topics of analysis and detailed classification of each structural dimension along which the collected material will be analyzed.

Step 4. Material evaluation: Analyzing the material according to the structural dimensions, identifying the issues and interpreting the results.

3.1. Material collection

It is particularly of prime importance to select the relevant documents in a systematic literature review. Keyword based search in electronic databases and library services are the most preferred ways of attaining the articles for literature study (Seuring and Gold, 2012). Additionally, some relevant articles that did not appear by the keyword sieve can also be obtained by scanning the table of contents of major leading journals (Webster and Watson, 2002). In view of this to perform the bibliographic research, we considered following step by step sequential process: selection of database, criteria for inclusion, criteria for exclusion, and search of relevant articles.

3.1.1. Database selection

SCOPUS database was considered for the study because of its wide coverage of peer-reviewed academic literature: scientific, engineering, social sciences journals; books and conference proceedings. Over 21,500 peer-reviewed journals, 360 trade publications, 113,000 books, nearly 7.2 million conference papers, 27 million patents, and other documents are included in SCOPUS database.

3.1.2. Criteria for inclusion

1. Articles published between January 2002 to 2016 were considered for the synthesis of peer-reviewed literature. Since the article collection for literature review was carried out just when the year 2016 started and as articles in the press was included in

search criteria a few accepted manuscript that is yet to get published in 2016 also appeared in the database which is also considered in the study.
2. "All Fields" category as well as all of the "Subject Areas" available in SCOPUS was chosen for the search.
3. The articles published in only English language and focus on management issues were aimed for analysis.

3.1.3. Criteria for exclusion

1. Conference proceedings, working papers, technical reports and book chapters are not considered in the review to maintain the quality of content. (Preliminary refinement of papers from the total database).
2. Those articles which did not address the sustainability issue in the supply chain were also eliminated via. abstract analysis. (Final refinement of papers).

3.1.4. Search of relevant articles

Structured keyword "sustainable supply chain" was used to search for related articles in the field. More than 10,000 articles resulted out in the database from an initial search that contains any one term of the phrase "sustainable supply chain". Hence to limit the articles, keyword "sustainable supply chain" as an exact phrase was searched in Title, Abstract and Keywords of online SCOPUS database. A total of 689 articles were generated during first step. Preliminary refinement of the total articles left us with 349 usable articles. Finally a total of 286 peer-reviewed papers were obtained after final refinement for analysis purpose, all from well reputed publishers [Elsevier **(111)**, Emerald **(57)**, Taylor and Francis **(32)**, Wiley Interscience **(35)**, SpringerLink **(27)**, Inderscience **(20)**, IGI Global **(02)** and IEEE transactions **(02)**]. Full paper analysis of 286 papers was done with the aid of excel sheet to gather the needed information.

3.2. Selecting criteria for content analysis

As decided earlier and to meet the research objectives, the criteria for content analysis need to be derived that are in correspondence to the research questions. Either a deductive approach or an inductive approach can be used for setting up the criteria to carry out the classification of the literature under study (Seuring and Muller, 2008a). The study derives analytic categories before the material is analyzed thus using deductive approach (Mayring, 2008; Seuring and Muller, 2008a). Assessment of the selected set of papers for descriptive analysis was carried along the following dimensions: distribution of publications across time period and main stream journals, research methodology and research design applied, OR/Mathematical tools and techniques used, use of data analysis techniques, type of industry focused in research, main authors contribution to research topic, universities and countries actively involved, enablers and barriers for SSCM. Table 2 lists out the analytic categories derived for literature study.

4. Descriptive analysis

This section provides analysis of reviewed papers along various dimensions. Tables and figures are used to summarize the results along each category leading to easy presentation of the material.

4.1. Analysis of articles according to publication years

Frequency analysis of the final sample (286 articles) based on the articles published year wise is shown in Fig. 1. It is clear from the trend that research on SSCM over a period between 2002 and 2009 (10.85%) was still lagging although its applicability can be traced much back in Brundtland Report of the World Commission on Environment and Development (Burton, 1987). During the period of 2002–2006 the articles published on SSCM was at a steady rate with 0, 1 or 2 articles. The uptrend in output of articles is observed since the year 2007 till 2015 with 2009 the only year as exception. Research publications on SSCM has gained a definite surge during the years 2014 and 2015 (137 papers) contributing to 48% of the total articles published. This is because the rising social and environmental concerns of the supply chain have created a pressure to search for sustainable solution. Academicians and practitioners came forward to address the social and environmental concerns of the supply chain. In addition, publishers have also come out with some special volumes to publish the research on SSCM. Articles in year 2016 are less because the search was performed just in the beginning of this year. Researchers increased attention and steep momentum on SSCM literature authenticates that the curiosity in the subject has really grown in the past few years.

4.2. Analysis of publications distributed in various journals

The selected 286 papers on SSCM have been published across 100 different journals. Table 3 depicts the list of journals where SSCM research has been published. Selected papers published along a wide variety of journals that focus on SSCM, validate different journals willingness to publish in this area. It was found that there are 55 journals that have published just one paper on the topic. The six leading journals that published ten or more than 10 papers on this topic are: Journal of Cleaner Production (32), Supply Chain Management: An International Journal (23), International Journal of Production Economics (21), Business Strategy and the Environment (13), International Journal of Production Research (12) and International Journal of Physical Distribution and Logistics Management (10). Hence these journals can be considered as a core journals on SSCM as the percentage of articles published in these journals on the research field is high.

4.3. Research methodology applied in reviewed papers

Research methods like Case study, Survey, Conceptual/Theoretical Model, Mathematical modeling, Survey + Interview and Simulation often used by various researchers have been used to classify the literature. Table 4 summarises the frequency of research methods after surveying the papers in detail. It has been observed that case study (100 papers) are the most common methodologies employed in different studies. Case study methodology is of prime importance at the preliminary stage of research for theoretical/concept development from the collected data, which acts as a base for future research when there is no prior hypothesis. This leads to the fact that research on SSCM is still unexplored and to identify the critical issues researchers are doing more case based studies to develop a clear understanding on the topic. Conceptual/Theoretical models (56 papers) are the second most used methods in the study. They serve as a foundation to develop important guidelines for future research in the area of SSCM. Developing questionnaire related to the study and gathering large sample sizes is included in survey. Survey methodology amounts to 43 papers of the total articles. Articles where quantitative approaches were used like development of mathematical model for decision making contribute to 35 papers. The articles that encompassed interview (27 papers), simulation (9 papers) and survey + interview (6 papers) were few in numbers. Hence, research in the field of SSCM is

Table 2
Categorical classification of the study.

Main categories considered in the study	Sub-categories	Description
Year wise		Analyzes the development of the research field along 15 years (2002–2016) time horizon
Journal wise		Identifying different journals publishing SSCM research
Research methodology	Case Study	In-depth study of a wider research area and narrowing for a real world problem
	Conceptual/Theoretical	Symphony of concepts and theory building for easy understanding
	Interview	Semi-structured interviews, structured interviews, focus groups
	Mathematical model	Use of mathematical concepts in the research field
	Simulation	Testing the validity of the model developed for real world case
	Survey	Online surveys, paper surveys, questionnaire based surveys
	Survey + Interview	Combination of survey and interview. For e.g. questionnaire survey + structured interview
Research design	Empirical quantitative	Survey based research
	Empirical qualitative	Case study or Interview based research
	Desk quantitative	Mathematical modeling, Simulation
	Desk qualitative	Conceptual/theoretical model building, development of propositions for future research
	Empirical triangulation	Combination of qualitative and quantitative techniques for data collection.
OR/Mathematical tools	LP, NLP, FL, VI, GM, RST, CLP, GP, etc.	Decision making tools to effectively and efficiently manage the resources
Data analysis technique	Sensitivity analysis, SEM, descriptive analysis, regression analysis, factor analysis, ISM, ANOVA etc.	Developing useful information, generating conclusions, and supporting decision-making by inspecting, cleaning, transforming and modeling data is referred to as data analysis
Industry sector		SSCM research finding recognition in industry sectors
MCDM techniques	DEA, AHP, TOPSIS, ANP, DEMATEL, MAUT etc.	Decision making methods role in the field development
Author wise		Leading authors publishing in the research field
University wise		Universities actively participating in the research field
Country wise		Countries role in the research field development
Enablers		Drivers that enable successful implementation of sustainability practices in supply chain
Barriers		Barriers that inhibit sustainability practices implementation in supply chain

Note: Linear programming (LP); non linear programming (NLP); fuzzy logic (FL); variational inequality (VI); game model (GM); rough set theory (RST); constraint logic programming (CLP); goal programming (GP).

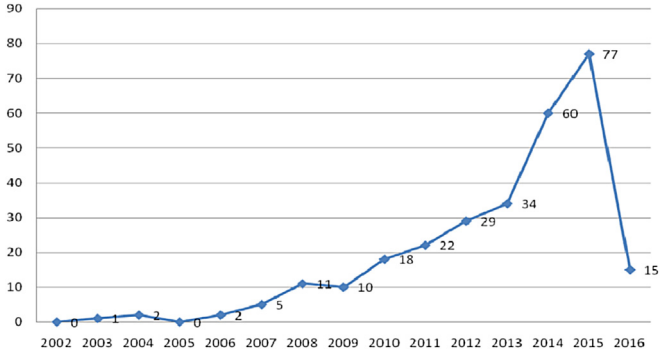

Fig. 1. Spread of the reviewed papers according to publication year.

driven by direct observation (case studies, field studies) and conceptual model development.

4.4. Categorizing the reviewed papers based on research design

The literature under study is classified based on whether empirical research or desk research has been employed. Empirical research and desk research are further subdivided under five categories: empirical qualitative, empirical quantitative, desk qualitative, desk quantitative and empirical triangulation. Table 5 demonstrates the type of research design reported in the reviewed papers. Percentage of each element is also provided in the table. Frequency of empirical qualitative (42.31%) type research design has been reported the most in peer-reviewed journals. Empirical qualitative type study is more of case study or interview based. About 15.03% of the study is survey based which is referred to as empirical quantitative. Desk qualitative (conceptual models, developing propositions for future research etc.) contributes to 19.58% of the papers reviewed and found to more popular than the desk quantitative (mathematical modeling, simulation etc.) which amounts 15.38%. Number of papers that consider empirical triangulation (data collection by more than one method such as questionnaire, interview, observations and documents) as research design is very few (4.20%). Literature review are included in the others category. Hence the analysis directs that research in SSCM area is more inclined towards qualitative approach as compared to quantitative type research method. Quantitative research in all contributes about 30.42% while qualitative research accounts for 61.89% of the reviewed papers.

4.5. Analysis of articles according to OR/Mathematical tools used

This section reviews different OR/Mathematical tools applied by various researchers as a solution technique towards SSCM development. Table 6 lists out these tools and techniques reported in the literature and their frequency. Linear programming/multi-objective linear programming (LP/MOLP) (27 articles) solution techniques are found to be most popular as compared to mixed integer non linear programming/multi-objective non linear programming (MINLP/MONLP) (8 articles) and mixed integer linear programming/multi-objective mixed integer linear programming (MILP/MOMILP) (7 articles). Application of fuzzy logic in the reviewed papers has been reported in 10 papers while variational inequality is used in 5 papers. Use of game model and rough set theory are found in 4 and 3 papers respectively. Very few papers report goal programming (GP) (2 papers), meta-heuristic techniques (genetic algorithms, simulated annealing, ant bee colony etc.) (2 papers), dynamic programming (1 paper) and input-output model (1 paper) as a solution technique depicting their poor recognition in SSCM development. Thus, researchers are more inclined towards linear programming approach in comparison to meta-heuristic, dynamic programming, graph theoretic approach because of their modeling complexity.

Table 3
Distribution of reviewed papers by journal.

Journal name	No. of papers	%
Journal of Cleaner Production	32	11.19
Supply Chain Management: An International Journal	23	8.04
International Journal of Production Economics	21	7.34
Business Strategy and the Environment	13	4.55
International Journal of Production Research	12	4.20
International Journal of Physical Distribution and Logistics Management	10	3.50
Corporate Social Responsibility and Environmental Management	7	2.45
Journal of Business Ethics	7	2.45
Journal of Supply Chain Management	7	2.45
Production Planning and Control	7	2.45
Computers and Operations Research	6	2.10
European Journal of Operational Research	5	1.75
Flexible Services and Manufacturing Journal	4	1.40
International Journal of Life Cycle Assessment	4	1.40
International Journal of Logistics Systems and Management	4	1.40
International Journal of Operations and Production Management	4	1.40
British Accounting Review	3	1.05
CIRP Journal of Manufacturing Science and Technology	3	1.05
Ecological Economics	3	1.05
Industrial Marketing Management	3	1.05
International Journal of Sustainable Engineering	3	1.05
Journal of Operations Management	3	1.05
Journal of Purchasing and Supply Management	3	1.05
Applied Soft Computing Journal	2	0.70
Business Process Management Journal	2	0.70
Corporate Governance	2	0.70
Energy Policy	2	0.70
European Management Journal	2	0.70
IEEE Transactions on Engineering Management	2	0.70
Information Technology and Management	2	0.70
International Journal of Advanced Manufacturing Technology	2	0.70
International Journal of Applied Decision Sciences	2	0.70
International Journal of Logistics Management	2	0.70
International Journal of Productivity and Performance Management	2	0.70
International Journal of Services and Operations Management	2	0.70
International Journal of Systems Science	2	0.70
Journal of Industrial Ecology	2	0.70
Journal of Manufacturing Technology Management	2	0.70
Management Research Review	2	0.70
Omega	2	0.70
Progress in Industrial Ecology	2	0.70
Resources Policy	2	0.70
Resources, Conservation and Recycling	2	0.70
Sustainable Development	2	0.70
Transportation Research Part E: Logistics and Transportation Review	2	0.70
Others	55	19.23
Total	286	100.00

Table 4
Distribution of reviewed papers based on research method.

Research method	No of papers	%
Case Study	100	34.97
Conceptual/Theoretical Model	56	19.58
Survey	43	15.03
Mathematical Modeling	35	12.24
Interview	27	9.44
Simulation	9	3.15
Survey + Interview	6	2.10
Others	10	3.50
Total	286	100.00

Table 5
Distribution of reviewed papers on research design.

Research design	No of papers	%
Empirical Qualitative	121	42.31
Desk Qualitative	56	19.58
Desk Quantitative	44	15.38
Empirical Quantitative	43	15.03
Empirical Triangulation	12	4.20
Others	10	3.50
Total	286	100.00

4.6. Analysis of articles based on data analysis techniques

Process of applying statistical and/or logical tool to raw data with the objective of extracting useful information and developing conclusion regarding that voluminous information is known as data analysis. Sachan and Datta (2005) suggest that data analysis technique aids researcher in the following way:

1. To sum up data available in large quantity (e.g. questionnaire data).
2. To understand the impact on final outcome due to the number of variables.
3. To minimize the confusing effects intrinsic in most questionnaire data.
4. To assess the effects of alternative future scenario.

There are various data analysis techniques like sensitivity

Table 6
OR/Mathematical tools used in the study.

OR/Mathematical tools	No of papers
LP/MOLP	27
Fuzzy Logic	10
MINLP/MONLP	8
MILP/MOMLIP	7
Variational Inequality	5
Game model	4
Rough set theory	3
Constrained Logic Programming	2
GP/MOGP	2
Grey Set Theory	2
Meta-heuristic	2
Accelerated Branch and Bound (ABB) Algorithm	1
DoE-guided MOGA-II	1
Dynamic programming	1
Graph theoretic approach	1
Input-Output Model	1
Nash's non-cooperative game	1

analysis, structural equation modeling (SEM), regression analysis, factor analysis, analysis of variance (ANOVA), interpretive structural modeling (ISM) etc.. Table 7 shows information about data analysis techniques used in the reviewed papers. It is clear that sensitivity analysis (23 papers) (8.04%) is the most popular data analysis technique and reports highest in the literature. This is followed by structural equation modeling (12 papers) and descriptive analysis (12 papers). Other data analysis techniques reported in the literature are regression analysis (10 papers), factor analysis (8 papers), ISM (7) and ANOVA (6). In order to sense the significant finding of the survey research and experimental manipulations in testing hypothesis, use of more advanced data analysis techniques are needed. However the data suggests that the study is more inclined towards traditional data analysis while use of advanced data analysis technique like discriminant analysis and path analysis are not reported in single paper.

Table 7
Distribution of papers according to data analysis technique.

Data analysis technique	No of papers	%
Sensitivity analysis	23	8.04
Structural Equation Modeling	12	4.20
Descriptive analysis	10	3.50
Regression analysis	10	3.50
Factor analysis	8	2.80
Interpretive Structural Modeling	7	2.45
ANOVA	6	2.10
Life Cycle Analysis	5	1.75
Partial Least Square	4	1.40
Cluster analysis	3	1.05
Input-Output Analysis	3	1.05
chi-square analysis	2	0.70
Correlation analysis	2	0.70
Cost analysis	2	0.70
Template analysis	2	0.70
Thematic analysis	2	0.70
Coding analysis	1	0.35
Consistent analysis	1	0.35
Delphi	1	0.35
Digraph and Matrix analysis	1	0.35
DuPont Analysis	1	0.35
Emergy analysis	1	0.35
Gap analysis	1	0.35
Grid analysis	1	0.35
Matrix analysis	1	0.35
Network analysis	1	0.35
NK theory	1	0.35
NVivo 7	1	0.35
Nvivo 9	1	0.35
Pinch analysis	1	0.35
Policy analysis	1	0.35
SIMUL8 software	1	0.35
Spatial analysis	1	0.35
Stimulus-response analysis	1	0.35
ε - constraint	1	0.35

4.7. Analysis of papers by industry sector

Various industries have been considered in the research in the area of SSCM. As sustainable practices important for a particular industry may not necessarily be equally influential for other industry, hence classifying and analyzing the study along industrial sector will give a better understanding of applicability of SSCM research sector wise. Table 8 summarises the industry focused by our sample in the area of SSCM. It is clear that majority of the articles that report SSCM concepts are mostly manufacturing industries. Hassini et al. (2012) suggest that emergence of manufacturing industries in applying sustainability concepts is due to two reasons: (i) OR traditionally focuses on production and manufacturing topics (ii) environmental regulations historically focuses on manufacturing plants. The frequency of research that considers food industry and electronic industry as their part of implementation programme are 12 each. The automobile industry stands at the third position with 11 articles contributing along this sector. However Table 8 suggests that research on SSCM is not limited to a few influential industries but diverse in nature with its applicability in logistic industry, retail industry, mining industry, energy industry etc.

4.8. MCDM techniques used in the research

Different MCDM techniques are used by researchers to model, analyze and support decision making in supply chain. Table 9 lists down various MCDM techniques reported in total 286 articles under study. Total 29 papers are reported to use MCDM techniques for

Table 8
Summary of industry considered in the research in the area of SSCM reported in the literature.

Industry type	No. of papers
Manufacturing Industry	18
Food Industry	12
Electric/Electronic Industry	12
Automobile Industry	11
Logistic Industry	5
Clothing Industry	4
Coffee Industry	4
Fashion Industry	4
Bioenergy Industry	4
Oil and gas Industry	3
Retail Industry	3
Textile Industry	3
Tourism Industry	3
Aerospace Industry	2
Air Conditioning Industry	2
Apparel Industry	2
Banking Sector	2
Container Depots	2
Cotton Industry	2
Dairy Industry	2
Energy Sector	2
FMCG Industry	2
Gas Industry	2
Mining Industry	2
Paper Industry	2
Resin Industry	2
Wine Industry	2
Others (reported in only one paper)	27

decision making. Analytic Hierarchy Process (AHP) and Data Envelopment Analysis (DEA) technique are used the most with each technique contributing 8 papers in the research field. Techniques for Order Preference by Similar to Ideal Solution (TOPSIS) is the second most used method reported in 5 papers. 4 papers were found that used Analytic Network Process (ANP), while Decision Making Trial and Evaluation Laboratory (DEMATEL) technique is employed in 3 articles. Multi-Attribute Utility Theory (MAUT) decision making technique is used in one article. When there are multiple criteria involved in organizational decision making, and of them most conflicting in nature MCDM techniques helps organization to arrive at effective decision.

4.9. Authors actively involved in publishing

A total of 227 authors contributed to the 286 articles on SSC. Table 10 lists the main authors (three or more than three articles each) who have published research articles on SSCM. Seuring, S. appears to be most prolific author in the area of SSCM with 6 articles published across different journals, followed by 11 authors. Beske P., Frota Neto J.Q. and Gualandris J. publish 4 articles each while Bai C., Buyukozkan G., Govindan K., Kannegiesser M., Nagurney A., Pagell M., Tachizawa E.M., van Hoof B. and Vermeulen W.J.V. contributes the research topic with 3 articles each. It is clear that fourteen of total 227 authors have written 16.78% (48 papers out of 286) of all papers in academic journals. This result shows that a vast majority of authors have contributed to just two articles or one article in the set of journals comprising our search data. Researchers that are actively and regularly publishing in the topical area, SSCM field appears to be quite narrow for them in terms of applicability.

4.10. Analysis of papers according to universities

A total of 202 universities/institutions have affiliated authors who were represented in the analyzed 286 articles on SSCM. Table 11 identifies the universities, which appear to be most active in the area of SSC research. The frequency of contributions of each university in SSCM research field varies in the range of 1–11. University of Kassel, Witzenhausen, Germany (with 11 papers) clearly emerges as the leading university in publishing articles on the research topic. This is followed by University College of Dublin, Ireland which contributes the research field with 5 papers. Universities like Masdar Institute of Science and Technology, Abu Dhabi, UAE; Sao Paulo State University, Bauru, Brazil; University of Bath, Bath, United Kingdom and University of Massachusetts, United States publish 4 articles each. Over a range of selected time horizon in the study there are other number of universities (254 in number) publishing research papers including 14 universities contributing to 3 articles each, 29 universities contributing to 2 articles each while universities that were source of just only one article publication reported 154. The universities that contributed to one and two articles in the research field are not included in the table due to space limitation.

Table 9
MCDM methods used.

MCDM techniques	No of papers
DEA	8
AHP	8
TOPSIS	5
ANP	4
DEMATEL	3
MAUT	1

Table 10
Main authors contributing to SSCM research.

Author	No. of articles	%
Seuring, S.	6	2.10
Beske, P.	4	1.40
Frota Neto J.Q.	4	1.40
Gualandris, J.	4	1.40
Chairini, A.	3	1.05
Bai, C.	3	1.05
Buyukozkan, G.	3	1.05
Govindan, K.	3	1.05
Kannegiesser, M.	3	1.05
Nagurney, A.	3	1.05
Pagell, M.	3	1.05
Tachizawa, E.M.	3	1.05
van Hoof, B.	3	1.05
Vermeulen, W.J.V.	3	1.05

Table 11
Distribution of reviewed papers according to universities.

Universities name	No of papers
University of Kassel, Witzenhausen, Germany	11
University College Dublin, Ireland	5
Masdar Institute of Science and Technology, Abu Dhabi, UAE	4
Sao Paulo State University, Bauru, Brazil	4
University of Bath, Bath, United Kingdom	4
University of Massachusetts, United States	4
Cardiff University, Cardiff, United Kingdom	3
Dublin City University, Dublin, Ireland	3
Erasmus University, Rotterdam, Netherlands	3
Galatasaray University, Istanbul, Turkey	3
Los Andes University, Bogota, Colombia	3
Lund University, Lund, Sweden	3
Nottingham University Business School, United Kingdom	3
Simon Fraser University, Canada	3
Technical University of Berlin, Berlin, Germany	3
Universidad Carlos III de Madrid, Getafe, Spain	3
University of Southern Denmark, Odense, Denmark	3
University of St.Gallen, St.Gallen, Switzerland	3
Utrecht University, Utrecht, Netherlands	3
Wageningen University, Wageningen, The Netherlands	3

4.11. Analysis of papers according to geography of authors

Information about the country represented by the authors of the selected studies is shown in Fig. 2. Analysis of the data reveals that authors from USA dominate the research field development by occupying 13.99% of the portion followed by Germany and United Kingdom each contributing to 11.19%. Canada contributes to about 5.24%. USA and countries of Europe leading the chart is relevant because of their developed nation's status. But it is interesting to note that contribution of authors from India and China is substantial and stands fourth in the tally. This indicates that the research topic is of great relevance for emerging economies like India and China. Most of the multi-national companies (MNCs) are targeting the developing and underdeveloped countries to either launch their products in their markets or sourcing of the raw material due to availability at low cost. Thus, developing nations like India and China would play a major role in coming years due to the significance they are paying to sustainability concepts in their supply chain.

4.12. Enablers for SSCM implementation

Organization need to consider motivational activities called enablers for successful implementation of SSCM. Enabler also considered as critical success factors (CSFs) is defined as “one that

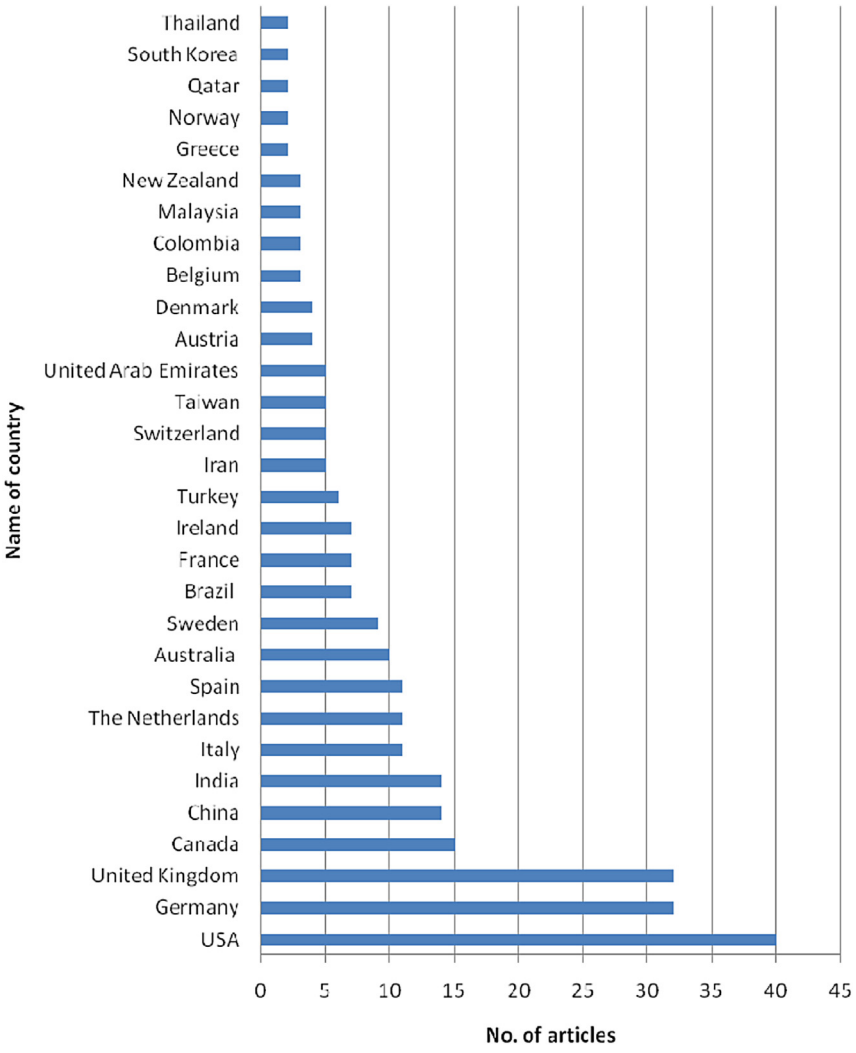

Fig. 2. Distribution of reviewed papers over country.

enables another to achieve an end" (Grzybowska, 2012). Works on enablers/drivers/CSFs for implementation of SSCM in supply chain is provided in Table 12. Researchers have identified enablers in context of various industrial applications and countries. Government regulations, information sharing, top management commitment, collaboration with partners, adoption of green practices, customer pressure, environmental management, reverse logistic, innovation, organization competitiveness has been identified as some important enablers to implement SSCM practices. Top management commitment, government regulations and collaboration are the most common enablers researchers have considered for SSCM practices implementation.

4.13. Barriers for SSCM implementation

Table 13 identifies the works on critical factors that hinder implementation of SSCM in supply chain. Various barriers have been identified by researchers in different industries and countries. Lack of information and transparency, lack of training and expertise, supplier in-competencies, cost implications, lack of top management commitment, lack of financial resources, complex in design to reduce consumption of resources and energy, inadequate facility for adoptions of reverse logistic practices, lack of IT implementation are some of the important barriers of SSCM implementation. Cost implications, lack of top management commitment, lack of training and expertise and poor supplier commitment are the most common barriers researchers have considered for successful SSCM implementation in supply chain.

5. Discussion on classified analysis results

The paper conducts a comprehensive review of 286 peer-reviewed articles on SSC published between 2002 and 2016. The research paper categorizes all the available literature along various perspectives: growing number of publications across time period and pioneering journals, research methodology and research design applied, OR/Mathematical tools used, use of data analysis techniques, type of industry focused in research, scholars contribution to research topic, universities and countries actively involved, enablers and barriers for SSCM. Findings of these categories enable us to unearth research gaps and develop further research opportunities. But before we discuss those let us list out some of the significant findings of the study which would be very valuable to understand the present state of field.

Table 12
Enablers to implement SSCM reported in literature (arranged in chronological order).

Authors	Enablers/Drivers/CSFs for SSCM implementation	Application; Industry focused; Country
Faisal (2010)	Information sharing, strategic planning to implement sustainable practices in supply chain, consumer concern towards sustainable practices, collaborative relationships, metrics to quantify sustainability benefits in a supply chain, regulatory framework, support to partners in the supply chain, top management commitment, awareness about sustainable practices in supply chain, availability of funds	SSCM; Manufacturing industry; Qatar
Wolf (2011)	Leadership commitment, organizational structure, interaction with NGOs, interaction with other stakeholders, supplier selection strategy, supplier relationship management, supplier performance measurement	SSCM; Manufacturing industry; Germany
Gopalakrishnan et al. (2012)	Government legislations and external support factors, dedicated department that ensures social, ethical and environmental considerations, organizational culture and employee involvement, supplier management and integration of supply chain, review the sourcing of raw materials to ensure sustainability, product reuse and recycle specifications, methods to reduce cost through periodic cost analysis, key performance indicators infused in the supply chain, quality and safety system products, carbon management across the supply chain	SSCM; Aerospace industry; UK
Walker and Jones (2012)	Government policy, competitors, customers, pressure from investors, influence of NGOs, top management commitment, employee involvement, culture, alignment of company strategy with purchasing, company SSCM strategy, firms competitiveness, reputational and environmental risk, EMS adoption, improve quality	SSCM; Multi-sector; UK
Wittstruck and Teuteberg (2012b)	Top management support, signalling, provision of information, IT and interfaces, adoption of standards, strategy commitment, pressure from competitors, mutual learning, closed ecological cycles	SSCM; Electric and electronic industry; Germany
Buyukozkan and Cifci (2013)	Price strategy, SC optimization, inventory management, forecast accuracy, lifecycle management, supplier management, flexible and cleaner technology, delivery performance, usage of effective systems and tools, environmental management system, green innovation, environmental product design, environmental activity capability, eco-friendly transportation, efficient handling and storage, reverse logistics, green and back packaging, collaboration with partners, employee practices, outsourcing, stakeholders rights monitoring and maintenance	SSCM; Logistic supply chain; Turkey
Beske and Seuring (2014)	Dedication to TBL, dedication to SCM, supply chain partner development, long term relationship, supply chain partner selection, enhanced communication, logistical integration, technological integration, joint development, standards and certification, selective monitoring, pressure groups, learning, stakeholder management, innovation, life cycle management	SSCM; Germany
Diabat et al. (2014)	Employment stability, health and safety issues, community economic welfare, adoption of safety standards, adoption of green purchasing, adoption of green practices, eco-design, government regulations, hazard management, customer satisfaction, environmental cost, economic input to infrastructural development, improvement of product characteristics	SSCM; Textile Industry; India
Grim et al. (2014)	Trust between focal firm and direct supplier, trust between direct supplier and sub-supplier, focal firms' buyer-power, direct suppliers buyer power, committed long-term relationship between direct supplier and sub-supplier, supply-know-how of focal firm, direct suppliers' willingness to disclose sub-suppliers, involvement of direct supplier, perceived value of direct supplier, perceived value of sub-supplier, low risk of supplier by-passing, sub-supplier's capability to comply with requested sustainability standards, geographical distance between supply-chain-partners, cultural distance between supply-chain partners	SSCM; Food industry; Switzerland
Stiller and Gold (2014)	Reconceptualizing supply chain design, supply base continuity, decommodization, traditional supplier development, novel supplier development, transparency and traceability, reward and incentive system	SSCM; Vegetable seed supply chain; India
Chkanikova and Mont (2015)	Existing national and international regulations, expectation of new regulations, costs savings associated with operational and material efficiencies, brand and reputation, customer demand and expectations, industrial norms (standards and voluntary industry agreements), food scares, bringing retail company to court (due to abusive practices of treating suppliers), risk of negative publicity, scientific alerts, increased investor appeal, NGOs campaign, competitors strategies	SSCM; Food supply chain; Sweden
Dubey et al. (2015)	Integrating social and environmental parameters in procurement policies, competitive advantage over competitors, green purchasing, logistics performance, coordination among supply chain partners, protecting the natural environment, alignment, collaboration, transparency, optimize energy consumption, reverse logistics, integration of product design, sourcing and purchasing, production and distributors	SSCM: Manufacturing industry; India
Ferreira et al. (2015)	Return on investment planning practices, external planning practices, internal environmental planning practices, sustainable storage and construction planning practices, sustainable design product operational practices, waste reduction and risk minimization operational practices, reverse logistics and operational practices, GSCM communication practices	GSCM; Battery industry; Brazil
Jabbour et al. (2015b)	Environmental training, performance evaluation and rewards based on environmental criteria, environmental team work, empowerment of employees applied to environmental issues, employees engagement supporting environmental management, environmental organizational culture, support from senior management for environmental activities, environmental organizational learning	SSCM; Goods sector; Brazil
Luthra et al. (2015)	Internal environment agreements, central government legislations, state government legislations, non-government organizations, involvement of suppliers and vendors in green practices, training programs of suppliers and vendors, technology transfer to suppliers and vendors, top management initiation and commitment, supportive company policies towards GSCM, efficient strategic planning, technology advancement and adaption, information technology enablement, information quality and sharing, human resources management practices, supply chain members' awareness and literacy, role of employees towards GSCM adoption, proper work place management, economic interests, high cost for disposal of hazardous materials/components/products, firms' competitiveness, awareness level of customers, enhanced brand image, support from customers, encouragement from customers, societal issues, scarcity of natural resources	GSCM; Automobile Industry; India
Marshall et al. (2015a)	Environmental supply chain monitoring, environmental new product and process development, environmental SCM systems, environmental supply chain strategy redefinition, social supply chain monitoring, social new product and process development, social SCM systems, social supply chain strategy redefinition	SSCM; Ireland
Jabbour and Jabbour (2016)	Internal environmental management, green purchases, cooperation with customers, eco-design, reverse logistics, investment recovery	GSCM; Brazil

Table 13
Barriers to implement SSCM reported in literature (arranged in chronological order).

Authors	Barriers for SSCM implementation	Application; Industry focused; Country
Wolf (2011)	Goal setting, limited communication between functions, limited availability of data and information on sustainability, lack of additional human resources, source situation, limited integration of supply chain partners	SSCM; Manufacturing industry; Germany
Walker and Jones (2012)	Regulation, competitive pressures, consumer desire for lower prices, poor supplier commitment, less regulated industries, lack of management commitment, cost, traditional accounting methods, smaller firms, lack of training, lack of understanding how to incorporate in purchasing and other SCM priorities, lack of corporate structures and processes	SSCM; Multi-industry; United Kingdom
Al Zaabi et al. (2013)	Too high cost for disposal of hazardous wastes, cost for environmentally friendly packaging, lack of clarity regarding sustainability, cost of sustainability and economic conditions, lack of sustainability standards and appropriate regulations, misalignment of short-term and long-term strategic goals, lack of effective evaluation measures about sustainability, lack of training and education about sustainability, complex in design to reduce consumption of resources and energy, inadequate facility for adoptions of reverse logistic practices, lack of IT implementation, inadequate industrial self-regulation, lack of top management commitment to initiate sustainability efforts	SSCM; Fastener industry; India
Rossi et al. (2013)	Industry specific barriers, costs, lack of legitimacy, poor commitment, regulations	SSCM; Logistics industry; United Kingdom
Grimm et al. (2014)	Lack of financial resources, lack of competencies, and skills, lack of personnel commitment, lack of commitment and trust between supply chain partners, lack of supplier competencies, lack of information and transparency, cultural and language differences	Supplier sustainability; Food Industry; Switzerland
Chkanikova O. and Mont (2015)	Lack of financial resources, conflict of interests between product sustainability policy and free trade provisions, lack of governmental leadership in outlining the vision for sustainability, lack of governmental initiative to harmonize labeling requirements, lack of knowledge and expertise, lack of power over supplies, complexity of supply chain configuration, higher prices of sustainable products, tradition of established supplier relationship, lack of scientific framework to identify the most profound sustainability impacts, customer confusion due to high number of labeling schemes, lack of availability of supply, lack of consumer awareness and interest about sustainability	SSCM; Food supply chain; Sweden

5.1. Significant findings

- The research on SSC is dominated by qualitative research methods such as case study, interview and conceptual/theoretical model which all together contribute to 61.89% of the study in comparison to the quantitative research (31.42%). Tajbakhsh and Hassini (2015a), Seuring and Muller (2008a) also found that most of the studies in the literature report qualitative type study (such as case study) in comparison to quantitative type study (such as survey). For example Jabbour et al. (2015a) conducted a multiple-case study in large Brazilian firms to access the effects on environmental and operational performance indicators due to the implementation of GSCM practices. The findings indicate that GSCM practice of "internal environmental management" and "cooperation with customers" influences the performance of the organization most. Because of the limitations in collecting empirical or secondary data, case study turns out to be the most admired research methodology in SSCM. In the coming years given the more importance to sustainability initiatives and companies increased keenness to adopt sustainability practices, this type of research methodology will find more recognition.
- Articles that reports survey as research methodology where in a large number of organizations are analyzed through data collection, needs to be checked for its biased nature in response and also conduct the reliability and validity tests. A poorly designed survey research that is executed inefficiently is of no mean and to effectively support the research field and to benefit the practitioners and researchers it is necessary to cautiously implement this methodology so that it produces reliable and usable data.
- Articles that used mixed method approach (triangulation) to address the research questions are handful (4.20%). Researchers that used combination of qualitative and quantitative method both at the same time for data collection, to generate multiple perspectives of the phenomenon of interest is fairly low (Ferenhof et al., 2014). SCM research can be advanced by means of mixed methodology which otherwise has mostly relied on limited set of quantitative methods (Golicic and Davis, 2012).
- Journal of Cleaner Production is the leading journal publishing research on SSCM. This is because journal scope involves publishing of articles that cover a wide range of topics that are subsets of SSCM such as environmentally friendlier technologies, green engineering, environmental management systems, environmental performance evaluation, life cycle assessment, corporate sustainability responsibility, sustainable development etc. Although journals specially focusing on sustainability and supply chain are playing a major role in publishing the articles on research field such as Journal of Cleaner Production and Supply Chain Management: An International Journal, it cannot be denied that SSCM research activities have also been published in journals that are not extensively dedicated to sustainable issues.
- Sensitivity analysis (23 papers) is the most popular data analysis technique considered by the researchers followed by other predominant techniques such as structural equation modeling and descriptive analysis each in 12 papers, factor analysis (8 papers) and many other data analysis techniques. Data analysis techniques help to improve the sensitivity of the noteworthy findings of survey research and experimental manipulations in testing hypothesis.
- It has been found that linear programming modeling (27) approach reports the highest in the literature followed by fuzzy logic (10) and non-linear programming (8). Also, Brandenburg et al. (2014) found that most the studies report linear programming as a solution technique for a given mathematical model, under a number of requirements represented as linear relationships.
- AHP (8) and DEA (8) is the most widely used multi-criteria decision making approach in SSCM followed by TOPSIS (5). Chai et al. (2013) also found AHP the most popular individual decision making approach followed by TOPSIS and DEA. Due to the kind of flexibility and robustness, AHP technique provides the decision maker to understand the problem apart from adequately handling the inherent uncertainty of human

decision making process makes it more acceptable amongst the academicians and practitioners (Govindan et al., 2015b).

- ➢ Most of the studies are conducted in the manufacturing sector (18) as industrial sector offers a greater potential to impact the triple bottom line (TBL) followed by electrical and electronic industry (12); and food industry (12).
- ➢ United States of America (40) is pioneering the research field followed by Germany (32), United Kingdom (32) and many more countries.

5.2. Gaps identified

- ➢ Given the more importance to a case study and theory development based research to date on the research topic highlights of the fact that there is lack of previous work which can act as guidance for future. Hence research on SSCM is still at preliminary stage with majority of the studies not supported by quantitative findings.
- ➢ Triangulation research design is lacking its credibility in the research topic which is a serious concern. Researchers' ignorance to mixed method approach referred to as triangulation, to deal with the research questions developed for the study would have negative impact on field development.
- ➢ Use of advance data analysis techniques such as multiple regression analysis and ANOVA by researchers to validate the implemented model are still limited. It is also found that discriminant analysis and path analysis techniques are not reported in a single literature. Although, regression analysis, ANOVA and path analysis are useful tools to test the relationship between the dependent and independent variables but the basic drawback in applying these techniques is their inability to handle non-linearity among the variables. Thus, an assumption has to be made that the relationship among the variables are linear when applying these techniques which may affect the result especially when the assumptions are taken in a subject of social sciences.
- ➢ Modeling approaches based on dynamic programming, goal programming and genetic algorithm has been rarely used in papers for model formulation. SSCM itself being multi-disciplinary in nature and also a large number of uncertain factors associated with the decision making further adds to the complexity of the problem. Solution approaches like dynamic programming, goal programming and genetic algorithm are used to solve complex real case problems (Brandenburg et al., 2014). Limited use of these solution approaches exposes researchers more focus on simple case problems and ignorance to complex SSCM problems due to modeling complications.
- ➢ Sectors like the automobile industry, logistic industry, energy industry, mining industry and few other sectors that have a significant impact on the supply chain sustainability are lagging behind in terms of research applicability.

5.3. Research directions and limitations

• It has been found that most of the previous studies are biased towards quantitative research and mostly reports qualitative research. Quantitative research method such as applying survey technique (online surveys, on-site surveys, web-based surveys and e-mail/mail surveys) to collect data from business organizations is needed in the proposed research topic to check the reliability and validity of the theory developed. For example, van Hoof and Thiell (2015) carried out a survey in 14 anchor companies and 177 small and medium sized suppliers to analyze how anchor companies initiatives contribute to cleaner production dissemination. They found that integrating anchor companies in environmental initiatives results into improving supplier performance, cost reductions, environmental leadership, and improved reputation. Also, Gualandris and Kalchschmidt (2016) conducted a survey in 86 Italian manufacturing firms to investigate how they develop their environmental and social practices and performance. They found that as SSCM develops, the firm's sustainability performance improves.

This is justified by Jakhar (2015) wherein an integrated method of SEM, fuzzy AHP and fuzzy MOLP is applied to a case study of an apparel industry and found that decrease in total cost by 12.32% can be achieved if an organization adopts cost saving strategy (sustainable purchasing, sustainable production, sustainable delivery and logistics). Also, in a case study analysis of a bag manufacturing company located in Mumbai, India; Ramanathan et al. (2014) found that incorporating reverse logistics (recycling) into its overall supply chain processes has resulted in reduction of product lead-time by 20–25%. They also found that collaboration with its suppliers and buyers has increased the company's sales by 24% and production efficiency by 22%.

- ➢ It is also proposed that much research is needed to collect data regarding a specific research problem via. methodological triangulation research design as it provides multi-dimensional insight into the research problem. For instance, Jia et al. (2015) conducts an interview with managers of different departments and also a survey for data collection to identify the dominant SSCM practices in Indian mining and mineral industries. Jabbour et al. (2014) use a mixed method approach (survey + case study) to analyze relationship between organizations environmental management maturity level and GSCM practices adoption.
- ➢ Modeling of real-world problems using linear programming approach is a difficult task due to their multi-dimensional nature. Hence much research is needed to use non-linear programming models (Diabat and Al-Salem, 2015; Khodakarami et al., 2015; Lieckens et al., 2015), graph-based models (Faisal, 2012), dynamic programming (Choi, 2013), goal programming (Buyukozkan and Berkol, 2011) to solve the complex and complicated real case problems.
- ➢ Organizations when making decision about their supply chain, the criteria that would always be focused will be the economic consideration. The objective to achieve cost effectiveness for complex SSCM problems demand decision-makers to use different modeling techniques and solution approaches for analysis. There is no generic methodology that would be applicable to all industries; however, the following approach is suggested to develop a model for cost savings or reduction.

(i) Identify the objectives of the organization. For e.g. cost minimization, material savings, reduction in carbon emission etc.
(ii) Collection of data for the specific problem through literature study, structured interviews with employees, questionnaire-based surveys or a combination of these.
(iii) Development of a mathematical programming model based on the variables, either single objective or multi-objective.
(iv) Analyzing the model using techniques such as LP, MILP, NLP, dynamic programming etc.
(v) Selection of a case study to demonstrate the effectiveness of the proposed methodology.

- ➢ Research is needed to study the applicability and implications of SSCM practices implementation in automobile industry and logistic industry. The logistic industry is a key

research area especially in India due to its status of one among the fast developing nations in Asia. Because of the fact that India happens to be an emerging market for developed nations to do business with; SSCM practices implementation in logistic industry needs to be explored in the Indian context.

- SCOPUS database was used for the search of the articles for review. It is worth noting that SCOPUS is a large database consisting of management and scientific journals but not all peer-reviewed journals are included in the database hence a few important related papers on SSCM may have been not included in the study.
- Only English publications within the SCOPUS database were searched, which may skip some relevant articles published in journals not included in this database, and also in others languages.

6. Research conclusion

The research on SSCM has emerged and burgeoned in the past decade. This study tries to enhance the knowledge of the research field by conducting an extensive literature review of 286 articles published on SSCM in the last one and half decade. Categorizing the selected papers for review along various dimensions and evaluating the content of the tables allows listing out and discuss fruitful findings. Undoubtedly, it can be seen that though significant amount of research is being carried out to implement sustainability concepts in industrial supply chain, but there still exist some potential opportunities (research gaps) that need to be addressed such as (i) quantitative study in SSCM (ii) modeling of real life complex sustainable factors using dynamic programming, goal programming, etc.

Additionally, global complexity, uncertainty in sustainability parameters, complex social-environmental relationship, and non-linearity amongst variables further demands to optimize the complicated realistic problems by developing efficient algorithms such as multi-objective metaheuristic algorithm (MOHEV) (Govindan et al., 2015c), multi-objective genetic algorithm (MOGA) (Validi et al., 2015). The present comprehensive study (classified analysis) thus provides a useful insight as to how the research in the field of SSCM has shaped up in past fifteen years thereby attempting to improve the knowledge and understanding of sustainability concepts in supply chain. The identified gaps and the potential opportunities for research as discussed may act as a starting point for other researchers and practitioners to further investigate these issues.

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